EXPANSION AND CONTRACTION: GOETHEAN POLARITY AND ARCHITECTURE

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EXPANSION AND CONTRACTION:
GOETHEAN POLARITY AND ARCHITECTURE

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[To the students of the Georgia Institute of Technology]

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SUMMARY

As a historic figure, Johann Wolfgang von Goethe (1749–1832) has been drawing interest in contemporary research in humanities due to his involvement in multiple fields such as literature, philosophy, natural sciences and aesthetics while having direct influence on the shaping of the Enlightenment era. Although his body of work has been mostly evaluated under the rubric of phenomenology, this dissertation will aim to develop a comprehensive understanding of his works using his ideas on polarity as the core principle. Polarity stems from Goethe's early involvement in botany where he describes the development of annual plants through cycles of expansion and contraction as opposite sexual forces of natural productivity. This principle forms the foundation of morphology; a unifying science where Goethe applies polarity to formulate ideas on osteology, geology and color. The thesis will be developed in three main chapters that primarily establish the theoretical aspects of polarity in Goethe's works and then extends it towards developing a novel morphological understanding of architecture as well as formulating polarity tools for design.

The first chapter presents an extensive analysis of Goethe's most controversial novel—*Elective Affinities*—as a prototypical literary work applying the concept of polarity for the structuring and development of its story. Using the novel as a theoretical-philosophical framework, the role of polarity is analyzed through character typology, affinity relations among characters, landscape formation and production of architectural projects. The allegorical aspects of the story show that Goethe's scientific writings and engagement with contemporaneous philosophy informed his novel, producing a literary expression of the transition from Idealism to Romanticism.

In the second chapter, polarity in Goethean morphology is analyzed focusing particularly on leaf morphogenesis to demonstrate formal principles of growth. *Metamorphosis of Plants* acts as the theoretical foundation of polarity, explaining the cyclic behavior of expansion and contraction in plants through Goethean principles. The terms “polarity” and “intensification” are further explored in Goethe’s works applied to other natural sciences such as botany and osteology, as well as color; extending both terms as core principles of an ontological system of nature. This system is explored through leaf morphogenesis studies developed in a computational framework to introduce a parametric understanding of topological polarity rules that explain leaf forms using alternating growth cycles.

In the third chapter, Goethe’s statement “All is Leaf” is extended to architecture by applying the concept of polarity through planar and vertical development of architectural massing organized through body-limb duality. Polarity is compared to the classical notion of symmetry and proportion to establish a new look at architectural morphology operating through axiality, primitive huts and parametric application of abstract polarity rules devoid of style. These rules are extracted from a historical analysis of various architectural case studies using samples of Palladian villas, Baroque palaces, Gothic cathedrals, and English manor houses. After developing an understanding of polarized architectural body-limb relations, a procedural polarity machine is developed to apply principles of metamorphosis towards generative studies of architectural massing focusing on Gothic cathedrals as a case study. In the last part of the thesis, polarized morphology is considered as an ecological strategy to approach architectural design under variable conditions of climate and altitude.

CHAPTER 1 POLARITY AND ELECTIVE AFFINITIES

1.1 Polarity during Enlightenment

The philosophical and scientific achievements of German Enlightenment present a few main actors who played major roles in shaping its development in late eighteenth century. This era begins with Kant's philosophical contributions that offer an epistemological framework to allow scientists to investigate natural phenomena by applying mechanical principles. This further leads to the foundation of different scientific categories that can approach both animate and inanimate aspects of Nature through experimentation. While the goal of Kantian Idealism is to mainly accommodate the discoveries of Newton, it appears highly anthropocentric and produces a dichotomy between subject and object that overlooks the intuitive bridge between nature's productivity and products. This problem is addressed in the subsequent development of *Naturphilosophie* by Schelling that remains primarily vitalist; but with its organic view of Nature presents a materialistic approach to consider all natural products to follow similar consistent laws of productivity.[1] Contrary to Baruch Spinoza's monistic view of Nature and Kant's mechanical principles, Schelling's application of polarized principles towards the philosophical and scientific description of organisms redefines this movement neither as monistic nor anthropocentric but as intrinsically dynamic and teleomechanistic.[2] As a central figure in this era, Goethe's major role in the philosophical development of Enlightenment is revealed through his close relationship to the Romantics, particularly to

[1] Friedrich Wilhelm Joseph von Schelling, *First Outline of a System of the Philosophy of Nature*, translated with an introduction and notes by Keith R. Peterson (Albany : State University of New York Press, 2004), 125.
[2] Robert J. Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2002), 294.

Schelling and his growing dissatisfaction with Kantian Idealism. With this spectrum of influence, his main objective could be defined as establishing a bridge between antagonistic philosophical developments of Idealism and Realism to find a viable ground for his science of Morphology. This way he aims to not only demonstrate an intuitive bridge between products and productivity but also develops polarized principles that can lead to fruitful experimentation and observations as an "adventure of reason".[3]

1.1.1 Kant and Idealism

Towards the end of the eighteenth century, Newton's discoveries were posing problems to the establishment of a secure and consistent basis for scientific categories and their development, separated from traditional morality and religion. This problem was addressed by philosopher Immanuel Kant (1774–1804) who aimed at redefining the scientific categories deductively as "there can be no metaphysical knowledge that derives from ideas…no a priori knowledge of things as they are in themselves."[4] Kant's goal was to establish transcendental idealism as "a reattunement of theoretical and practical reason" to counter "the threat posed by Spinozist/naturalist transcendental realism."[5] In *Critique of Pure Reason* (1781) Kant opposed the ideas of Skepticism developed by Hume to establish a scientific avenue to investigate a link between the reality of the phenomenal world and the transcendental realm of noumenon that prescribed its laws.[6] Although the natural world developed temporal, spatial and causal relationships that

[3] Philippe Huneman, "Naturalising Purpose: From Comparative Anatomy to the 'Adventure of Reason'," in *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, 37, (2006): 671.
[4] Robert E. Butts, "Kant's Philosophy of Science: The Transition from Metaphysics to Science," in *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 1984, Volume Two: Symposia and Invited Papers (1984): 686-7.
[5] Sebastian Gardner and Paul Franks, "From Kant to Post-Kantian Idealism," in *Proceedings of the Aristotelian Society*, Supplementary Volumes, Vol. 76 (2002): 219.
[6] Immanuel Kant, *Critique of Pure Reason*, trans. Norman Kemp Smith (London : Macmillan, 1929).

grounded the fundamental laws of nature, our subjective understanding of such laws was insufficient to identify the transcendental reality.

> I understand by idea a necessary concept of reason to which no corresponding object can be given in sense-experience. Thus the pure concepts of reason, now under consideration are *transcendental ideas*. They are concepts of pure reason, in that they view all knowledge gained in experience as being determined through an absolute totality of conditions. They are not arbitrarily invented; they are imposed by the very reason itself, and therefore stand in necessary relation to the whole employment of understanding. Finally, they are transcendent and overstep the limits of all experience; no object adequate to the transcendental idea can ever be found within experience.[7]

Bridging this dichotomy between theoretical and practical reason became the basis of all *a priori* knowledge in Kantian Idealism where subjective modes of inquiry, grounded by senses and judgment, were the sole mode of discovering transcendental principles of production. In the second critique, *Critique of Practical Reason* (1788), Kant aimed at advancing this approach by developing moral consequences over the first critique to formulate a practical cognitive approach for *a priori* principles to determine universally applicable laws.[8] Since Idealism anchored the moral ego of the subject with the transcendental ego of the ideal object under the causally determined world, Kant required a model for the free actions of beings without resorting to absolute determinism advocated by Spinoza's monism. However he presented a dichotomy for extending the

[7] Ibid., 318-9 (A 328, B 384).
[8] Immanuel Kant, *Critique of Practical Reason*, trans. Werner S. Pluhar (Indianapolis: Hackett Pub. Co., 2002).

empirical cognition of the subject towards a universal basis of the will as "a law that is *subjectively necessary* is *objectively* a very *contingent* practical principle."[9] Kant considered a "unity" between two moral aspects of the subject of happiness and virtue, "either as *analytic* (logical connection) or as *synthetic* (real connection), the former according to the law of identity, the latter according to the law of causality."[10] Kant defines this connection as the "highest good" that is the object of pure practical reason, that without its acceptance produces a paradoxical problem to ground morality.

> But because this linkage is cognized as a priori and hence as practically necessary, and consequently not as derived from experience, and because this possibility of the highest good therefore does not rest on any empirical principles, the *deduction* of this concept will have to be *transcendental.* It is a priori (morally) necessary *to produce the highest good through freedom of the will;* therefore the condition for the possibility of this good must also rest solely on a priori bases of cognition.[11]

Kant defined a reciprocal solution for practical philosophy with the concept of highest good that is "both as immanent and as transcendent", where the necessity of the former is "assured by means of its constitutive employment" and the latter "as a regulative principle is a necessary condition of its employment as an immanent constitutive principle."[12] However, Kant's first two critiques developed a dichotomy between idealism and realism, analytic and synthetic, as "two completely distinct realms—inhabited by phenomena or appearances, related to man through knowledge, and

[9] Ibid., 38.
[10] Ibid., 111.
[11] Ibid., 113.
[12] John R. Silber, "Kant's Conception of the Highest Good as Immanent and Transcendent," in *The Philosophical Review*, Vol. 68, No. 4 (Oct., 1959): 492.

characterized by the principle of necessity; and that of morality, inhibited by noumena or the intelligible, general grounds of appearances, related to man through action, and characterized by the principle of freedom."[13] Kant aimed at solving this problem in the third critique, *Critique of Judgement* (1790), to establish a bridge between aesthetic and teleological judgments by bringing closer the purposive character of beautiful objects and productive capacity of organic nature.[14] He considered the components of an artifact or an organic being as purposive as they indicate design and define a means to an end specified by a causal concept. This can be achieved in two ways, either linearly in the form of "an ever-progressive series" defined as "effective causes [*nexus effectivus*]", or reciprocally "a series would lead either forwards or backwards" that are called "final causes [*nexus finalis*]."[15] While the former "may be judged as an effect through" the latter, Kant considered such a product as a "natural purpose" or "organized and self-organizing being," that cannot be solely explained by mechanical principles.[16] Thus, organisms were considered products of a "thing-in-itself" [*Ding an sich*] that can only "serve as a regulative concept of the reflective Judgment" and "give to the science of nature the basis for a teleology."[17] Organized beings seemed to be the product of a designing intelligence extrinsic to them, since the parts can only be understood as resulting from an overall *Bauplan* or *archetype* that can never be determinative.

> Here we see at once why it is that in natural science we are not long contented with an explanation of the products of nature by a causality according to purposes. For there we desire to judge of natural production merely in a manner

[13] Leonard Krieger, "Kant and the Crisis of Natural Law," in *Journal of the History of Ideas*, Vol. 26, No. 2 (Apr.-Jun., 1965): 196.
[14] Immanuel Kant, *Critique of Teleological Judgement*, trans. James Creed Meredith (Oxford: Oxford University Press, 2007).
[15] Ibid., 163.
[16] Ibid., 164.
[17] Ibid., 165.

> conformable to our faculty of judging, i.e. to the reflective Judgment, and not in reference to things themselves on behalf of the determinant Judgment. It is here not at all requisite to prove that such an *intellectus archetypes* is possible, but only that we are lead to the Idea of it—which contains no contradiction—in contrast to our discursive Understanding which has need of images (*intellecus ectypus*) and to the contingency of its constitution.[18]

In pursuit of natural principles, a Kantian researcher would judge organisms *as if* they owed their existence to a set of rules governing the whole, ultimately to a designing mind or an idea external to them. In a teleological sense a biologist judges an organism to have a purpose following a *Bauplan* or *Archetype,* even if he cannot determinatively claim that the plan was the cause of such an organism. Furthermore, Kant never believed that organisms could be explained by mechanical principles alone, and boldly stated that "it is absurd for men to make any such attempt or to hope that another *Newton* will arise in the future, who shall make comprehensible by us the production of a blade of grass according to natural laws which no design has ordered."[19] With the rise of Romanticism and natural sciences, a lot of scientists—including Goethe—would take the challenge of what Kant coined as an "adventure of reason," as they "shifted its meaning, eliminating the mechanistic reading of 'archaeology of nature' that Kant held and replacing it by a formal reading" to seek potential justification of archetypes.[20]

1.1.2 Goethe and Idealism

[18] Ibid., 191.
[19] Ibid., 185.
[20] Huneman, "Naturalising Purpose," 671.

Before positioning Goethe within the philosophical development of Enlightenment and particularly in Idealism, it is necessary to visit the origin of his thought that begins with a study of Baruch Spinoza (1632–1677). In an early essay titled "Nature" Goethe shows signs of a monistic view of nature which is later abandoned in a following commentary, where he states that an early "tendency toward a form of pantheism" led to the belief that the "world springs from an unfathomable, limitless, humorous, self-contradictory being."[21] Goethe calls this approach "'comparative' which strove to express its development toward a 'superlative' not yet reached."[22] The former has its roots in realism and experience that seeks to locate ideas in the infinite productivity of nature to ground philosophy and science. While Goethe is an admirer and defender of Spinoza, he becomes aware of the problems in the absolute determinism of pantheism, and seeks alternative solutions in the modern philosophical development of his time, beginning with a study of Kantian Idealism.

In "The Influence of Modern Philosophy" Goethe reviews Kant's *Critique of Pure Reason* and the division of philosophical spheres stating "knowledge may be prompted by experience, it does not therefore follow that it arises wholly from experience."[23] While Goethe likes "the ideas of knowledge *a priori* and synthetic judgments *a priori"*, he aims to develop a methodology that alternates between "a synthetic approach and an analytic one" that he sees inseparable.[24] He finds analogous development to his work and thought in *Critique of Judgement* that aims to draw a connection between poetry and comparative science, where "products of these two infinitely vast worlds were shown to exist for their own sake; things found together might

[21] Johann Wolfgang von Goethe, *Scientific studies*, Edited and translated by Douglas Miller (New York, N.Y.: Suhrkamp, 1988), 6.
[22] Ibid.
[23] Ibid., 29.
[24] Ibid.

be there *for* one another, but not *because* of one another."[25] However, Goethe shows dissatisfaction with Kantian final causes and calls them as a "trivial idea" that obstructs the development of natural philosophy because it is "neither advisable nor possible to refute" and prohibits a teleological approach in applying the faculty of judgment towards a unified view of poetry and science.[26]

> There are other reasons for man's general difficulty in abandoning this concept. However, the simple example of botany will show that the scientist must leave this view behind if he wishes to make progress in thinking about things in general. The brightest and fullest flowers, the most delicious and attractive fruits, have no more value to the science of botany than a lowly weed in its natural setting or a dried and useless seed capsule, and may even be of less value in a certain sense.[27]

Avoiding the teleological causality is a critical problem within the Kantian framework. Goethe comments on his growing dissatisfaction with Kantian philosophy in an essay titled "Judgment through Intuitive Perception" where Kant's subjective approach is considered as a limitation to philosophy that only permits "reflective, discursive faculty of judgment" but excludes a "determinative" result to derive archetypes.[28] While Goethe borrows the idea of archetypes from Kant to establish a comparative unity for the study of multiplicity, he questions the ability to ascend to the level of God through faith to enable such reasoning. Instead, he aims to present an alternative route where the scientist can directly participate in the creative processes

[25] Ibid. Here Goethe also shows growing antipathy towards "ultimate causes" that are instead defined as purpose and effect.
[26] Ibid., 53.
[27] Ibid., 54.
[28] Ibid., 31. Here Goethe quotes directly from Kant's text on *intellectus archetypus*, that following a "synthetical-universal" approach (from whole to parts) enables an idea of divine reason that "contains no contradiction." For Goethe, the archetype is addressed as a "primal image and prototype" that intends a more generative principle.

"through an intuitive perception of eternally creative nature."[29] Following Kant, Goethe anticipates a relationship between archetypes and their intuited experience that "can and must be analogous," yet he finds this to be problematic as "we are seemingly plunged into madness by a natural process which must be conceived of in idea as both simultaneous and sequential."[30] To avoid this dilemma Goethe proposes a scientific method involving an analysis-synthesis cycle coupled with *Anschauung* [Intuitive Perception] that involves the "uncovering the multiplicity of form by relationship" among parts of a whole to develop the archetypes.[31] While Goethe's study of Kantian philosophy proves to be beneficial for the development of his ideas, his growing tension with teleology and reflective judgments results in Goethe's embarkation of an "adventure of reason" since for him "types were more 'real' and objective than they were for Kant."[32] While he remains dissatisfied with Kantian Idealism, he seeks an alternative philosophical resolution to his ideas that he finds in the *Naturphilosophie* of Schelling.

1.1.3 Schelling and Realism

Towards the end of the eighteenth century, German philosophy was shifting away from the rational and reductionist philosophy of Idealism under the influence of Romanticism. A prominent figure in this development was Friedrich W. J. Schelling (1775–1854) who developed *Naturphilosophie* to counter the dichotomy established by Kant and provide an alternative to teleological thinking. In *First Outline of the System of Philosophy of*

[29] Ibid.
[30] Ibid., 33. Goethe highlights these problems in an essay titled "Doubt and Resignation" where he somewhat admits defeat to Kantian epistemology. "Our intellect cannot think of something as united when the senses present it as separate, and thus the conflict between what is grasped as experience and what is formed as idea remains forever unresolved."
[31] Malte C. Ebach, "Anschauung and the Archetype: The Role of Goethe's Delicate Empiricism in Comparative Biology," in *Janus Head*, 8(1), (2005): 261. Ebach describes this method as "delicate empiricism in comparative biology" that aims to develops homology. Goethe sought to establish this intuitively, by implementing *Anschauung* as a form of active participation with the phenomena.
[32] Huneman, "Naturalising Purpose," 671. Huneman argues for the shifting of definition for "adventure of reason" from a mechanical to a regulative formulation.

Nature, Schelling aims to develop a reformulation of Nature using dual concepts by contrasting productivity and products while giving more priority to the former.[33] Schelling defines Nature's productivity as an "absolute organism" that never appears fixed and "could not be presented through an individual product, but only through an infinity of individual products" that seeks the absolute within the continuity and transmutation of forms.[34] Instead of positing the Absolute as a "*unity* of the product", Schelling considers its dualist core as "a *unity* of force of production throughout the whole of organic nature" that expresses "*the organic forces of sensibility, irritability* and *formative force*" as gradations of polar forces.[35] These opposed forces, presented as expansion and contraction, are activated by division and differentiation and succeed by a homogeneous third state that is not "of absolute *homogeneity*, it is only a state of *indifference.*"[36] This way Schelling tries to reformulate a chemical basis of duality and alternating formation in nature while favoring productivity over products.

> As the object is never unconditioned, something absolutely nonobjective must be put into Nature; this absolutely nonobjective factor is nothing else but the original productivity of Nature. In the conventional view productivity vanishes in the product; conversely, in the philosophic view the product vanishes into the productivity.[37]

[33] Schelling, *First Outline of a System of the Philosophy of Nature*. Schelling's *Naturphilosophie* focuses on the development of process philosophy, a form of dynamic realism to counter being with becoming.
[34] Ibid., 49-50.
[35] Ibid., 149. The three forces that Schelling defines also define a continuum among different realms of nature: "the plant is what the animal is, and the lower animal is what the higher is. In the plant the same force acts that acts in the animal, only the stage of its *appearance* lies lower. In the plant it has already wholly dispersed into force of reproduction, which is still distinguishable as irritability in the amphibians, and in the higher animals as sensibility, and conversely."
[36] Ibid., 185.
[37] Ibid., 202.

For Schelling this dynamic duality "is not something in matter, but is *matter itself*" and this formulation of productivity is contrasted with a third factor to define indifference as a temporal fixed stage where products occur.[38] This materialist formulation remains as a consistent theme throughout Schelling's philosophical development and becomes a central focus in *System of Transcendental Idealism* where Schelling develops a novel dialectic to consolidate two trends in modern philosophy in order to ground a transcendental unity of the self and nature, of subject and object and of products and productivity.[39] These oppositions are presented through discussions of matter that either "shapes itself automatically into purposive products" where concept of purpose and intelligence emerge out hylozoism as an objective realism; or stays as "inert, and to have the purposiveness in its products brought about by an intelligence outside it" that then fails to reconnect intelligence and nature as in the case of idealism.[40] Schelling's solution to this problem is to develop a third option by combining two possible approaches in philosophy that may either develop an intelligence out of nature or develop a nature out of intelligence.

> Just as the two activities reciprocally presuppose each other, so also do *idealism* and *realism*. If I reflect merely upon the ideal activity, there arises for me idealism, or the claim that the boundary is posited solely by the self. If I reflect merely upon the real activity, there arises for me realism, or the claim that the boundary is independent of the self. If I reflect upon *the two together*, a third view

[38] Ibid., 215.
[39] Friedrich Wilhelm Joseph von Schelling, *System of Transcendental Idealism*, trans. P. Heath, intro. M. Vater (Charlottesville: University Press of Virginia, 1978).
[40] Ibid., 216.

> arises from both, which may be termed *ideal-realism*, or what we have hitherto designated by the name of transcendental idealism.[41]

The goal of Transcendental Idealism is to develop a system "of explaining how the ultimate ground of the harmony between the subjective and objective becomes an object to the *self itself*."[42] In his later philosophical works Schelling aims to advance this formulation through the concept of ground [*Grund*] by positing an absolute indifference for polar oppositions found in philosophy. In his first attempt found in *Philosophical Investigations into the Essence of Human Freedom*, the decoupling between idealism and realism is contrasted as God and Ground (or Nature), where the latter is considered in a mirroring relationship of the former.[43] This comparison enables Schelling to remove the ontological dichotomy between the two and consider God under the concept of *Becoming* that is temporal, in contrast to *Being* [*Ein Wesen*] which is postulated as eternity that presents no purpose or differentiation.

> Does creation have a final purpose at all, and, if this is so, why is it not reached immediately, why does what is perfect not exist right from the beginning? There is no answer to these questions other than that which has already been given: because God is a life, not merely a Being. All life has a destiny, however is subject to suffering and becoming.[44]

In *Invisible Remainder*, Slavoj Žižek revisits Schelling's ideas on Absolute productivity, indifference, and dynamic polar forces; calling him as "first and foremost a

[41] Ibid., 41.
[42] Ibid., 217.
[43] Friedrich Wilhelm Joseph von Schelling, *Philosophical Investigations into the Essence of Human Freedom* (Albany: State University of New York Press, 2006), 66.
[44] Ibid.

philosopher of freedom."[45] Žižek ties the concept of freedom towards the polarization of primordial forces that poses some limitation on productivity. He states that "freedom is not, in the usual idealist vein, the full autonomy of the Absolute, its power to deploy its content 'freely', to determine itself independently of any external limitations, to posit its limitations as its self-determinations; rather, it concerns the most concrete experience of the tension within a living, acting and suffering person between Good and Evil–there is no actual freedom without an unbearable anxiety."[46] Žižek considers Schelling's teleology to posit some form of "self-predestination" for nature's productivity where "freedom and necessity coincide" in the Absolute: "a step which is strictly prohibited within the Kantian perspective."[47] Schelling even advances this further by considering man and the Absolute as sharing an "act of contracting being" where the freedom in man "*has to be a repetition of the same act of the Absolute itself.*"[48] To achieve this Schelling offers a non-materialistic "theory of time whose unique feature is that it is not formal but qualitative" that locates primordial rotary motion in its past, their splitting in the present and their reconciliation into the future to criticize the standard structuring of time that requires "mechanical necessity over freedom, of actuality over possibility."[49] Schelling's philosophy remains essentially positive, signaling the "victory of Good over Evil: in opting for Creation, God shifted from the contractive power B to the expansive power A."[50] In its contractive power, the Absolute plays with ideas before they sprung out of "a state of indifference, when they are not yet posited as actual" as in their timeless quality they "designate a kind of virtual reality of things in which multiple, incompatible

[45] Slavoj Žižek, *The Indivisible Remainder: An Essay on Schelling and Related Matters* (London: Verson, 1996), 15.
[46] Ibid., 17.
[47] Ibid., 19.
[48] Ibid., 20-21.
[49] Ibid., 32.
[50] Ibid., 33.

possibilities coexist prior to the 'collapse' of the wave function which brings about the actual existence of things."[51] While *Naturphilosophie* remains essentially dynamic and material-realist in its core ideas, the usage of polar forces and their application to philosophy draws Schelling closer to Goethe who plays a major role in the development of Romanticism in Germany.

1.1.4 Goethe and Romanticism

In his *Romantic Conception of Life,* Robert Richards presents a complex mosaic of relationships among the Romantics, particularly focusing on Schelling and the much older Goethe, that helped flourish new ideas on nature that were both philosophical and scientific.[52] Richards states that Schelling's engagement with Goethe from 1798 to 1803 during the time he taught at Jena, and developed *Naturphilosophie*, moved the young philosopher towards an "ideal-realism" that would enable him to develop a "Spinozistic objectivism" on nature.[53] In return, Schelling was able to show Goethe that "scientific understanding and artistic intuition did not play out in opposition," instead both presented "complementary modes of penetrating nature's underlying laws" thus enabling a bridge between idealism and realism that Kant sought to achieve.[54] In their epistemology, both Schelling and Goethe utilize polarity as a central concept however they differ slightly on the role of archetypes and teleology. For Schelling, "the only way archetypes could be realized in nature was through dynamic evolution" where species "moved toward the

[51] Ibid., 52.
[52] Richards, *The Romantic Conception of Life,* 463. Richards states that "the deep personal relationship between Goethe and Schelling inevitably affected their intellectual lives, and the reciprocal impact was striking."
[53] Ibid., 465.
[54] Ibid., 469.

realization of the ideal of absolute organism" in a teleomechanistic way.[55] In this sense, Schelling's *Naturphilosophie* excludes any notion of fixed archetypes that recapitulate productivity as he considers a cyclic destiny for the Absolute developing an "intrinsic temporality" that is "self-productive", "organic" and "could have a history."[56] In contrast, Goethe's work on morphology fundamentally relies on a discussion of polarity through physiological and conceptual types, opening up a dialogue of both comparative and determinative studies. Before the conception of his work on plant metamorphosis, Goethe believed that "a law governing the structures of all plants had to exist, for otherwise we could not recognize something *as* a plant–a quasi-Platonic principle that carried enormous weight with him."[57] Richards considers Goethe's formulation of Urtypes necessarily "transcendental," where an "idea" connects all organs that display a similar physiology back to an underlying generative origin–"a Proteus", that could not only relate different organs to each other, but also explain how it "would give rise to endless varieties."[58] Thus, Goethe's notion of the archetype combines two main properties: a unity among variability, and an open-ended transformative capacity. In Kantian terms: Goethe's archetype is "not merely a regulative or hypothetical concept" but a "determinative" one.[59]

Another aspect that marries the two could be found on their view on teleology. In *Philosophies of Nature after Schelling*, Grant finds similarities in Schelling's *Naturphilosophie* and Goethe's development on morphology as a cumulative science

[55] Ibid., 305-6. In *First Outline of the System of Philosophy of Nature*, Schelling weighs productivity over fixed products, where Nature is "an infinitely polymorphic being for every *moment* of time, but not a fixed and determinate product of *all time*" (p.189). "But the product is supposed to be productive to infinity; it will therefore be productive at every stage in a determinate way; the productivity will remain, but not the product. "The product will appear to be gripped in *infinite metamorphosis*" (p.213).
[56] Ibid., 11.
[57] Ibid., 416.
[58] Ibid.
[59] Ibid., 451.

built on types.[60] While Goethe's "morphology has less to do with morphogenesis than with the presumption of the reversibility of the 'ascending process' by which the phenomenon is generated," the dynamic relationship between nature's productivity and product in *Naturphilosophie* gives rise to more complex products by repeating its internal process while constantly perfecting it.[61]

> …the polar tension between the physicochemical and the intellectual is assumed to be 'following in nature's footsteps as thoughtfully as possible': *what is produced in phenomena is the recapitulation of its production in nature.* Since, therefore the phenomenon arises through the reciprocity of subject and object that forms Goethe's experimental method, the polarity by which the phenomenon is generated is dissociable from the 'vegetal type' that will rise to the 'original plant [Urpflanze], or the 'osteological type', the intermaxillary bone thus phenomenalized.[62]

While products become more evolved, the developmental process becomes one of perfection as well: "just as there is an ascending recapitulation of type in phenomenon, so there is an ascending recapitulation from the simple to the complex."[63] In his morphology, Goethe embraces this "reversability of 'nature's footsteps" which "eliminates time, or reduces it to the measure of organization" thus giving Nature an open ended trajectory in its drive as it leads to ever more complex products that are in ideation similar.[64] Grant finds a similar development in Schelling's philosophy that considers

[60] Ian Hamilton Grant, *Philosophies of Nature after Schelling* (New York, NY: Continuum International Pub. Group, 2006).
[61] Ibid., 130.
[62] Ibid., 130-1.
[63] Ibid., 131.
[64] Ibid., 132.

organisms as the basis of nature's productivity and not the reverse, where "linear recapitulationism is necessarily organicist: regardless of its objects' physicochemical make up (intermaxiallary bones, protoplasm), the more complex governs the less, elevating organization to the principle of nature."[65]

Another aspect that unites Schelling and Goethe is their consideration for the parity between art and science and the presence of genius in both aesthetic and intiutive realms. Richards elaborates on this topic in his essay "Nature is the Poetry of Mind, or How Schelling Solved Goethe's Kantian Problems" in which he considers Goethe to follow an ideal-realism where "scientific understanding and artistic intuition did not play out in opposition to one another", instead "they reflected complementary modes of penetrating to nature's underlying laws."[66] Goethe's philosophical position remedies Kantian dichotomy in two ways. Firstly, "the intellectually intuitive action of nature" produces "archetypal ideals" that become productive, and secondly, such an "intellectual intuition" could be shared by "the artist who created an aesthetic object" and also by "the scientist who penetrated the veil of nature to intuitively understand the archetypal unity underlying its variegated displays."[67] In this sense, artistic intuition and scientific reasoning overlapped as "God, nature and our intellect were one."[68] For Goethe, the temporary fixed stages that occur during the continual metamorphosis constitute to the idea of archetype that are used as regulative and determinative to aid comparison. These are determined through his method of experimentation that combines analysis and synthesis, in drawing products and productivity closer.

[65] Ibid., 133.
[66] Robert Richards, "Nature is the Poetry of Mind, or How Schelling Solved Goethe's Kantian Problems," in *The Kantian Legacy in Nineteenth Century Science*, ed. Michael Friedman and Alfred Nordman (Cambridge : MIT Press, 2006): 43.
[67] Ibid., 46.
[68] Ibid.

1.1.5 Goethean Method: Analysis and Synthesis

The dichotomy embedded in Enlightenment between products and productivity is a highlight of Goethe's "Fortunate Encounter" with Schiller in Jena where they oppose each other on the nature of philosophy during Enlightenment.[69] In their meeting, Goethe gives an "enthusiastic description of the metamorphosis of plants" by drawing a "symbolic plant"; however, Schiller considers Goethe's description not as "an observation from experience" but an "idea."[70] Schiller who was a follower of Kantian philosophy states that "an experience can never be congruent with an idea–that is precisely what makes the idea unique."[71] Goethe, anticipating a connection between ideas and experiences states that "if [Schiller] viewed what I called experience as an idea, surely some mediating element, some connecting element, must lie between the two!"[72]

In his short essay titled "Analysis and Synthesis" Goethe considers a bridge between the two scientific methods that establish a connection between mechanical principles applied to natural phenomena and developing general principles that can connect sequential observations.[73] This approach requires a direct engagement with nature and is intended to open up a feedback mechanism that can guide the scientist towards establishing certain morphological laws. Goethe contrasts this dual approach with Newton's treatment of physics as "intensive analysis" that relies on a "single phenomenon" which lacks "every known phenomenon in a certain sequence so that we

[69] Goethe, *Scientific Studies*, 20. In his meeting with Schiller in Jena, Goethe tries to give a brief description of the concept of metamorphosis using a "symbolic plant" that is "derived directly from empirical observation." But Schiller refutes this presentation as a "cultivated Kantian" because for him an "experience can never be congruent with an idea." Goethe contemplates that there must still be a link between ideas and experiences: "if he viewed what I called experience as an idea, surely some mediating element, some connecting elements, must lie between the two!" Kant clearly states this dichotomy in *Critique of Pure Reason*, 318: "I understand by idea a necessary concept of reason to which no corresponding object can be given in sense-experience. Thus the pure concepts of reason, now under consideration, are transcendental ideas" (A327/B384).
[70] Ibid.
[71] Ibid.
[72] Ibid.
[73] Ibid., 48.

could determine the degree to which all might be governed by a general principle."[74] He states that scientists need to approach experimentation from two sides to ground the principles of dynamic organic phenomena.

> A century has taken the wrong road if it applies itself exclusively to analysis while exhibiting an apparent fear of synthesis: the sciences come to life only when the two exist side by side like exhaling and inhaling.[75]

In *The Wholeness of Nature,* Bortoft examines Goethe's dual methodology towards scientific investigation of nature and considers him "as a phenomenologist of nature, since his approach to knowledge was to let the phenomenon become fully visible without imposing subjective mental constructs."[76] Bortoft defines polarity between analytic and synthetic methods that are complementary to each other where the former works with abstract, quantifiable and general concepts and the latter operates on the sensuous ones that are qualitative. He considers the synthetic ability as "holistic mode of consciousness" that is "nonlinear, simultaneous, intuitive instead of verbal-intellectual, and concerned more with relationships than with the discrete elements that are related."[77] The two approaches present a split role in consciousness that contrary to subject-object duality, confronts the scientist simultaneously with the one and the many during experiments; the one representing ideas or theoretical constructs, and the many as variations of the type that are physical.[78] Bortoft considers a bridge between the two

[74] Ibid.
[75] Ibid., 49.
[76] Henri Bortoft, *The Wholeness of Nature: Goethe's way of science* (Edinburgh: Floris Books, 1996), 21.
[77] Ibid., 63.
[78] Manuel DeLanda, *Intensive Science and Virtual Philosophy* (London ; New York : Continuum, 2002), 49. DeLanda also makes similar distinction between intensive and extensive properties: "the latter are divisible in a simple way, like lengths or volumes are, while the former exemplified by properties like temperature or pressure, are continuous and relatively indivisible." He extends both terms towards understanding the properties of the virtual where they could potentially constitute a continuum among the "heterogenous space made out of a population of *multiplicities*, each of which is a topological space on its own."

modes that are defined as the *intensive* and *extensive* dimensions for the multiplicity of sense experience. The intensive dimension seeks "multiplicity in unity" and uses the analogy of a "hologram" where difference between forms is captured by virtual mental constructs that are infinitely divisible yet remain as a whole.[79] The hologram signals the impossibility of assigning a definitive formal image to an idea that essentially remains formless and potentialized. In contrast, the extensive aspects of synthesis look at "unity in multiplicity" to relate all the different forms towards a common origin. Bortoft highlights the paradoxical aspect of this duality where "all cognitive perception entails not only sense perception but also an organizing idea, a concept" where "a concept cannot be formed by generalization from several instances because it is only by means of the concept that we can recognize an instance in the first place."[80] Goethe writes on this paradoxical status of subject-object duality in an essay titled "The Experiment as Mediator between Object and Subject" and proposes to devise sequential, self-regulating experiments that can guide the scientist towards developing ideas on nature. Goethe criticizes the anthropocentric approach towards judgmental ways of perceiving science that may produce errors. In contrast, he considers that natural phenomena needs to be observed without prejudice or concerns for utility, while the discoveries need to be approached objectively and extensively providing abundant observation to develop hypothesis.

> …if the observer is called upon to apply this keen power of judgment to exploring the hidden relationships in nature, if he is to find his own way in a world where he is seemingly alone, if he is to avoid hasty conclusions and keep a steady eye on

[79] Ibid., 86.
[80] Ibid., 331.

> the goal while noting every helpful or harmful circumstance along the way, if he must be his own sharpest critic where no one else can test his work with ease, if he must question himself continually even when most enthusiastic–it is easy to see how harsh these demands are and how little hope there is of seeing them fully satisfied in ourselves or others. Yet these difficulties, this hypothetical impossibility, must not deter us from doing what we can.[81]

Goethe often draws parallels between scientific pursuit and adventurous walks along a landscape structured with paths providing routes through valleys and divided with constant running water as a supply of knowledge.[82] To achieve success in scientific categories, he calls for collaboration among scientists who do not focus on singular discoveries or extensive use of analysis that require inaccessible and difficult experiments. Instead, variable knowledge needs to be consolidated to develop a complementary alternative path that arranges separate discoveries into a higher view. This process can be found throughout his scientific studies, which are organized by devising sequential experiments and observations in order to ground dynamic phenomena under simple, accessible principles that aim to make nature itself accessible.

1.2 The Influence of Goethe's Scientific Studies on *Elective Affinities*

Among many of his literary and scientific works, Goethe's famous romantic novel *Elective Affinities* [*Die Wahlverwandschaften*] has been one of the most influential and

[81] Goethe, *Scientific studies*, 12.
[82] Johann Wolfgang von Goethe, *Goethe's Botanical Writings*, trans. Bertha Mueller, intro. Charles J. Engard, (Woodbridge, Conn. : Ox Bow Press, 1989), 218. Goethe compares scientific "adventure" to walk on a landscape in his encounter with Schiller: "Those who command a higher vantage gorund from which to survey the easy confidence of human mind, the understanding innate in the healthy individual with no doubts about facts and their significance nor about his own ability to comprehend, judge, and properly evaluate them-men who command such a vantage point will freely admit that a virtual possibility is undertaken when one attempts to describe transitions to a purerm freer, and more objective phase – transitions of which there must be thousands upon thousands. We are not speaking here of levels of education, but of those false trails, pitfalls, and circutious by-paths which are followed by sudden progress and vigorous upswing to a higher state of culture."

controversial novels since the time of its first publication in 1809.[83] In her *Goethe's Elective Affinities and the Critics,* Astrida Tantillo gives a collective analysis of the novel's reception in the past two hundred years and examines the interpretative confusion it has caused among scholars.[84] The novel's reception and textual analysis shows changing trends spanning over the past two centuries. Due to the harsh criticism in its early reception between 1809–1832, Goethe "attempted to fashion public opinion about it" by not only writing "his own advertisement for the novel" but also "he attempted to solicit reviews for publication from those who would be favorable disposed towards it."[85] Goethe's anonymous advertisement of the novel in the *Morgenblatt für gebildete Stände* aims to defend the work against its early negative reception and instead reveals the influence of his ongoing investigations in natural sciences.

> It seems as if the author's continued natural studies have caused him to use this unusual title. He may have noticed that in the natural sciences one often uses ethical parables in order to bring closer what is quite distant from the circle of human knowledge; and so he also probably wanted, in a moral case, to bring a chemical figure of speech back to its spiritual origins, especially since there is only *one* nature overall, and also since throughout the realm of cheerful freedom

[83] Johann Wolfgang von Goethe, *Elective Affinities*, trans. Judith Ryan, in Volume XI of the American Suhrkamp edition of Goethe's works (Princeton University Press, 1995).
[84] Asrida Orle Tantillo, *Goethe's Elective Affinities and the Critics* (Rochester, New York: Camden House, 2001). Tantillo's work covers the history of literary interpretation of the novel in four main parts. In the first part she considers the novels negative reception and Goethe's efforts to defend the work until 1832. In the second part she looks at the literary interpretation of the novel in the 19th century following Goethe's death. There are two main theoretical schools that actively seek to understand the novel, the Hegelians and the positivists. Their attempt was to analyze the novel through written biographies of Goethe. This brought discussions between morality and immorality as the main conflict intertwined his life and his works. In third chapter Benjamin's seminal essay on the novel is exclusively analysed that created an immense influence on the novel's reception in the twentieth century. The final chapter traces the reception of the novel from 1925 to the end of twentieth century.
[85] Ibid., 5.

> of reason the traces of sad, passionate necessity irresistibly pull themselves and may only be erased by a higher hand, and perhaps even then not in this life.[86]

Following Goethe's death, the novel was often analyzed as a conflict of morality and immorality in the shadow of his life and works. This approach was challenged with the publication of Walter Benjamin's seminal essay titled "Goethe's *Elective Affinities*" written around 1924–25, who rejected reading it as a tragic or classical work, but instead turned to the mythic side of the novel.[87] The novel could present a struggle Goethe faced in his marriage that forced him to write *Elective Affinities* to protest the institution against the mythic powers of nature that he was scientifically interested in defining. Benjamin states that Goethe stressed these mythic powers of his work with his literary technique.

> The domain of poetic technique forms the boundary between an exposed upper layer and a deeper, hidden layer of the works. What the author was conscious of as his technique, what contemporary criticism had also already recognized in principle, certainly touches on the concrete realities in the material content; yet it forms the boundary opposite its truth content, of which neither the author nor the critics of his time could be entirely conscious…The author sought, however, to keep this technique as his artistic secret. He appears to allude to this when he says that the novel was worked out according to an idea. The latter may be understood as an idea about technique.[88]

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[86] Johann Wolfgang von Goethe, Werke: Hamburger Ausgabe in 14 Bänden (München : Beck, 1981), 6: 639. Also quoted in Tantillo, *Goethe's Elective Affinities and the Critics*, xiix.

[87] Walter Benjamin, *Selected Writings: Volume 1,* 1913 – 1926, ed. Marcus Bullock and Michael W. Jennings (London: The Belknap Press of Harvard University Press, 2002).

[88] Ibid. Benjamin thinks the novel is more about the mythic essence of the protagonists that experience love in life through their careless interplay of relations. Here Goethe's missed opportunities in his erotic life are exposed as he tries to find the freedom not in a tragic hero that is expelled from life. Instead he seeks to find redemption in assessing a freedom to the "imprint of the spirit" that finds

Among the interpretations of the novel, the investigation of this idea that structured the novel became a point of debate among scholars. Goethe talks on the influence of his scientific studies towards the conception of the novel during his conversations with Eckermann.

> If I still wished, as a poet to represent any idea, I would do it in short poems, where a decided unity could prevail, and where a complete survey would be easy, as, for instance in the "Metamorphosis of Animals," that of the plants, the poem 'Bequest' (Vermächtniss) and many others. The only production of greater extent, in which I am conscious of having labored to set forth a pervading idea, is probably my 'Wahlverwandschaften' [Elective Affinities]. This novel has thus become comprehensible to the understanding; but I will not say that it is therefore better. I am rather of the opinion that the more incommensurable, and the more incomprehensible to the understanding, a poetic production is, so much the better it is (Sunday, 6 May 1827).[89]

Although Goethe considered a technical idea as the basis for the generation of his literary work, its investigation in contemporary research provided no consensus. In *Goethes Wahlverwandtschaften: Werk Und Forschung* [*Goethe's Elective Affinities: Work and Research*], Helmut Hühn outlined the novel's complexity through a

former binding conditions through feeling. Thus marriage is not the ethical problem or the core of the novel since it decays throughout the story.

[89] Johann Wolfgang von Goethe and Johann Peter Eckermann, *Conversations of Goethe with Johann Peter Eckermann*, trans. John Oxenford, ed. J.K. Moorhead, (New York : Da Capo Press, 1998), 206.

conglomerate of essays showcasing how it raised conflicting issues for scholars in different fields.[90]

> The novel linked natural science and history of science, cultural criticism and reflection about the possibilities of art as a medium of knowledge, analysis of social change and the management of social conflicts, ethical and anthropological reflection, psychological and psychopathological recognition in complex poetic form. Like no other narrative work of the early nineteeth century, the novel has to bridge art and literature, philosophy and science.[91]

The novel's complexity, detailed narrative, characters' dynamic interaction and structuring of the landscape have raised conflicting issues for scholars in different fields. Gould found the dynamic activity of the main two characters to be "presented as a result of internal and external forces, of individual and environment" where "events progress by an interaction of forces, which are clearly stated, although not explained."[92] Brodsky considered the characters as bearing chromatic properties that draw a close relationship between Goethe's *Theory of Color* and *Elective Affinities*.[93]

In *Self-generation: Biology, Philosophy, and Literature around 1800,* Müller-Sievers looks at the influence of the scientific debate between epigenesis and preformation that resulted in the triumph of the former in philosophy and literature

[90] Helmut Hühn, *Goethes Wahlverwandtschaften: Werk Und Forschung* [*Goethe's Elective Affinities: Work and Research*] (Walter de Gruyter: 2010).
[91] Helmut Hühn, "Wirklichkeit und Kunst. 200 Jahre Goethes *Wahlverwandtschaften* [Truth and Art. 200 Years of Goethe's *Elective Affinities*] Art" in *Goethes Wahlverwandtschaften: Werk Und Forschung* [*Goethe's Elective Affinities: Work and Research*], ed. Helmut Hühn (Walter de Gruyter: 2010), 3.
[92] Robert David Gould, "Elective Affinities: An Investigation of the Influence of Goethe's Scientific Thinking on *Die Wahlverwandtschaften*" (unpublished Princeton University Ph.D thesis, 1970): 270.
[93] Claudia J. Brodsky, "The Coloring of Relations: Die Wahlverwandtschaften as Farbenlehre," in *MLN*, vol. 97, no. 5 (Dec., 1982): 1147-1179. Brodsky considers the relationship between people and nature in Elective Affinities to take major influence from Goethe's work on color. Goethe's subjective investigation of color phenomena leads to unreconciled aesthetics associated with Classicism and Romanticism. Rather than seeing the novel in a literary form, Brodsky sees the narrative to be turned towards nature's own phenomenality to show how colors appear. In the novel, light substitutes "the character of human being", and "colors" for human "actions" and "deeds". Goethe uses "colors" as non-mimetic conveyors of meaning, or figures.

however "the ideas of scientificity, autonomy, originality, and self-expression proposed with reliance on the epigenetic model either fail or carry unbearable consequences."[94] Müller-Sievers finds an example of this model in Goethe's *Elective Affinities* that when compared to ideas of preformation in *the Marriage of Figaro* "the contrast between the two texts promises to be productive."[95] The comparison between preformation and epigenesis "stand in the same relation to each other as allegory and symbol" where the "historical and philosophical developments seem to have rendered the former obsolete, but the older form "reappears inscribed upon its descendant".[96] Although the book is based on the development of literature featuring both poles and does not provide any supportive arguments in biology, the author makes supplementary remarks on the metaphysical aspects of epigenesis that also structures the novel. Although Goethe's best work has been confusing and is thought to be misunderstood by many modern readers, Müller-Siever's tries to provide a new philosophical interpretation of the work to highlight the ever winning stand point of epigenesis in historical development of biology and literature.

Apart from the hermeneutic studies focusing on the usage of marriage, social classes, and literature, scientific readers often associated the title of the novel to the dissertation of Torbern Bergman's dissertation *De attractionibus electivas* [A Dissertation on Elective Attractions].[97] This chemical origin has been explored in "Goethe's use of chemical theory in his *Elective Affinities*" by Jeremy Adler who suggested that the novel "powerfully combines science—that is, natural philosophy—

[94] Helmut Müller-Sievers, *Self-generation: Biology, Philosophy, and Literature Around 1800* (Stanford, Calif.: Stanford University Press, 1997): 8.
[95] Ibid., 18.
[96] Ibid., 23.
[97] Torbern Bergman, *A Dissertation on Elective Attractions*, trans. J.A. Schufle, (New York: Johnson Reprint Corp., 1968). "Wahl" means choice, selection or election and "Verwandtschaft" means affinity, relationship or kinship.

with literature" drawing attention on the novel's title that brings a "chemical analogy into the characters' innermost thoughts."[98] This chemical origin also provides technical properties to the activity of characters that can remedy "the gulf between natural philosophy and the arts" by offering "the basis for a universal theory of affinity" that "might yet make an original contribution to philosophic debate."[99] Adler considers the theory of affinity as the basis of Goethe's idea for the novel that "could unite celestial physics with terrestrial chemistry under a single, physical law"—a law that can manifest itself in character actions and interactions.[100] This chemical origin shows Goethe's interest in scientific developments of his time while its application within the novel gives it a technical aspect through dynamic character properties and behavior under changing external conditions.

A more contemporary reevaluation of the novel is provided by Tantillo in "Polarity and Productivity in Goethe's *Wahlverwandtschaften*" where she examines the character behaviors by "applying Goethe's principle of productive and destructive polar unions from his scientific works" to state that the characters "in their theoretical discussions, activities, and relationships, concentrate not on productive unions, but on non-productive ones."[101] Polarity is found in many of Goethe's works on color, botany and meteorology that define it as a central theme running in his scientific works that could also play a significant role in the structuring of the novel. Tantillo finds the concept of polarity particularly in *Metamorphosis of Plants*, where Goethe "draws analogies

[98] Jeremy Adler, "Goethe's Use of Chemical Theory in His *Elective Affinities*," in *Romanticism and the Sciences*, eds. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge UP, 1990): 263.
[99] Ibid. Adler emphasizes a strong theoretical origin for the novel as "no other novel of the world literature both makes such detailed and extensive use of a scientific doctrine, and actually contributes to it, too, by developing unresolved theoretical issues."
[100] Ibid. Adler considers Goethe to be on a Spinozist agenda seeking a monistic idea in affinity. "At a time when both the empiricist and the rationalist philosophies were seen to have alienated humanity from Nature through the pursuit of science, serious fiction could offer a different, no less differentiated, but holistic vision of the world."
[101] Astrida Orle Tantillo, "Polarity and Productivity in Goethe's *Wahlverwandtschaften*" in *Seminar: A Journal of Germanic Studies*, 36 (2000): 323.

between natural and human productivity" through polar forces that, in contrast to the novel, show "their productive capabilities and not their destructive ones."[102] She states that "the novel is not primarily about productivity, but about the failure to produce" that is exhibited in character interactions that produce static and passive outcomes that strengthens its tragic nature.[103]

Extending the concept of polarity towards a more philosophical and technical reading of the novel could present a deeper insight into *Elective Affinities* that can position it within Goethe's scientific works rather than limiting its narrative to literary interpretation only. To evaluate the role of polarity in the *Elective Affinities* and its productive capacities, the story will be first summarized followed by distinguishing main themes that structure the novel using polarity as a central principle. These topics will explored through character interactions, landscape formation and character typology in the following chapters.

1.3 Summary of *Elective Affinities*[104]

The story of *Elective Affinities* takes place in a valley where a married couple, Edward and Charlotte, are spending their adulthood together. Edward is "a well-to-do baron in the prime of his life" and he spends his time at the court, in the army and on travels (EA, 93). Charlotte manages the daily operations and landscaping of the property that is left to Edward from his past marriage. In order to spend their "long-desired happiness" alone, Charlotte had sent her only daughter from a previous marriage–Lucianne to a boarding

[102] Ibid., 311. Tantillo also draws examples from Goethe's anatomical writings where "he does not limit nature's polar creativity to procreativity" and instead gives freedom to animals to alter their form as "balance to polar considerations of freedom and constraint."
[103] Ibid., 322.
[104] Goethe, *Elective Affinities*. For the summary of the book this English translation will be further referred to as "EA" in the text to avoid excessive footnotes. All illlustrations used throughout the text are reprinted from the engravings of Philipp Grotjohann.

school along with her beloved niece Ottilie who she adopted after Ottilie's mother passed away (EA, 96). They live in a white manor house that is located on top of a hill facing a view of a small village bounded by the inn on one side and an old couple's house on the other. The village is separated from the house and the gardens by a brook that flows through it. The gardens are located on a lower level and connected to the village with a bridge that leads to two paths to reach the new gardens located on the opposite side of the valley facing the manor house. The path on the right passes through the churchyard, and is closer to the village directly facing the cliff, whereas the one on the left is a longer path covered with "charming shrubbery" (EA, 93). Both paths are joined before the beginning of the climb up to the cliff with "all kinds of steps and stairs along a narrow, increasingly steep path" that leads to the moss hut which is newly built under Charlotte's supervision (Fig.1.3.1.1) (EA, 94). The hut is small but it has enough room for four people to see an extensive picturesque view of the valley including "the village down below, the church with its spire" that are barely visible from the manor house (EA, 93).

1.3.1 Elective Affinities: Picturesque Landscape

As a part of their daily life, Edward and Charlotte are occupied with their landscape to improve the quality of their property (Fig.1.3.1.1). Edward feels an incentive to share these plans by inviting his close friend the Captain to the manor house whose "many-sided talent and training" would be useful for the currently undertaken expansion of projects and modification of the landscape (EA, 94). However, Charlotte has "an inner feeling that doesn't augur well" with this proposal because she believes that "the arrival of a third party" would throw their relationship out of balance (EA, 97). They decide to consult Mittler, translated as the mediator, who persuades the couple to take whatever

decision necessary. Although Charlotte remains unsatisfied with Mittler's intervention, Edward convinces her to take the risk and invites the Captain by writing a letter.

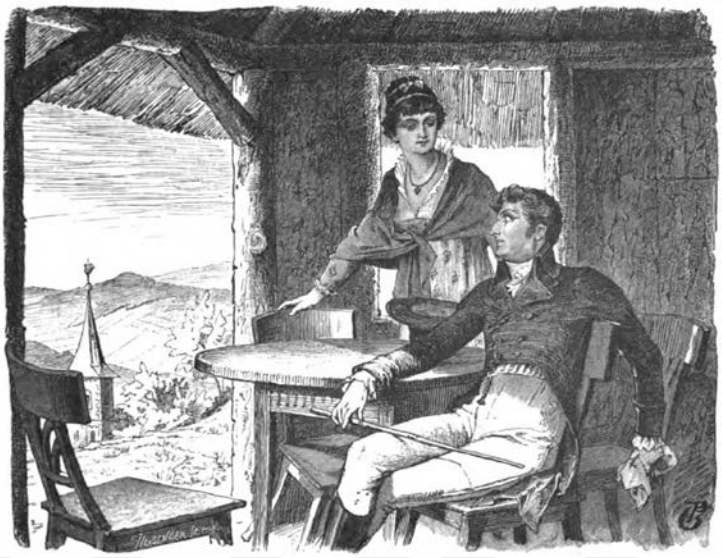

Figure 1.3.1.1 – Charlotte conversing with Edward at the moss hut.

After the Captain's arrival he is introduced to the landscape by first visiting the moss hut. He is impressed with the "new pathways" that enhance the quality of every beautiful spot on the landscape (EA, 104). When they reach the moss hut, Charlotte uses the arrival of the Captain as a "threefold occasion" to celebrate the completion of the structure on Edward's name day. She recalls that both Edward and the Captain shared the same name "Otto" when they were at the boarding school. As a "childhood bargain" Edward had given this "laconic name" to his close friend. Leaving the moss hut behind they take the "tortuous old footpath" that Charlotte is working to improve (EA, 105). They are placing "new steps and stairs" that will make the climb "conveniently to the top" of the hill. "Over rocks, through bushes and shrubbery, they reach the summit" that forms "a whole series of fertile ridges without a single flat spot." The village and manor

house are no longer visible from this spot, but they can see “an expanse of ponds; beyond them green hills, whose contours they followed; and finally steep cliffs forming a clearly defined vertical boundary to the furthest watery expanses, in whose surface their majestic outlines were mirrored.” They notice a half-hidden mill “down the valley where a rapidly flowing brook ran into the ponds,” together with the plane and poplar trees by the middle pond.

Figure 1.3.1.2 – Edward and the Captain surveying the landscape.

The Captain plans to prepare a map to discuss the plantation and landscaping of the whole area in order to give suggestions to Edward about how the property could be improved (Fig.1.3.1.2). Meanwhile Charlotte receives letters from the schoolmaster about Ottilie and Lucianne’s progress at the boarding school. From these letters she learns that Lucianne is “quickly picking up languages, history and other knowledge” that “distinguishes her from all the others by her free and natural behavior” (EA, 99). In

contrast, Ottilie is “unable to develop talents or skills.” The schoolmaster informs Charlotte that “she does not learn like a person being educated, but like a person destined to teach” (EA, 109). Learning about Ottilie’s struggle at the school, Charlotte consults Edward to invite her to the property as well so that she could enjoy the company of her niece. Edward suggests for her to spend time with Ottilie while he enjoys the Captain’s company and proposes to “hazard the experiment” (EA, 100). Although Charlotte is worried that Ottilie’s beauty might attract the Captain, Edward recalls not having any “slightest impression” of her pretty nature nor beautiful eyes. Interestingly Charlotte conceals how she had introduced Ottilie to Edward after returning from his travels “in the way of a fine match: for she had no longer thought of herself in connection with Edward” (EA, 101). In fact, the presence of the Captain at that time “was evidently so attractive” for him, that he “ignored the budding beauty-to-be” (EA, 100).

1.3.2 Elective Affinities: The Natural Law of Affinity

After finishing their daily works on the property and plans, Edward and the Captain spend the evenings with Charlotte, talking and reading about topics related to bourgeois society. One night Charlotte draws attention to a book that Edward is reading about chemical affinities that is “dealing with minerals and different types of earth” (EA, 112). Charlotte’s curiosity on the subject draws Edward and the Captain to explain the fundamental principles behind this natural law. The Captain takes the lead to explain the first principle of affinity (Fig.1.3.2.1).

With all natural objects the first thing we notice is their relation to themselves. It may seem strange to mention something so obvious, but we can only move to the unknown when we are clear about the known (EA, 113).

Figure 1.3.2.1 – Charlotte, Edward and the Captain discussing the theory of affinities.

Like water, oil or mercury, every substance has a tendency to "retain their unity unless it is broken by some outside force" while "this pure and perfect cohesiveness natural to fluids" tends to form round shapes. With second principle of affinity every substance "also has a relation to other things" and show a tendency to mix well, like water and wine. The Captain calls these substances "related" that tend to "rapidly combine and interact" (EA, 114). While others, like water and oil, "persistently refuse to blend" could be brought together using mediators like the alkaline salt. The final principle of affinity involves how these related substances impose "degrees of affinity" in complex cases. In these chemical reactions both separations and combinations take place that make substances "choose one combination in preference to the other" (EA, 115). For

instance, when limestone is placed in sulfuric-acid, the acid turns lime into gypsum while sulfur evaporates as a gaseous acid. However Charlotte questions the role of choice and necessity in this reaction as the chemist decides on how the reaction takes place. She feels sorry for the “poor sulfur” that needs to return to earth after its banishment as gas. Seeing Charlotte’s attempt to postulate human behavior and feelings into substances Edward and the Captain show that the “chemists are much more gallant” because they add another substance into the reaction so that none of them end up alone (EA, 116). In these reactions “separation and combination, repulsion and attraction” can be shown to take place in a “crosswise pattern” where four substances united in pairs abandon their original combinations to make new compounds. This way they justify how the term “elective affinities” takes place. Using letter symbols Edward further explains how this crosswise reaction could take place among the characters if they could invite Ottilie as the fourth component.

Figure 1.3.2.2 – The Captain is assisting Charlotte during walks

Figure 1.3.2.3 – Edward is playing music with Ottilie.

After Ottilie arrives, she intuitively grasps the organization of the house and surrounding properties and starts to take role in the daily activities. In order to complete the plans for a projected summer house, the Captain starts working with Charlotte. Consequently, Edward starts spending more time with Ottilie (Figs.1.3.2.2-3). Both couples start to grow “mutual affections” towards each other that have “delightful effects” (EA, 126). Their growing affinity leads them “towards the infinite” as they are no longer “confined to the house” and their walks are “extended farther and farther” reaching “newly discovered spots and unexpected views” (EA, 127). During one of their daily walks they discover a circular path around the cliff that provides a longer but more gradual climb to the top of the hill. Using this path by the three lakes they reach the top of the hill and realize that they have “circumscribed a separate little world” (EA, 128). When they come back to the manor house, the Captain opens his map to relocate the site

for the summer house. Edward asks Ottilie's opinion about the location of the project and she proposes the "highest point of the rise" where the house will face an "extraordinarily beautiful" view (EA, 129). From here they won't be able to see the village and the house, but the view will be open to "a new and different world" with the lakes, mill, hills, mountains and countryside, expanding the further elaboration of paths (EA, 129). Captain and Edward like this proposal as they think the summer house will be used for solemn social occasions and the extensive walks on the landscape would embellish these encounters.

The ceremony for the foundation of the summer house takes place on Charlotte's birthday. The mason describes this "secret task" as an event that "takes place in the depths of the earth" (EA, 133). The foundation stone, which resembles the outline of the building, is laid down by the mason and "will not be visible" after the "walls of earth" are erected. The house is going to be built with the "cohesive powers" of the stones without using any mortar. The guests and observers are asked to bestow "various items" in metal containers to be buried in the foundation for "remote posterity" (EA, 134). After the ceremony, the count and baroness—two of Charlotte and Edward's close friends from the court—visit the manor house. The count becomes interested in the talents of the Captain and he offers him a job causing Charlotte to realize the affection she has had for him. Meanwhile the baroness senses a threat for the relationship of Edward and Charlotte with the presence of beautiful Ottilie. She wants to send her away to a private school to protect their marriage. In the evening they all sit around a dinner table and later the group is divided into pairs before the women and men withdraw to their wings.

At night Edward escorts the count to the women's wing where he would be reunited with the baroness. As he passes through the corridor he feels an "uncontrollable longing" towards Ottilie (EA, 146). But her room is located on the mezzanine level that is not accessible from the corridor. He finds himself in "a strange confusion" outside his wife's room knocking on the door. They spend the night together "in the dim lamplight" making love (EA, 147). Because of their "secret affections" their "imagination took over from reality" as Edward "clasped none other than Ottilie in his arms" while Charlotte "saw Captain more or less distinctly before her mind's eye." Despite this secret incident Edward and Ottilie's affinity for each other keeps growing in the following days. On the other hand Charlotte realizes that she is going to have a baby from Edward. She starts drawing apart from the Captain who will leave to accept the count's job offer. In desperation they try to separate Edward and Ottilie but their efforts remain unsuccessful. Before leaving, the Captain assigns a former pupil of his, a young architect, to maintain the "continuity and certainty" of the projects as well as the union of the three lakes into a large one (EA, 155). For her birthday, Ottilie receives a "precious little chest on her table" as a gift from Edward which is filled with fabric and jewelry that could "clothe her several times from head to foot" (EA, 160).

After the Captain's departure Charlotte confronts Edward to make a decision on Ottilie's future (Fig.1.3.2.4). Rather than sending Ottilie away, Edward decides to leave home until "prospects are better and calmer" (EA, 163). Before his departure, he confronts Mittler to discuss a solution for "this uncertainty of life" as he is deeply in love with Ottilie however Charlotte is (EA, 172) willing to save her marriage and her unborn child. In desperation Edward writes his own will leaving the estate to Ottilie and making

“provisions for Charlotte, for the unborn child, for the Captain, for his servants.” He longs for “external danger to preserve his internal balance” and decides to join the recently broken war as it suits his plans. When Ottilie learns that Charlotte is going to have a baby and she withdraws into herself.

Figure 1.3.2.4 – Edward discussing with Mittler.

1.3.3 Elective Affinities: Ottilie

In the second part of the novel the central theme turns from love to death. Similarly the constructions on the landscape address the graveyard and the church rather than gardens and the barely completed summer house. After the Captain’s departure, the architect assumes the role for managing the organization and completion of tasks. He finds a little old chapel in the cemetery to be renovated “as a special monument for former times and

tastes" (EA, 179). Ottilie joins the architect in this extensive undertaking. Following his instructions she begins to neatly and skillfully draw an "elaborately draped garment" with paint and brush (EA, 182). Soon Ottilie's presence at the chapel makes a "vivid impression upon the young man, who had not yet drawn from nature or art" (EA, 183). All the figures on the walls start to look like her while the building takes on an unfamiliar aspect and creates a special atmosphere. The architect opens the chapel on the eve of Edward's birthday. Despite its "crude and bare" look, it leaves alternating impressions on Ottilie who thinks of her memories with Edward (EA, 184).

After the completion of the chapel, Charlotte's daughter Lucianne visits the house. Lucianne's dominant character appears as a contrast to the naïve Ottilie who displays a more introverted persona. As Lucianne gains more control of the daily procedures of the manor, she starts giving orders to everyone while limiting their activity in a commanding fashion. Because of her "mischievous egotism" she treats people in the same way she treats objects (EA, 193). She openly shows dislike for Ottilie whose natural beauty makes her jealous. One night Lucianne organizes the guests to enact various paintings in the form of a *tableaux vivant* such as van Dyck's *Belisarius*, Poussin's *Ahasuerus and Esther* and Ter Borch's *The Paternal Admonition* (Figs.1.3.3.1-2). The architect sets up the stage and lighting for these dramatizations. While Lucianne decides on her parts in the tableaux, Ottilie does not take part in any of them. With every different painting, Lucianne gives herself a better role in these dramatizations as an expression of her growing power in the household. After the overwhelming entertainment, Lucianne and her friends decide to carry the amusements away from the manor house and travel to the countryside.

Figure 1.3.3.1 – Lucienne in *tableaux vivant.*

Figure 1.3.3.2 – Ottilie in the crèche.

After Lucianne's departure the architect feels an urge to satisfy a "secret motive" because of Ottilie's exclusion from the living pictures (EA, 203). He plans to organize a *crèche* [the reenactment of the birth of Jesus] from which all the other living pictures had originally sprung. Completing all the details for such presentation he uses Ottilie as "the mother of God." On Christmas Eve when everything is ready, he shows the scene to Charlotte who is surprised with "the reality which had here been turned into a picture." As the baby falls asleep "in the most charming pose", Ottilie's shawl appears with "an infinite grace to reveal the hidden treasure beneath" (EA, 204). At this moment the *crèche* seems "caught and transfixed"; leaving all the participants and Charlotte moved with the "unmeasurable bliss" on Ottilie's face that expressed "her own inner feelings and her conception of the role" (EA, 204). The architect then switches the *crèche* to a daylight scene with bright illumination from all sides. In this case Ottilie appears as "surrounded by infinite brightness" where instead of shadows "only the colors could be seen" (EA, 205).

1.3.4 Elective Affinities: Novella and Otto

Ottilie's schoolmaster arrives and discusses with Charlotte taking Ottilie as his wife who will help him manage the boarding school. Charlotte is afraid to let her go because she fears to upset and lose Edward. She expects that when Edward returns to find himself as a happy father, his mind would change and the issue of Ottilie will be taken care of respectively. Soon after, Charlotte gives birth to her child who is christened with the name "Otto" who "could hardly have any other name than that of his father and his father's friend" (EA, 215). Ottilie takes the principal care of the baby, becoming his closest guardian (Fig.1.3.4.1). The baby boy has a "dual resemblance" that makes his

figure look like the Captain while his eyes are “harder to distinguish from Ottilie’s” (EA, 232).

Charlotte and Ottilie notice that the overall landscape gets closer to completion as they climb up to the top of the hill to see the surrounding views. The summer house is almost ready and the views from the rooms are most picturesque. During this pleasant period of summer, Charlotte receives a visit from an Englishman whom Edward had met during his travels. They take him around the landscape where he appreciates all the details and qualities that they have accomplished. At night, he tells them a novella of the “Curious Tale of the Childhood Sweethearts [*Die Wunderlichen Nachbarskinder*]” that has a deep impact on his listeners (EA, 224).

Figure 1.3.4.1 – Charlotte and Ottilie amusing the baby.

The novella is about two teenage neighbors that show a strange passion towards one other in their aggressive childhood games. Noticing “these strange passions” their parents decide to separate them as they go down different paths in their lifes (EA, 225). The boy with his energetic character becomes a fast learner and wherever he goes he is liked and respected. In contrast the girl feels something is missing in her life as she isn’t able to find anyone to love. Later, for the first time she encounters someone to be a friend, a lover, and an admirer. Others see them as a perfect match that makes their engagement as *fait accompli*. Subsequently, the two neighbors reunite and realize a mutual attraction. Now that the girl discovers these inner feelings, she realizes the “innate affection in the guise of resistance” towards him when both of them were young. As the boy contemplates departure, her “insidious passion” is aroused and she decides to die in order to “punish for his lack of interest” (EA, 227). Before the boy leaves he arranges a party on a large decorated yacht inviting the girl with her family and fiancé. As they are drifting towards a dangerous narrow river bed, the girl appears on the upper deck with a wreath of flowers in her hair and shouts: “Take this as a memento!” and jumps into the river only to cause her neighbor to dive into the water to save her (EA, 228). He brings her onto dry land to receive help from a young couple who try to bring her “naked body back to life” (EA, 229). Their efforts succeed and she regains consciousness reuniting with her childhood sweetheart. The young couple offers them their wedding clothes to cover their bodies so that they could receive their parents’ blessings. Charlotte and the guests become deeply affected by the Englishman’s story.

Edward is discharged from his long campaign and plans to come back to the estate to reunite with Ottilie. He consults the Captain, who has been promoted to the

status of Major, to gain information on the property. Edward tells him that during battle he thought of his relationships and compared them, ultimately choosing Ottilie. He convinces the Major to help him devise a plan to fix the situation. According to the plans there will be a divorce and afterwards Edward will take Ottilie on a vacation. The Major and Charlotte will have complete authority to initiate and organize plans for the property, money and other arrangements. Otto will stay with his mother and he will receive education under the Major's tutelage.

Edward sends the Major to meet with Charlotte to tell her about this course of action. Meanwhile, he stays at the inn to hide, but due to his "uncontrollable impatience" he wanders through the gardens to find Ottilie with the baby (EA, 238). Edward sees Otto for the first time and recognizes his physical resemblance to the Major and Ottilie calling the baby "the result of a double adultery." He declares his love for Ottilie as they share intimate kisses for the first time and agree to let Charlotte decide their fate. After Edward leaves them, Ottilie hurries back to the summer house to reunite with Charlotte. While she tries to get on the boat to cross the lake she loses her balance and drops the baby into the water. She pulls the child from water but notices that his eyes are closed and he is not breathing. Having lost the oar, she drifts towards the middle of the lake on this "faithless unfathomable element" (EA, 240). A gentle breeze carries the boat towards the other side of the lake.

As soon as she reaches the opposite shore Ottilie hurries to the summer house and summons the doctor (Fig.1.3.4.2). In all this trouble, the Major arrives and tells Charlotte about Edward's plans while Ottilie is "unable to move or speak" (EA, 243). Feeling sorry for Ottilie who Charlotte sees "as the tool of a mysterious fate" she agrees to the divorce

as “[her] hesitation, [her] resistance have caused the baby’s death” (EA, 242). They consider the baby as a necessary sacrifice for the happiness of all of them. Ottilie, having heard their conversation, traces “out a new path for herself while in a trance-like state” (EA, 244). She appears fully determined to renounce her love for Edward and decides to go back to the boarding school.

Figure 1.3.4.2 – Ottilie hurrying to the summer house with the baby.

1.3.5 Elective Affinities: Hope

Charlotte buries the child without a ceremony in the chapel “as the first victim of an impending fate” (EA, 244). She realizes how much the landscape serves to renew their sense of tragedy. After a discussion with Mittler, Edward decides to go after Ottilie who is about to leave for the boarding school. They have an unintentional encounter as Ottilie

enters the room before Edward has time to give her a note. In desperation Edward declares his love to Ottilie but she gives no response. She neither wants to go with him, nor to the school. She gives a “serene nod” to be taken back to the manor upon Edward’s insistence (EA, 251). After their arrival at the manor, they each rush to their separate rooms. Ottilie’s room has been cleared of furniture “except her little chest” left standing in the middle of the room as “no one had known where to put it” (EA, 252). Edward is devastated because Ottilie shows no response to his love. Mittler arrives to take advantage of Ottilie’s state of paralysis to save Edward and Charlotte’s marriage.

Figure 1.3.5.1 – The architect by Ottilie’s coffin at the chapel.

Towards the end of the novel, Ottilie prepares herself for death. She puts together a bridal dress using the contents of her little chest. While Mittler is lecturing the other characters on the Ten Commandments to protect the matrimonial bond, Ottilie loses consciousness and passes out in her room. In her final moment she pulls her strength together and with “an angelic, silent movement of her lips” cries for Edward to promise

to live (EA, 258). After she passes away her dead body is carried in an open oak coffin to be buried under a vault at the chapel (Fig.1.3.5.1). They place Otto's coffin to her head while her little chest is placed at her feet. After the funeral ceremony Edward takes out a collection of Ottilie's belongings to recall his memories with her. In this "sorry state" he is struck by an "infinite emotion" and he dies away thinking of his saint (EA, 262). Charlotte gives him a place beside Ottilie in the vault so that the lovers can "rest side by side" to be reunited in another life.

1.4 Polarity and Landscape

Starting from the first chapter of *Elective Affinities* Goethe gives a detailed description of the landscape, presenting views from focal points occupied by structures that are connected by paths traveled by coupled characters. A discussion of the role of landscape as a structuring element of the novel is given by Friedrich Nemec in *Die Ökonomie der Wahlverwandtschaften* [The Economics of Elective Affinities] who considered "the roads and buildings of the idyllic landscaped gardens to present an appropriate expression of the intentions and relationships of the people" and "a sign of their hidden destiny."[105] While the overall valley is circumscribed by two alternative paths to reach to the summit of the summer house, the structures illustrate contrasting relationships with their altitudes, materials, and views. Tantillo relates the movement and relations of characters to Goethe's interest in polarity but considers these to be eventually "non-productive" or "undirected activity."[106] While most of the scholars restrict the discussion of the landscape to the novel's narrative, considering Goethe's relationship to Romantics and

[105] Friedrich Nemec, *Die Ökonomie der Wahlverwandtschaften* [Economics of Elective Affinities] (Munich: W.Fink, 1973): 45. "Die Wege und Baulichkeiten des idyllischen Landschaftsgartens erwiesen sich zugleich als angemessener Ausdruck der Absichten und Beziehungen der Personen, d. h. ihres Lebenszusammenhangs; die Landschaft wurde zum Zeichen ihres verborgenen Schicksals."
[106] Tantillo, "Polarity and Productivity in Goethe's *Wahlverwandtschaften*," 318.

his ideas on polarity presents a novel, two-fold role of the landscape. Firstly, the landscape offers a scientific avenue that explores Goethe's relationship to Humboldt and his interest in environmental ecology. Secondly, the grounding of structures—particularly the ceremony of summer house—shows a speculative philosophical narrative by drawing kinship to Schelling's *Naturphilosophie*.[107] These two avenues aim to explore Goethe's interest in landscapes and architecture by offering a new look at the map of the valley executed by the Captain.

1.4.1 Humboldt's Influence on Goethe

The development of Goethe's morphological studies, particularly his ideas on archetypes, received much interest and influence among the Romantic circle in Jena. One of these figures was Alexander von Humboldt (1769–1859), a German geographer and naturalist, whose relationship proves to be mutually influential.[108] In 1797, Humboldt spent some time at Jena "associating with Goethe and Schiller" and their "impressions from this time were vital" for his future "work on earth magnetism, geology, botany, hydrographic and climatic patterns–and particularly the salience of isothermal maps as bases for understanding patterns of vegetation, settlement, health and disease."[109] Throughout his travels he studied how each location on earth's surface was a product of global forces acting locally. Goethe found interesting remarks in Humboldt's work on the American expedition that presented various environmental conditions such as temperature,

[107] Müller-Sievers, 157. Müller-Sievers considers the summer house as "an allegory of the system of epigenetic reason."
[108] Richards, *The Romantic Conception of Life*, 449. Richards writes that Goethe "attended the young scientist's lectures, conferred with him frequently, and witnessed some of his experiments on electrical transmission in the nerves."
[109] Anne Buttimer, "Beyond Humboldtian Science and Goethe's Way of Science: Challenges of Alexander von Humboldt's Geography," in *Erdkunde*, v55 n2 (2001): 108. Buttimer states that Humboldt's reflections on nature, landscape and life resonate contrasting views to Goethe's. Goethe had an object-based mode of understanding nature that is called "delicate empiricism" while Humboldt's main goal was to depict nature's primordial forces in order to find proof of its inner relations and develop a sense of enjoyment for scientific engagement.

atmosphere, solar radiation and rock types as relevant parameters for plant growth and expressions of form. Humboldt's first book on his expeditions to the Americas was dedicated to Goethe who read the "text carefully" and responded with a "cross-sectional diagram" where he imagined a landscape with different heights for European and American mountains including the "snowlines and vegetations."[110] Later he sent a copy of his *Elective Affinities* to him noting that Humboldt's name was mentioned by Ottilie in the novel (EA, 212) which shows their growing affinity for each other.

Humboldt's struggle in the 1790s was to develop a quantifiable scientific approach to elaborate on the philosophical debate between the Enlightenment and Romanticism. Before his work on biogeography, he was mainly occupied with "the sensitivity of plant and animal tissues to chemical changes" and such "physiological work was dedicated to the investigation of the powers of living matter, and especially the phenomenon of galvanism."[111] This approach was admired by Schelling who praised Humboldt's scientific approach to discover Nature's creative potentials and in return, Humboldt praised Schelling's philosophical achievements in his *Ideen zu einer Geographie der Pflanzen* that showed the "the possibility of reducing all natural phenomena to the incessant conflict of elemental forces of matter."[112] In his work on natural phenomena Humboldt showed coherence with Schelling's view of nature where

[110] Ibid., 113. After their first meeting at Jena 1794, they shared ideas and became impressed by each other's work. They had a good dialogue. Goethe wrote to Humboldt to keep him updated of his interests and their investigation with natural phenomena from two opposite perspectives. In a letter on June 18, 1795 Goethe writes: "Do tell me, from time to time, about your experiences and be sure of my vital interest in participation. Your observations start from the *Element* and mine from the *Gestalt,* so we could not hasten too much to meet each other in the middle. I am grateful for the share in your works that you also will give me publicly; I am indeed flattered by this proof of your friendship."

[111] Michael Dettelbach, "Alexander von Humboldt between Enlightenment and Romanticism," in *Northeastern Naturalist*, Vol. 8, Special Issue 1: Alexander von Humboldt's Natural History Legacy and Its Relevance for Today (2001): 13. In his experiments, Humboldt was neither being a naïve empiricist nor a Romantic idealist, but he was engaging in philosophical inquiries in the science of Enlightenment. Romantic intellectuals and philosophers were preoccupied with the same task. Humboldt's character, work and intellectuality was admired by many Romantic contemporaries including Goethe and Schelling. Humboldt recognized that geography was not principally about compiling maps but about cultivating one's own view of Nature.

[112] Alexander von Humboldt, *Schriften zur Geographie der Pflanzen*, ed. Hanno Beck (Darmstadt: Wissenschaftliche Buchgesellschaft, 1989), 44-45.

he describes conflicting polarized forces acting on matter under basic chemical interactions that are driven by electricity. The determination of these forces between the environment and plant forms became the goal of Humboldtian science where "a comprehensive understanding of nature by way of comparative analyses of its complex structures with their bewildering number of static and functional interrelationships was deeply rooted in his artistic genius."[113]

After meeting Goethe, Humboldt started working on a theory on the topographical environment of plants. He believed that "similar vegetative forms might be found distributed throughout the globe along corresponding latitudes and altitudes."[114] The descriptive taxonomical work in botany was unsatisfactory to Humboldt who underlined the importance of the geography for the expression of variation for plant forms. He instead preferred an approach guided by rigorous quantification, where "the physical data were then correlated with the occurrence of various types of vegetation" to establish laws of distribution within a confined landscape.[115] This was achieved by dividing the topography into zones using data that "were not, however, imagined to be topographically or vegetationally homogeneous" as different plant forms were not distributed equally, yet "the general appearance and habit of growth, of the constituent plants" provided a classification of physiognomy.[116] Rather than classification by taxonomy, Humboldt favored a classification of growth patterns that still produced distinguishable regions yet enabled variation for the expression of material forces. This

[113] Otto Fränzle, "Alexander von Humboldt's Holistic World View and Modern Inter- and Transdisciplinary Ecological Research," in *Northeastern Naturalist,* Vol. 8, Special Issue 1: Alexander von Humboldt's Natural History Legacy and Its Relevance for Today (2001): 62. Fränzle considers Humboldt to view nature holistically: "when analyzing interrelationships in the sense of functional networks, Humboldt basically tried to practice a holism" to develop "the basis for modern science in general and ecology in particular."
[114] Robert J. Richards, *The Tragic Sense of Life: Ernst Haeckel and the Struggle over Evolutionary Thought* (Chicago: University of Chicago Press, 2008), 21.
[115] Malcolm Nicholson, "Alexander von Humboldt and the Geography of Vegetation" in *Romanticism and the Sciences*, eds. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge UP, 1990): 181.
[116] Ibid.

technique was used in his illustrations in *Essai* where he showed how plant forms were able to migrate and adapt to different altitudes using this internal mechanism for transformation and adaptation.[117] These differentiated plant types found an expression in Humboldt's artistic renderings of landscape profiles and geographies (Fig.1.4.1.1).

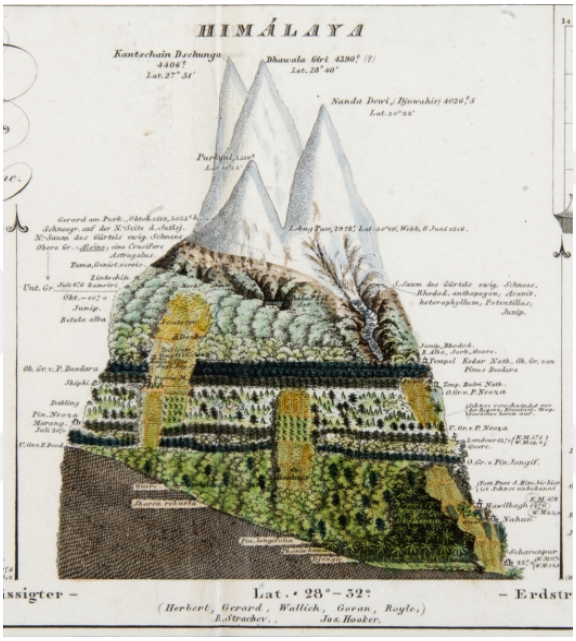

Figure 1.4.1.1 – An example of Humboldt's renderings of the landscape showing different plant formations on different altitudes with changing properties (Reprinted after H Berghaus, 1851, *Physikalischer Atlas…, v*ol.V, plate No.1).

1.4.2 Polarity and Productivity in Schelling's Naturphilosophie

As an alternative to the scientific perspective, the landscape of *Elective Affinities* also presents philosophical narratives that are symbolized through the horizontal movement of characters and the foundation of their projects along the landscape that is treated as an ontological playground. Walter Benjamin mentions this hidden mystical nature of the

[117]Alexander von Humboldt, *Essai sur la Géographie des Plantes* [Essay on the Geography of Plants] (London: Society for the Bibliography of Natural History, 1959, Orig.1807).

landscape where the characters' "wondrous movements form the ground not for an intensely inward spiritual harmony of beings but only for the particular harmony of the deeper natural strata" that turned the topographical landscape into a philosophical model hidden within the story.[118] Goethe also relates the birthdays of the characters to transformation of the landscape. The grounding of the summer house takes place on Charlotte's birthday (EA, 132), its completion ceremony coincides with Ottilie's (EA, 155), Ottilie's visit to the chapel occurs on Edward's birthday eve (EA, 184) as well as the blossoming of flowers in the gardens (EA, 168), and the moss hut is completed on the Captain and Edward's name day (EA, 104). Furthermore, the future movements generated by these structures also act as constructive forces that engrave deeper paved paths. The projects are separated from this constant dynamism through foundation ceremonies that give them an ontological character. For instance, the mason's speech requires "three things" that "are necessary for a building: that it be rightly situated, that it have a good foundation, and that it be properly constructed" (EA, 133). He explains how "this ceremony takes place in the depths of the earth."[119]

> We could easily just lower this stone, whose corner marks the right hand corner of the building, whose rectangular form represents, in miniature, the building's rectangular shape, and whose horizontal and vertical planes stand for the true level of all its walls; we could do so because it would rest evenly by virtue of its own weight. But there shall be no lack of mortar, the substance that binds stone to stone; for just as people who are naturally fond of each other stay together better

[118] Benjamin, *Selected Writings*, 304.
[119] For the construction of the house the ground has to be first leveled. Then the mason calls for the guests at the ceremony to place "various items to bear witness for remote posterity" into the "hollowed-out spaces" in the foundation (EA, 134). The stone mason lays the foundation stone to cover the "treasure" in the ground that will not be revealed unless everything that is not "even finished building were to be destroyed."

> when they are bound together by the law, so stones that have already been shaped to fit together are held together by its cohesive powers; and as it is not proper to be idle when others are working, you will doubtless not refuse to participate (EA, 133).

This narrative shows similarities to Schelling's philosophical formulation of the Absolute, where natural products are isolated from pure productivity by contractive forces. In his *Naturphilosophie* Schelling creates this differentiation by positing a ground [*Grund*] that distinguishes the spirits that are created from the God that created them:

> The oldest formations of the earth bear such a foreign aspect that we are hardly in a position to form a concept of their time of origin or of the forces that were then at work. We find the greatest part of them collapsed in ruins, witnesses to a savage devastation. More tranquil eras followed, but they were interrupted by storms as well, and lie buried with their creations beneath those of a new era. In a series from time immemorial, each era has always obscured its predecessor, so that it hardly betrays any sign of an origin; an abundance of strata–the work of thousands of years–must be stripped away to come at last to the foundation, to the ground.[120]

For Schelling the ground as an ontological model positions polarity at its core that "feels a conflict of two principles in it; one strives forward, driving toward development, and one holds back, inhibiting and striving against development."[121] These forces create products out of the Absolute "through the unconditioned [*Unbedingt*] and totally

[120]Friedrich Wilhelm Joseph von Schelling and Žižek S., *The Abyss of Freedom/Ages of the World* (Ann Harbor, Michigan: University of Michigan Press, 1997), 121.
[121] Ibid., 123.

generative force" of nature that in return recapitulate the same forces for their internal dynamism.[122] This way, each product becomes differentiated; such that it becomes "free, conscious and intelligent" in a different level on "the ground of his own existence."[123] Schelling extends this potentiation towards the beginning of time to postulate a primal ground that precedes any differentiation of the products from the Absolute.

> ...there must be a being before all ground and before all that exists, thus generally before any duality–how can we call it anything other than the original ground or the non-ground [*Ungrund*]?[124]

In *Philosophies of Nature after Schelling*, Ian Hamilton Grant considers Schelling's formulation of the ground as an ontological model and finds compatibility with Deleuze's transcendental geology—the volcanic stratum.[125] While for Schelling the transcendental "consists in physical series of products susceptible of potentiation," turning the earth into a "productive product" or a "*Scheinprodukt*", Deleuze adds "the dimension of *ungrounding"* to it that opens the surface to the "turbalances beneath the ground, where everything is fiery rather than aqueous, demanding construction."[126] Grant considers a link between physics and *physis* [Nature] where the "physical ground is a product of the dynamic ungrounding that *precedes* it as the subject of nature itself."[127] For Goethe, the landscape in *Elective Affinities* becomes a transcendental polarity playground where "*the depths are not transcendental, but rather the transcendental is the*

[122] Ibid., 139.
[123] Ibid., 149.
[124] Schelling, *Philosophical Investigations into the Essence of Human Freedom*, 68.
[125] Grant, *Philosophies of Nature after Schelling.*
[126] Ibid., 201.
[127] Ibid., 204.

surface of the world, while both are physical."[128] The opening up of the stratum that grounds the summer house becomes a recapitulating act of the same un-grounding that aims to separate the physical construction from the dynamism of the ground that un-conditions it.

Schelling's *Naturphilosophie* is mainly constructed on the "struggle between two forces of attraction and repulsion, the result of which is an equilibrium."[129] The freedom and potentiality in the Absolute [*Ungrund*] carry these dynamic forces towards their limitation that brings a transition from un-conditioned to the conditioned while "the unground remains as absolute, and does not contain, but merely potentiates differentiation."[130] Out of the asymmetry of forces that has a "raw power as non-being" a product could rise as a "substratum of any actual being."[131] Thus, the artistic ability of the forces still preserve the dynamism of the absolute that potentiates a transition from the Un- to the Ur-, as *an act of polarization* to condition and produce possible productive products when the grounding of nature [*Ur-grund*] recapitulates itself.

1.4.3 Polarity as the Structuring Principle of Landscape

Goethe's considerable engagement with other Romantics prior to the conception of *Elective Affinities*, particularly the influence of Humboldt and Schelling can be found in the topographical map sketched by the Captain. This map has been an item of investigation among scholars as a structuring diagram for the novel. In the past century there have been various attempts to reconstruct this map to discuss its role for the

[128] Ibid.,205.
[129] Herbert M. Schueller, "Schelling's Theory of the Metaphysics of Music," in *The Journal of Aesthetics and Art Criticism*, Vol.15, No.4 (Jun., 1957): 465.
[130] Ian Hamilton Grant, "The Chemistry of Darkness," in *Pli 9* (2000), 40.
[131] Robert F. Brown, "Schelling and Dorner on Divine Immutability," in *Journal of the American Academy of Religion*, Vol. 53, No.2, (Jun., 1985), 241.

progression of the story.[132] "The only comment on the landscape came not from Goethe" but from Friedrich Wilhelm Riemer (1774–1845) who lived with Goethe as his literary assistant between 1803 and 1812 and noted in a diary entry that "the landscape for Elective Affinities was designed."[133] In this entry "Riemer testified that Goethe had drawn a map for *Elective Affinities* together with him."[134] Stefan Blechschmidt has recently presented such a drawing from Riemer's estate that resembles the map drawn by the Captain.[135] In this sketch, Riemer was not only able to locate certain structures and main paths of the landscape that hold key roles, but also includes altitudinal representations of primary architecture expressed by pen strokes (Fig.1.4.3.1). On Riemer's map, several elements show features of a picturesque landscape. The picturesque originates from the early eighteenth century English landscape theory ,where "intellectual speculation about nature and the development of neo-classicism in architectures led to a new style of gardening that explicitly refused a geometrical layout."[136] This aesthetic theory considered gardens to have "a formal character like landscape paintings, which were already an abstraction and analysis of the visible order of the world."[137] However, it is the "movement" that defines "how pictures were to guide the design of sequential or continuous spatial experience" which differentiates the picturesque from landscape pictures.[138]

[132] An reconstruction of this map could be found in Nemec, *The Economics of Elective Affinities*, 45.
[133] Ibid., 19.
[134] Hühn, *Goethes Wahlverwandtschaften*, 96.
[135] Stefan Blechschmidt, "Der Schauplatz von Goethes *Die Wahlverwandtschaften*: Kartographischer Zugang und modellhafte Vergegenwärtigung," in"*Eine unbeschreibliche, fast magische Anziehungskraft,"* Goethes *Wahlverwandtschaften*, ed. Ernst-Gerhard Güse (Weimar: Klassik Stiftung Weimar, 2008): 28-35.
[136] John Macarthur, *The Picturesque: Architecture, Disgust and other Irregularities* (London ; New York : Routledge, 2007), 3.
[137] Ibid.,5.
[138] Ibid., 233.

Figure 1.4.3.1 – Riemer's sketch for the landscape of the novel [?] (Reprinted from Hühn, *Goethe's Elective Affinities*, 97. Original source: Friedrich Wilhelm Riemer [?]: Skizze zu Goethes Roman "Die Wahlverwandtschaften," [Sketch for Goethe's *Elective Affinities*], Goethe and Schiller Archive, Weimar, GSA 78/539,2).

The description of views and positioning of structures shows Goethe's particular interest in picturesque landscapes that became an area of study during his travels to southern Europe, as narrated in his *Italian Journey*.[139] But he was interested in describing motion as much as static views where "the polarity of movement and tranquility and their many respective associations express perhaps best of all the principle of oscillation as it applies to nature."[140] Goethe often expressed the idea of movement as climbing

[139] Johann Wolfgang von Goethe, *Italian Journey: 1786-1788*, trans. W. H. Auden and Elizabeth Mayer (New York: Pantheon Books, 1962). An architectural review of Goethe's interest in Italian landscape could be found in David Lowe and Simon Sharp, *Goethe & Palladio: Goethe's Study of the Relationship Between Art and Nature, Leading through Architecture to the Discovery of the Metamorphosis of Plants*. (Great Barrington, MA : Lindisfarne Books, 2005).

[140] Allen E. McCormick, "Young Goethe in the Landscape," in *Modern Language Studies*, Vol. 18, No. 4 (Autumn, 1988): 66. McCormick also emphasizes this opposition in Goethe's view in describing forms: "The unifying embrace of opposites to which we referred earlier and which obviously characterizes so much of Goethe's philosophy of form operates also as the basic technique in viewing and describing nature."

mountains in his poetical work, not to "compose poems at their summit" but to seek refuge in experiencing nature presenting "the importance of haven—hut, garden, enclosure, a solitary spot in nature—to the entire problem of opposites and their reconciliation or balance in Goethe's landscapes."[141] In *Elective Affinities*, this balance is presented with the movement along the paths and the static views seen from key structure that present contrasting relationships.

In the novel Goethe uses views and heights to provide a comparative analysis of how the structures are placed in relation to one other. For instance, the view from the hut [*Urhütte*] is located on a higher location relative to the manor house [*Schloß*]; therefore, its view of the village is extensive whereas "the village down below, the church whose spire you hardly notice" from the manor house can be seen (EA, 93). From the summer house it is not possible to see the village, nor the manor. Instead, it is directed towards "an expanse of ponds; beyond them green hills, whose contours they followed; and finally steep cliffs forming a clearly defined vertical boundary to the furthest watery expanses, in whose surface their majestic outlines were mirrored" (EA, 105). Goethe gives the newly built summer house a higher location with a broader view as an indication of contrast with the old structures that have limited views of the valley. Following the Captain's topographical map in the novel, the heights and surrounding views become essential to the study of movements of each character.

After revisiting Riemer's sketch with these details a new construction of the Captain's map becomes possible (Fig.1.4.3.2). This map shows the new structures, views and contours as a diagram of the novel's potential events, encounters and projects. In this

[141] Ibid.

sense, the map—as the polarity diagram of the novel—presents the philosophical and morphological productivity of the novel, generating new paths, buildings, vistas and relationships among characters. The reconstruction of the map shows that the landscape is organized by topographical divisions, positioning the moss hut in a central location connecting all structures via paths. As a mystical and primordial structure, the moss hut resonates with Vitruvius' primitive hut [*Urhütte*], which offers an epigenetic model for the architecture of the novel.[142] As a generative structure, huts became "a starting point for pavilions used in landscape gardens, broke away from Classicism and the Enlightenment, and, being closely defined as to time and place, became in various ways symbols of different civilizations idealized by Romanticism."[143] The materiality of the hut presents a polarity with the newly built summer house, which requires a grounding ceremony where "stone thought of as lasting, stable, and possessing basic metaphysical and cosmological values, while wood was considered temporary, to a certain extent mobile, and easy and quick to construct and adapt to day-to-day practical needs."[144]

As an epigenetic model, the landscape connects the hut with four stylistically different types of buildings that appear as transformations of a primitive archetypal structure. The manor house with its symmetrical wings appears as a Baroque palace that is contrasted with the Gothic church located at the valley with tall spires visible from the house. While the summer house is presented as a Renaissance villa constructed out of

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[142] Vitruvius Pollio, *Ten Books on Architecture*, translated by Ingrid D. Rowland, commentary and illustrations by Thomas N. Home, (Cambridge University Press: 1999). See also Samir Younés, "Constructing Architectural Theory," in *Philosophy*, Vol. 78, No. 304 (Apr., 2003): 235. Younés questions on the ontological significance of the primitive hut whether it points towards "an origin and a beginning." He favors the latter as it does not point towards the first construction but the first form of a built shelter.
[143] Adam Milobedzki, "Architecture in Wood: Technology, Symbolic Content, Art," in *Artibus et Historiae*, Vol. 10, No. 19 (1989): 178.
[144] Ibid., 177.

stone, the distributed houses in the valley have pitched roofs and chimneys, reminiscent of Victorian manor houses. The section of the landscape show the altitudinal relationship of the structures that acquire contractive and expansive vistas that either limit views to the valley or extend them to the combined lakes and mountains (Fig.1.4.3.3).

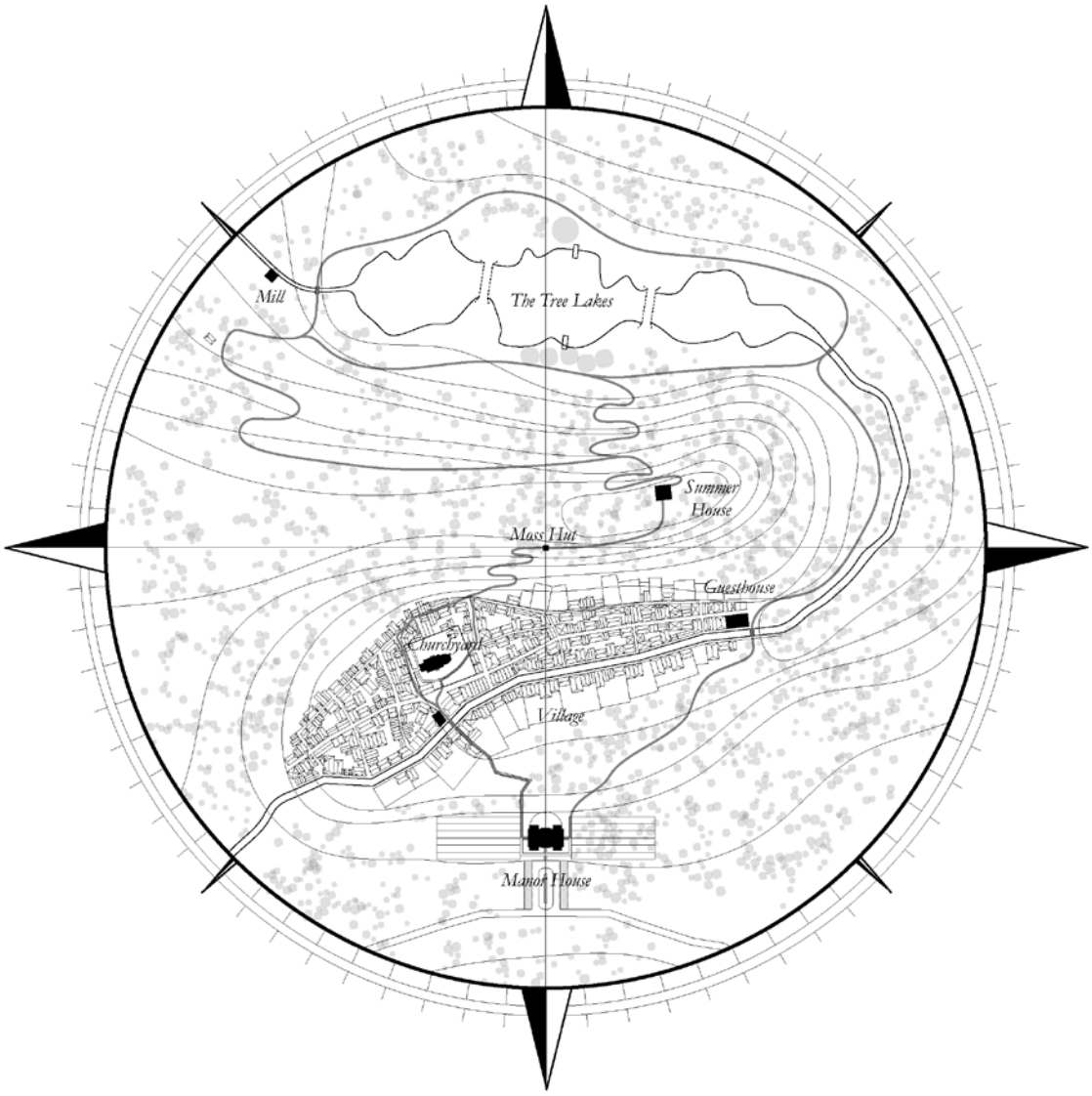

Figure 1.4.3.2 – The "compass" of *Elective Affinities*: A reconstruction of Riemer's sketch showing the topography, the structures, lakes, paths and views of Edward's estate. The longitudinal section passes through the manor house, moss hut, the summer house and the lakes. Key structures are highlighted in black, while the contours show height relationships among paths and structures.

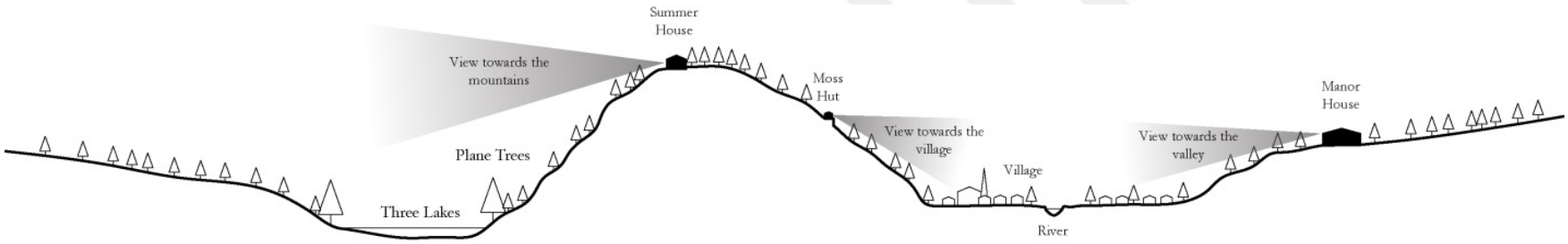

Figure 1.4.3.3 – The section of the valley in *Elective Affinities* along north-south axis showing altitudinal relationships of the manor house, the village, the moss hut, the summer house and the lakes. Notice the difference in heights and views that distinguish the structures.

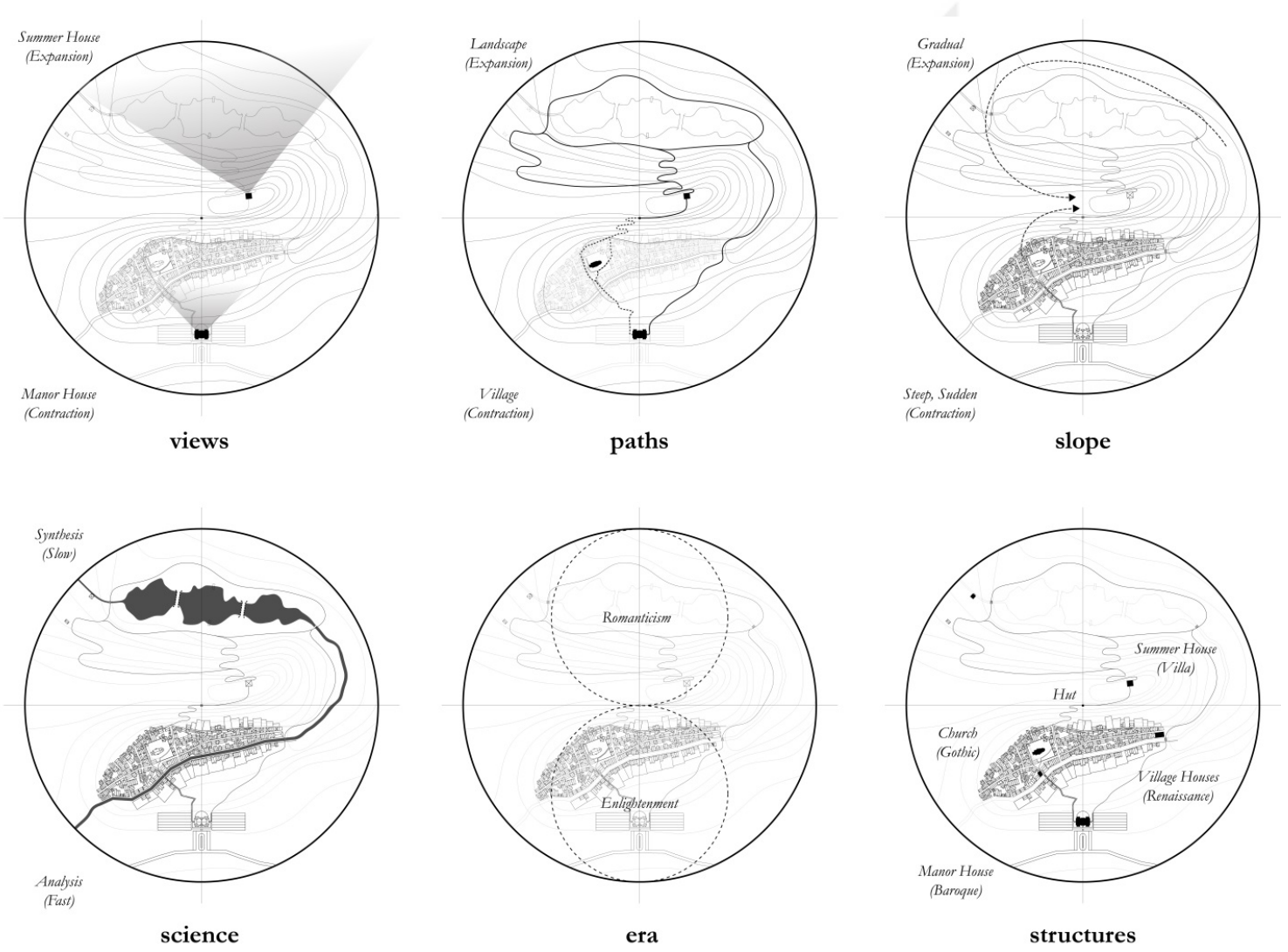

Figure 1.4.3.4 – Diagrams showing polarized relationships that structure the landscape.

The reconstruction of the map offers various comparative analysis for the structuring of the novel, presenting polarized relationships along the valley, between buildings, paths and views (Fig.1.4.3.4). The picturesque landscape shows polarized pathways of two routes to reach the summit, either passing through the valley before the actual climb to the top of the cliff with "all kinds of steps and stairs along a narrow, increasingly steep path" (EA, 94) or winding around the three lakes in a longer, slower, and more gradual climb. The speed of the paths also relates to the symbolic water flow accumulating in the three lakes, which Goethe often compares to the way "knowledge is like flowing water confined by a dam and gradually lifted to a higher level."[145] Considering Goethe's view on the sciences of his era, the contractive valley represents the age of Enlightenment; highly based on analysis, the tremendous effort of scientists in collecting specimens, and experimentations figuratively laying stones to reach to the summit. In contrast, the expansive valley around the lakes combine three separate scientific categories; and demands synthesis that requires more investigation and sequential experimentation to circumscribe the valley using longer paths.[146] Goethe draws on this contrast in his botanical writings, particularly on the "Genesis of the essay on the metamorphosis of plants," where he abandons "the path marked out by Linné" who offered a highly analitical and taxonomical view of plant kingdom and states that "it would take a lifetime to gain a panoramic view of one single natural realm" that echoes with the long paths inscribed into the landscape to reach to the summit following an

[145] Goethe, *Goethe's Botanical Writings*, 222.
[146] Ibid., 222. In his botanical writings Goethe often uses water as an analogy for scientific knowledge: "We may point out that knowledge is like flowing water confined by a dam and gradually lifted to a higher level, for the most magnificent discoveries are not made so much by individuals as by an age. Evidence of this are the many important discoveries made simultaneously by two or even more trained thinkers."

alternative route.[147] In this sense, the "circular arrangement of paths" traced by the movement of characters "circumscribed a separate little world" symbolizing Goethe's aim to reconnect the two distinct scientific methods of his time: analysis and synthesis (EA, 129). Additionally, the high altitude of the summer house whose foundation is filled with "various items" of significance left for "remote posterity" (EA, 134) symbolizes the romantic Goethean science of Morphology offering the highest vantage point for the study of nature.

1.5 Polarity and Chemistry

The title of *Elective Affinities* and discussion of a chemical law between Edward, Charlotte, and the Captain in the fourth chapter (EA, 112–17) has inspired scholars to consider character interactions and relations from a metaphorical perspective. This has been mainly suggested by Jeremy Adler in his essay titled "Goethe's Use of Chemical Theory in His Elective Affinities" in which he considers the novel to follow Goethe's interest in early development of alchemy as a forerunner of chemistry as a science.[148] "By extending the reference of an established chemical theory to encompass social interaction," Adler thinks that "the novel provides the basis for a universal theory of affinity."[149] This theory is introduced as a chemical law by characters (EA, 112–17) conditioning their internal and external relations taking place throughout the story. This dynamic notion of chemistry and its historical development will be explored by discussing the interaction of characters, their changing relationships and Goethe's childhood interest in the mystical writings on alchemy.

[147] Ibid., 165-6.
[148] Adler, "Goethe's Use of Chemical Theory in His Elective Affinities."
[149] Ibid., 263.

1.5.1 Goethe's Early Interest in Alchemy

Prior to the foundation of chemistry as a scientific category, Goethe was interested in treatises on alchemy especially studying "the works of Georg von Welling, Paracelcus, Basilius Valentinus, van Helmont, and the *Aurea Catena Homeri*" that were either read by him or to him by his mother and Fräulin von Klettenberg.[150] In *Goethe the Alchemist,* Ronald Gray emphasizes young Goethe's particular interest in *Aurea Catena Homeri* [The Golden Chain of Homer] that was written by Joseph Kirchweger (?–1746) and published in 1723.[151] This book presents philosophical ideas about "the origin of Nature and natural things, how and whence they are born and created," and presents a polarized chain of creation bounded by perfection and chaos on each end.[152] This binary division of the universe into microcosm and macrocosm, the death and rebirth, and the return to primal matter and rotary movement defined the philosophical framework of alchemists who searched for the Philosopher's Stone believing it had the ability "to transmute base metals into gold."[153] The spiritual and embryonic ideas of the alchemists were brought to the European philosophy through Jakob Boehme (1575–1624) whom Goethe learned about "either verbally, through his Pietist friends, or from the numerous long extracts contained in Gottfried Arnold's work" and interested him since an early age.[154]

[150] Albert Bielschowsky, *Life of Goethe*, Vol.1, trans. William A. Cooper (New York: AMS Press, 1970), 93.
[151] Ronald D. Gray, *Goethe, the Alchemist: A Study of Alchemical Symbolism in Goethe's Literary and Scientific Works*, (Cambridge [Eng.]: University Press, 1952), 6. When Herder met Goethe in Strasbourg in 1770, he was working on chemisty. In the summer of 1770 he kept reading alchemical works and confessed to Fräulein von Klettenberg that chemistry was his "secret love."
[152] Ibid., 8.
[153] Ibid., 15.
[154] Ibid., 38.

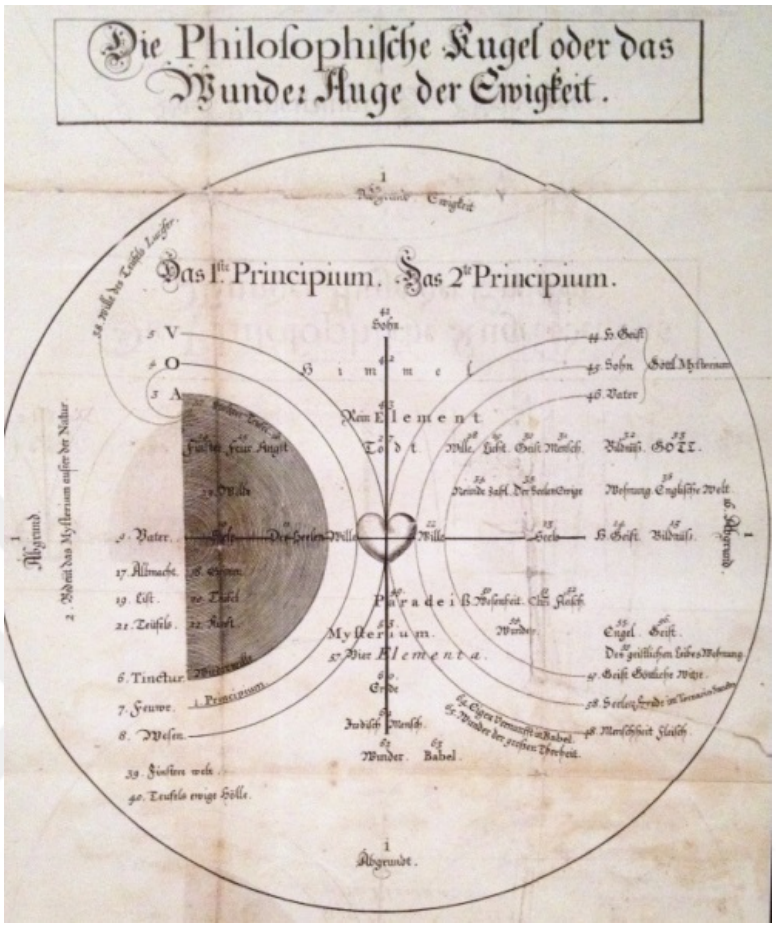

Figure 1.5.1.1 – Jacob Boehme's representation of his Cosmogony showing polar opposition at the heart of the cosmos (Reprinted from *Vierzig Fragen von der Seele* [Forty Questions Concerning the Soul], 1620).

In his work *Aurora*, Boehme defined "Seven Qualities of God" that emerge from a "formless chaos" and exert conflicting forces of systole and diastole; an early form of polarity (Fig.1.5.1.1).[155] In this text he also introduced the term "*Salitter*" which "demonstrates knowledge of both theoretical and practical alchemy."[156] Salitter acts as a "life-force" and is "analogues to chemical saltpatre" that "attributed the maintenance of

[155] Ibid., 39-40. In his work *Aurora*, Boehme defines the Abyss [*der Ungrund*], the formless chaos as having a desire to mirror itself. It conceives a desire for substance bringing itself from abyss to byss that fills the universe with matter. The second quality is an expanding force, in opposition to the contracting force of the first quality that defines the seed. The two are eternally conflicting forces like Darkness and Light. The state of these forces creates a tension in the universe which leads to a rotary movement that defines the third quality. For Boehme, this is the alchemical return of the matter to its mother, enclosing a circle. The remaining four qualities are divided in correspondence to the first stage, while the last one is related to the Philosopher's Stone.

[156] Lawrence M. P. and Weeks A., "Jacob Boehme's Divine Substance Salitter: Its Nature, Origin, and Relationship to Seventeenth Century Scientific Theories,"in *The British Journal for the History of Science*, Vol. 22, No. 1 (Mar., 1989): 61.

life to a nitrous substance in the air."[157] Boehme's philosophical writing was highly influential on Hegel, Schopenhauer and Schelling. Mills states that "the concept of the abyss [*Abgrund, Ungrund*]," central to Schelling's later philosophy originally "derives from Boehme's theosophic Christianity."[158] Despite its religious and mystical origins, Schelling embraced the concept and made "the Absolute the *Urgrund*, the essence prior to all duality, to all ground or existence."[159] In addition, Schelling also borrowed "the idea of process within God, of a theogony" from Boehme which he used "to surmount the pantheistic monism of German idealist philosophy."[160]

From 1806 to 1812 Goethe was working with the German chemist Johann Wolfgang Döbereiner (1780–1849) who "led their work on an astonishingly varied group of chemical processes."[161] "Inorganic chemists still regard Dobereiner's system of triads as an important step in the evolution of the periodic table" whose foundations were laid at that time. An early goal of chemistry was "to discriminate and classify different bodies, to note, and if possible explain, their individual characteristics, powers and interactions as a qualitative science."[162] In his notes on "arbitrary distinction between inorganic and organic matter," Goethe followed a similar descriptive approach, stating "that the bonding of minerals is in some instances conditioned by external circumstances rather than by their law or accident."[163] Goethe's interests in theoretical texts on alchemy and chemical experiments with substances were highly influential in his discussion of the theory of affinity discussed by the characters in the novel.

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[157] Ibid.
[158] Jon Mills, *The Unconscious Abyss : Hegel's Anticipation of Psychoanalysis (A*lbany : State University of New York Press, 2002), 23.
[159] James Lindsay, "The Philosophy of Schelling," in *The Philosophical Review*, Vol. 19, No. 3 (May, 1910): 274.
[160] Nicolaus Berdyaev, "Studies Concerning Jacob Boehme," in *Journal Put'*, No.20 (Feb. 1930): 47-79.
[161] Albert John Gehrt, "Goethe the Chemist," in *Journal of Chemical Education*, Vol.11, Issue 10 (1934): 545.
[162] Henry Guerlac, "Quantification in Chemistry," in *Isis*, Vol. 52, No. 2 (Jun., 1961): 196.
[163] Karl J. Fink, "Atomism: A Counterpoint Tradition in Goethe's Writings," in *Eighteenth-Century Studies*, Vol. 13, No. 4 (Summer, 1980): 388.

1.5.2 Bergman's Affinity Tables

The term "affinity" is widely discussed by many historical figures in the eighteenth century who are interested in the chemical attraction amongst natural substances. Among them, Étienne François Geoffroy (1672–1731) published the first affinity table in 1718, which remained a great influence throughout the development of chemistry in the eighteenth century. Following Descartes, Geoffroy believed that minerals exerted a natural attraction towards each other with gradable relations. Showing an "entirely empirical research" that separates him from the mystical and philosophical works of the alchemists, Geoffroy constructed a table of relations based on relative observations with substances that are mixed together. First, each substance was placed at the head of a column and the other substance "that has the most 'relation' with the substance at the top is written down first."[164] Using mixtures of two substances he showed that when a third substance with "more relation to one of these two" is added to the mixture, it will "combine with that one forcing the other one let go."[165] These experiments were reflected on the construction of a "table of relation" where "any substance will detach from the one at the head of the column all those that are below it. Conversely it will be separated by those above it."[166] Although Geoffroy was not able to study all possible combinations, he produced a table with sixteen substances showing on each column their comparable relation to others in a vertical order (Fig.1.5.2.1). He drew attention to the fact that the chemical separation often exhibited unpredictable results; however, he considered the ordering of affinity tables to be consistent. In his treatise he deliberately picked the word

[164] Etienne Roth, "Etienne Francois Geoffroy's table of relations and concept of affinity," in *Frensenius Journal of Anaytical Chemistry*, 337(2) (Jan.,1990): 192.
[165] Ibid., 191.
[166] Ibid., 192.

"relation," because he considered affinity to have "anthropomorphic implications and avoided using attraction that "could imply adhering to Newton's conception of forces acting between distant objects."[167]

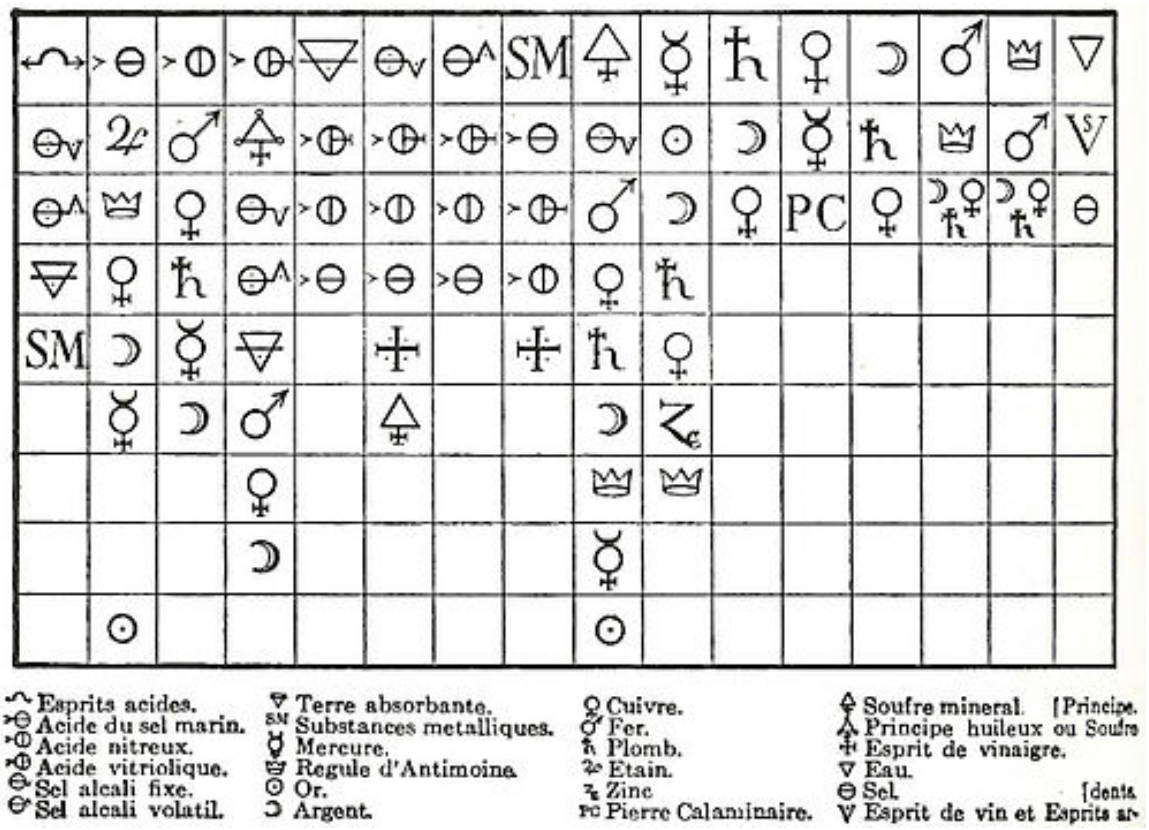

Figure 1.5.2.1– Étienne François Geoffroy's table of relations (Reprinted from "Table des differents rapports observes en chimie entre differentes substances," in *Mémoires de l'Académie royale des sciences* (Paris, 1718), 202-212).

In the late eighteenth century the concept of chemical affinity was further developed by Swedish chemist Torbern Olof Bergman (1735–1784) in his *Dissertation on Elective Attractions* [*Disquisitio de Attractionibus Electivis*] (1775).[168] Similar to Geoffroy's table of relations, Bergman constructed an affinity table showing 50 columns of various substances, including acids, metals, alcohols, air, phlogiston (oxygen), heat

[167] Ibid.
[168] Bergman, *A Dissertation on Elective Attractions*.

and water. This table consisted of four individual tables, each separately dealing with acids, alkalis, phlogiston and metals. The affinity table is organized in vertical columns with each substance placed at the top showing the level of attractions they exert towards other substances in a descending vertical order. In his experiments he defined short-range attractions "observed between any nearby bodies in the surface of the earth of the earth," whose "effects of attraction vary greatly" compared to the "quantities which can be neglected in long-range attractions."[169] For short and long-range attractions it was "possible for the same force to vary greatly in the degree" in order to understand the "attractions of bodies for each other" while "the relationships are beyond being determined."[170] Bergman also defined an "elective attraction" to understand these changing short-range attractions among substances (Fig.1.5.2.2).[171] His concept of chemical affinity was mostly mechanical in nature, in an attempt to apply Newton's law of universal attraction to reactions between chemical substances. For each substance, the placement on the table represented the "degree" of affinity towards other substances. If there is no reaction between two elements then they are not included in the table. Bergman did not state that his table was a final construction because if one of the materials in the experiment "gradually changes its previous nature, than its attractions are undoubtedly subject to change also."[172] Following this empirical process he provisioned to complete all the necessary experiments to construct the affinity table that represents the attractions among paired substances with definite numbers.

[169] Ibid., 2.
[170] Ibid.
[171] Ibid., 3.
[172] Ibid., 12.

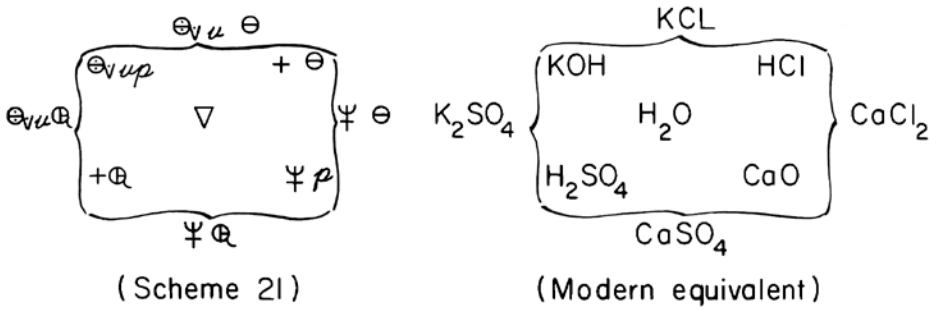

Figure 1.5.2.2 – An example of Bergman's Schemes, and modern equivalents (Reprinted from Bergman, *A Dissertation on Elective Attractions*, 1968).

Bergman's goal was to construct a an affinity table that could predict the course of chemical reactions among substances. However, many of the substances produced "irregularities" in reactions, as variations occurred in his early assumptions.[173] The French chemist Antoine-Laurent de Lavoisier (1743–1794) criticized the inconsistent measurements stating that the "affinity table is only valid at a given temperature."[174] In fact, Bergman himself remarked that the experiments showed variation of results as "almost all environmental conditions in which a chemical relationship takes place can alter and direct the specific form of the product."[175] Under different conditions, substances showed gradual changes that affected their relative attractions. Since chemists needed "a quantitative index of chemical behavior," an alternative solution was "found in the *combining weights* or *equivalent weights* of the elements."[176] It was John Dalton (1766–1844) who proposed "that the distinguishing character of the different elementary atoms might be their weight, and that this differential character, if measurable, might in

[173] Roth, "Etienne Francois Geoffroy's table of relations and concept of affinity," 195.
[174] Ibid.
[175] Peter Hanns Reill, *Vitalizing nature in the Enlightenment* (Berkeley : University of California Press, 2005), 86. In his dissertation Bergamn also related such inconsistencies due to the "variation in the intensity of heat." Bergman, *A Dissertation on Elective Attractions*, 6.
[176] Guerlac, "Quantification in Chemistry," 204.

some way be correlated with the varieties of chemical behavior."[177] In his experiments Dalton showed that substances had "relative weights of atoms" that enabled them to combine under definite proportions of atoms defining his "law of multiple proportions."[178] However, there were difficulties at the time in measuring the exact weight of atoms due to currently undiscovered sub-atomic particles. In fact, Bergman himself "also came very close to the conception of equivalent weights of metals as a result of his studies in phlogiston chemistry."[179] Yet, he never arrived at a stable construct for the changing degrees of affinity for each substance on the table. While "the complex 'substance identity' phlogiston acquired in the early decades of the eighteenth century was based on chemists' manipulative capacity, theoretical framework, and 'ontological attitude'," the later discovery of oxygen by Lavoisier initiated a "Chemical Revolution" and the theories related to phlogiston—including the concept of affinit—were abandoned; leading modern chemistry with quantifiable measurements using atomic weights.[180]

In 1869 Dmitri Mendeleev (1834–1907) defined a "periodic law," that follows "Dalton's atomism," where "the link between the chemical character of the elements and their mass or atomic weight appears as a general property of elements."[181] In his famous periodic table, Mendeleev showed that "the properties of the elements are in periodic dependence upon their atomic weights."[182] In addition, "elements falling in the same group resemble one another closely in a wide variety of qualitative and quantitative characteristics: their chemical behavior, their boiling or melting points, conductivity for

[177] Ibid., 208.
[178] B.M. Kedrov, "Dalton's Atomic Theory and Its Philosophical Significance," in *Philosophy and Phenomenological Research,* Vol. 9, No. 4 (Jun., 1949): 644-662.
[179] J.A. Schufle and George Thomas, "Equivalent Weights from Bergman's Data on Phlogiston Content of Metals,"in *Isis*, Vol. 62, No. 4 (Winter, 1971): 500.
[180] Mi Gyung Kim, "The 'Instrumental' Reality of Phlogiston," in *International Journal for Philosophy of Chemistry*, 14(1) (2008): 27-51. See also Mi Gyung Kim, *Affinity, That Elusive Dream – A Genealogy of the Chemical Revolution* (MIT Press: 2003).
[181] Kedrov, "Dalton's Atomic Theory and Its Philosophical Significance," 646.
[182] Guerlac, "Quantification in Chemistry," 212.

heat and electricity, magnetic susceptibility, appearance and texture, hardness, color of the salts in aqueous solution, and crystal form."[183] Mendeleev's biggest contribution to chemistry was the "quantitative index called the atomic number" that "yielded a most extraordinary amount of qualitative information" on the ordering of elements on the periodic table.[184] Modern chemistry still follows Mendeleev's periodic table as a template for identification of chemical substances, and leading further investigation with the discovery of new substances and sub-atomic particles.

In *Philosophical Chemistry: Genealogy of a Scientific Field* Manuel DeLanda discusses the historical development of chemistry as a science of conflict among researchers between the seventeenth and nineteenth centuries who aimed to develop it as an ontology that evolved around the theory of affinity.[185] In its early development, chemists were "using the *analysis-synthesis cycle* to establish the identity of a compound substance" that had "combinatorial tendencies" defined as "elective attraction."[186] DeLanda particularly focuses on the evolution of the theory of affinity that presents an ontological history leading to the ordering of the periodic table where "the chemical properties of the elements repeated at regular intervals, creating groups" that signaled their ordering "could not be the product of chance."[187] After the discovery of charged subatomic particles, a polar basis of positive and negative attractions was achieved where chemists developed "two rival versions of the Affinity schema, each captured part of the truth: some bonds were polar (or ionic) while others were non-polar (or covalent)."[188]

[183] Ibid., 213.
[184] Ibid.
[185] Manuel DeLanda, *Philosophical Chemistry: Genealogy of a Scientific Field* (New York : Bloomsbury, 2015).
[186] Ibid., 4. See also Reill, *Vitalizing nature in the Enlightenment*, 80. Reill notes on the split in chemistry that exists between analysis and synthesis. The former focuses on "wet" reactions mixing two or more fluids or fluids with solids. The latter "dry" reactions utilize heat as a "mediating force and as a solvent" that causes reactions to be dynamic.
[187] Ibid., 66.
[188] Ibid., 68.

Further experiments with currents passed through compounds revealed that "forces of affinity were electrical in nature, and that their intensity accounted for the different degrees of attraction exhibited by different substances."[189] While the later formulations for reactions avoided the analysis-synthesis cycle, chemistry became restricted to "measurements of highly simplified phenomena" that "were carried out to test the validity of a mathematical model."[190]

1.5.3 Polarity in Character Relations

Goethe's interest in chemistry is apparent in the fourth chapter of *Elective Affinities* where the characters discuss the law of affinity in a book and compare it to the relations of human beings.[191] In the text, human beings are depicted as "Narcissius" as they impute their own actions to "animals, plants, elements and the god" that share same principles in nature (EA, 112). They assign every natural object two kinds of relations. Firstly, all natural objects "have a relation to themselves. Once this relation is established as a whole it can create external relations to other objects. An affinity between two substances exists when they are similar. In complex cases compounds are decided by the degree of affinities that each substance has towards others. For instance, the Captain gives the example of how limestone and sulfuric acid produce gypsum while "gaseous acid evaporates in the form of sulfur" (EA, 115). In this example, both separation and combination occur making the substances "choose" one combination over the other, demonstrating the term "elective affinity." The way these relations are established is

[189] Ibid., 72.
[190] Ibid., 102.
[191] See the introduction to Tantillo, *Goethe's Elective Affinities and the Critics*. Another confusion lies in the title of the novel. While "Wahl" means "choice", "selection" or "election" and "Verwandtschaft" meaning affinity "relationship", "kinship" or "affinity", Tantillo writes: "the term 'Wahlverwandtschaften' originates from a 1782 translation of Torbern Bergman's *De attractionibus electivas*." Considering Goethe's contemporary interests when the novel was written, this book remains the strongest candidate for Edward's book on chemistry.

considered "not accidental or determined," but as "a matter of opportunity [*Gelegenheit*] depending on conditions in which an individual or substance is placed."[192] Once two related substances are brought together they can form a compound as "God preserves them" (EA, 115). While the conversation between the Captain and Edward is "atomistic and scientific," Charlotte's "sympathy" for the "poor gaseous acid" identifies "the paradox between determinism and freedom in the interaction of individual entities" where affinity acts as a force that pulls and pushes the characters in a dynamic motion like "magnetism, electricity and gravity."[193] Using chemical affinities as a law, Goethe relates scientific rules of *actio in distans* to a sensuous principle that separates him from the dominant rationalist thought of his era.[194]

> One has to see these substances, which are seemingly inanimate, but in actuality always full of *potential life*, interacting before one's eyes-one has to watch with some *empathy* as they seek each other out, attract, attack, destroy, swallow up, devour each other, finally emerging from their former close connection in a new, fresh and unexpected form. This is the point at which one attributes an *eternal soul*, or even common sense and intelligence to them, since our own senses hardly suffice to observe them properly and our intellect is hardly adequate to understand them (EA, 116, my italics).

[192] Fink, "Atomism: A Counterpoint Tradition in Goethe's Writings," 389. Charlotte's comments pose an in-between position against atomism and Neo-platonism. Without committing to any one of them she considers an act of choice in the law of affinity. Fink states that Goethe's scientific thinking in the late eighteenth century developed the idea of "free will" that denied a preexisting order and constant influence of Divine Being. This also draws Goethe away from deterministic theories on nature.
[193] Ibid., 389.
[194] Hugh Barr Nisbet, *Goethe and the Scientific Tradition* (London: Institute of Germanic Studies, University of London, 1972). In this book, Nisbet examines Goethe's relationship to three European traditions, neo-Platonism, empiricism and rationalism. While Leibniz follows neo-Platonic metaphysics and post-Cartesian rationalism, Newton closely unites empiricism and rationalism. Nisbet argues that Goethe provides a third option that combines all three tendencies together. He blends neo-Platonic and empirical attitudes and inserts rationalism as a negative factor against which he sets up his own original doctrine that unites art and science.

In his explanation, the Captain assigns anthropomorphic qualities to natural substances that will exhibit affinity. But Charlotte questions the applicability of this principle to human beings as they are "above primitive drives of nature and able to accept or reject natural inclinations to challenge materialist determinism, through the irony of *actio in distans*."[195] Because of Goethe's "opposition to the scientific method of his time" that considered "the theory of chemical affinity" as a "fixed typology," he rather "studied the living relationships" to understand natural phenomena.[196]

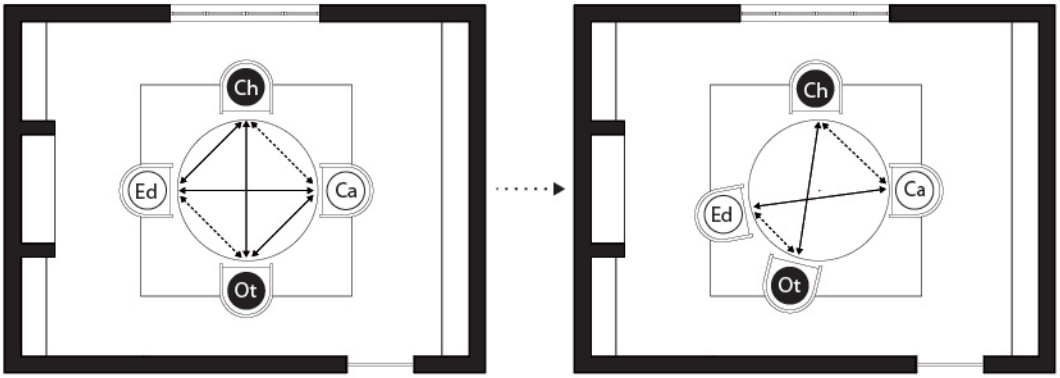

Figure 1.5.3.1 – Diagram showing the arrangement and affinity among the characters in chapter eight while they are sitting in the reading room. The dashed arrows indicate the attractive forces and solid arrows show repulsive forces. Characters are shown with initials as Charlotte (Ch), Edward (Ed), Ottilie (Ot), Captain (Ca).

In *Elective Affinities* Goethe uses two scenes featuring seating arrangements where "Bergman's chemistry is represented in a spatial character."[197] The first scene is narrated in chapter eight, where the main four characters sit in a room around a small

[195] Fink, "Atomism: A Counterpoint Tradition in Goethe's Writings," 389.
[196] Jeremy D. Adler, "*Eine fast magische Anziehungskraft : Goethes "Wahlverwandtschaften" und die Chemie seiner Zeit* [An almost Magical Attraction: Goethe's Elective Affinity and the Chemistry of its Time] (München : C.H. Beck, 1987), 155."In der Opposition des Erzählers zu Eduard spiegelt sich Goethes eigene Opposition zur naturwissenschaftlichen Methode seiner Zeit. Die Theorie der chemischen 'Verwandtschaft' arbeitete eine feste Typologie heraus. Goethe betrachtete die lebendigen 'Verwandtschaften'. Ging es in der Chemie um die Isolierung einzelner Reaktionen, so ging es Goethe gerade um ihre natürlichen Verbindungen."
[197] Ibid., 168. "Eduard unterhält sich mit Ottilie. Der Graf beschäftigt sich mit dem Hauptmann. Wie die Chemie Bergmans bringt der Roman den räumlichen Charakter der 'Wahlverwandtschaft' zur Darstellung. So wird symbolisch sowohl Eduards Liebe zu Ottilie als auch die bevorstehende Abspaltung des Hauptmanns vor Augen geführt."

table.[198] Nemec considers the table depictions to be "a symbol of marriage" that provide a "clear contradiction between marriage and affinity."[199] However when considered as a reaction setting, the early positioning of characters show polar alignment and their radial movement signals a change of proximity. This could be read as an insight to their changing affinity towards other characters (Fig.1.5.3.1).

Another configuration reappears in chapter ten where the count and baroness visit the manor house. This time they are placed around a dinner table.[200] For Nemec the table acts as "a picture of the seating arrangements in the marital union" that shows the Baroness's "aim to disturb" the coupling of Edward and Ottilie, while Charlotte becomes "aware of her separation from the Captain."[201] The depiction of forces of affinity around the table reveals a hidden chemical reaction that takes place (Fig.1.5.3.2). This setting shows that both the count and the Baroness act as "catalyst [*Katalysator*] in the relationship between the main characters."[202] The placement around the table is not a result of any "mechanical predetermined scheme" but "reminiscent of other chemical processes" where attractive and repulsive forces shape the relations of characters.

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[198] In this scene Charlotte sits on the sofa and Ottilie is in an armchair opposite her. Edward and the Captain are situated on the other two sides defining a polar axis. Ottilie is sitting on the right side of Edward but she moves closer to him so that "she could look over his shoulder" (EA, 130). Edward also moves closer "to make it easier for her" to read the book under the light of the lamp (EA, 131). While Charlotte and the Captain notice "Ottilie's secret affection" they contain their distance.

[199] Nemec, *The Economics of "Elective Affinities*, 52."Weshalb wird gerade auf diese Stellung Wert gelegt? Wir haben den Tisch als Symbol der Ehe verstanden; die übliche Ordnung ist, daß die dem Mann verbundene Frau zur Rechten sitzt. So gesehen zeigt sich auch in der Gruppierung am Tisch der Wahlverwandtschaft die verborgene Zuordnung der Personen: öffentlich ist Eduard mit Charlotte verbunden, im geheimen aber mit Ottilie. Ein deutlicher Widerspruch zwischen Ehe und Wahlverwandtschaft."

[200] In this scene the count converses with the Captain about his replacement who is seated beside him. The Baroness is on the count's right side, having "little entertainment" from Edward who has been "talking animatedly with Ottilie, whom he had drawn to his side" (EA, 114). When the group stands up from the dinner, the count and the Captain "paced up and down one side of the drawing room"; Edward "stimulated with wine and desire" talks to Ottilie by the window; Charlotte and Baroness are quiet on the other side of the room (EA, 114).

[201] Ibid., 60. "Sehen wir auch hier in der Tischordnung ein Bild der ehelichen Gemeinschaft, so können wir sagen : der Graf und die Baronesse, am Tisch der Ehe zu Gast (dies entspricht ihrer Auffassung der Ehe als Verhältnis auf Zeit), stören zwar wirksam die Wirklichkeit des Verhältnisses, nicht aber die ideelle Zuordnung; die Baronesse, die die Zuordnung von Eduard und Ottilie durch psychologische Operationen stören will, scheitert, und Charlotte wird sich gerade in der Trennung ihres Verhältnisses zum Hauptmann bewußt; der Graf dagegen ohne Kenntnis der inneren Situation, hat dagegen Erfolg mit seiner Bemühung, den Hauptmann aus' dem Zirkel herauszulösen, wodurch auch Eduard gezwungen sein wird, sich zu entfernen."

[202] Adler, *An Almost Magical Attraction: Goethe's Elective Affinity and the Chemistry of its Time*, 168. "Dadurch wird suggeriert, das Paar sei eine Art 'Katalysator' im Verhältnis zwischen den Hauptpersonen-eine Beziehungsart, die in der Theorie der 'Verwandtschaft' von I.4 nicht vorkam. Der Erzähler versucht keineswegs, vorgegebene Schemata mechanisch anzuwenden, sondern führt neue Anspielungen ein, die an andere chemische Prozesse erinnern. Dadurch erst enthüllt sich die geradezu explosive Kraft, die im Zusammenwirken der vier Personen-erscheint."

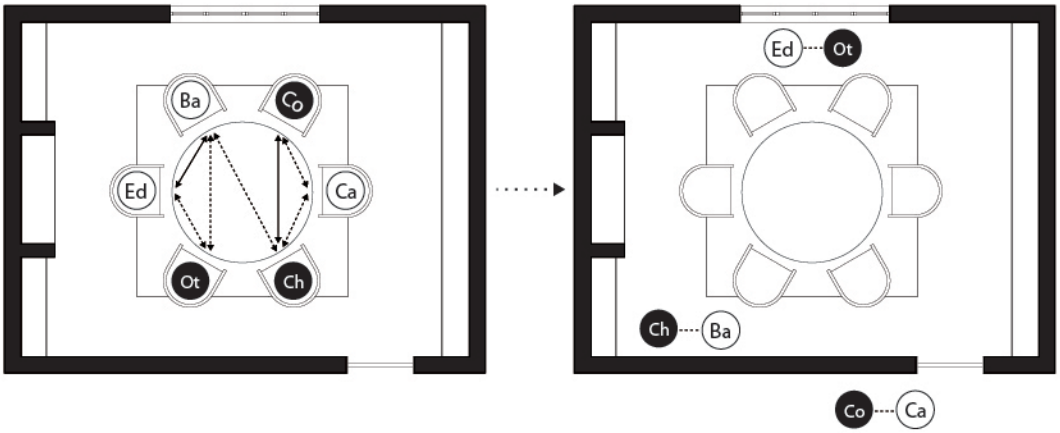

Figure 1.5.3.2 – Diagram showing the arrangement and affinity among the characters in chapter ten around the dinner table. The dashed arrows indicate the attractive forces and solid arrows show repulsive forces. Characters are shown with initials as Charlotte (Ch), Edward (Ed), Ottilie (Ot), Captain (Ca).

For Goethe the characters are both symbols of substances going under reaction, and anthropomorphized versions of how affinity works in nature. In both cases the chemical law of affinity is central to the dynamic relations of characters within the novel. Adler also draws attention to a "chemical" connection between Goethe and Schelling that with the "recognition of polarity" and "the understanding of the related matter as alive" it tries to define "metamorphism in the chemistry."[203] As a result, Goethe's affinity could be considered a physiochemical law that provides an alternative to the mechanical understanding of chemistry. This metamorphism in characters' affinities shows how Goethe "accepted the general theory, yet rejected the possibility of establishing a fixed

[203] Ibid., 139."Hier geht Schelling unmittelbar auf Goethes biologische Metamorphosenlehre ein und wendet sie selbständig auf die Chemie an. Diese Übertragung seines eigenen Gedankens scheint Goethe selbst in seinen Wahlverwandtschaften aufgegriffen zu haben, indem er Macquers Typologie in eine Morphologie, in die Meta-, morphose der Materie verwandelte, die von den <<leblosen Dingen» bis zum «ewigen Leben» fortschreitet. In wesentlichen Punkten, wo Goethes Roman von der Chemie abweicht, berührt er sich mit Schelling. Dazu gehören: die Bewertung der Kohäsion als Prinzip der Einheit; die gleichzeitige Anerkennung der Polarität; das Verständnis der verwandten Materie als lebendig; die Übernahme der Metamorphose in die Chemie. Andere Aspekte von Schellings Denken decken sich mit der Darstellung Ottiliens. Betrachtet man sämtliche Berührungspunkte, so begreift man, daß Schellings Naturphilosophie für Die Wahlverwandtschaften nicht ohne Bedeutung war."

'order' that could be summarized in a table."[204] Goethe uses proximities, speech and activities as an expression of the relatedness of characters as well as how similar they become throughout the novel.[205] This social depiction provides a "science-historical analysis of the novel" where not only "the social relations are recycled back into the chemistry," but also "the chemistry is itself intelligible only in terms of the social relations" depicted in the novel.[206]

1.6 Polarity and Characters

With its large array of characters, *Elective Affinities* uses opposite personality types to present a polar understanding of character attributes and relations. Polarity as a character structuring mechanism is observed in three cases. The first case is found in baby "Otto" as a symbolic connection among the characters; whose name "is not only the original name of Edward and the Captain, but of Goethe's other three main characters: Charlotte's name conceals the word 'Otto,' Ottilie's is its diminutive, feminine version."[207] The second example is traced to the dual structuring of the novel as a whole that not only has two opposing parts of the plot, but also in the second half where a short novella is nested, offering redemption to its tragic ending. Walter Benjamin considered this structure "a mythic shadowplay staged in the costumes of the Age of Goethe" where "the mythic is the real material content of this book."[208] The last example is found in the antagonism

[204] Adler, "Goethe's Use of Chemical Theory in His Elective Affinities," 268.
[205] In the story musical parity is used as an analogy to depict likeness among characters that compares two couples Edward and Charlotte with Edward and Ottilie where the latter shows better harmony.
[206] Olaf Breidbach, "*Die Wahlverwandtschaften*–Versuch einer wissenschaftsh–Historischen Perspektivierung [*Elective Affinities* – Attempt of a science – Historical Perspective]" in *Goethes Wahlverwandtschaften: Werk Und Forschung* [*Goethe's Elective Affinities: Work and Research*], ed. Helmut Hühn (Walter de Gruyter: 2010), 307. "Die naturwissenschaftsgeschichtliche Analyse des Romans macht deutlich: Es wird nicht einfach das Soziale in den Chemismus zurückgeführt, sondern der Chemismus wird seinerseits erst in den Termini des Sozialen verständlich."
[207] Christina Lupton, "Naming the Baby: Sterne, Goethe, and the Power of the Word," in *MLN*, Vol. 118, No. 5, *Comparative Literature Issue* (Dec., 2003): 1227.
[208] Walter Benjamin, *Selected Writings*, 309.

between Lucianne and Ottilie, who display opposite personality traits and physical attributes that are highlighted in the living pictures. As Müller-Sievers points out, this dualism embedded within "the strictly symmetrical structure of the text, as well as its many formal interrelations, seems to invite an allegorical, or typological, reading, in which episodes are related like anticipation to fulfillment."[209] These epigenetic character typologies and opposite relations will be re-evaluated with the concept of polarity as the structuring mechanism of the novel.

1.6.1 Otto

The conception of Otto takes place in chapter eleven after Edward escorts the count to his room, reuniting him with the baroness in the women's wing. While in the women's wing Edward feels "an uncontrollable longing" that draws him to Ottilie; however, her room is only accessible through Charlotte's bedroom (EA, 146). In this scene "the old castle built by Edward's ancestors in the strict French style" which has a fixed layout and winged organization for the "acquisition and continuation of the tradition" becomes an obstacle for Edward.[210] Yet, this irresistible attraction, draws Edward only so far as Charlotte's room where they spend the night together making love while both of them imagine their other beloved partners, Ottilie and the Captain.

> In the dim lamplight secret affections began to hold sway and imagination took over from reality. Edward clasped none other than Ottilie in his arms; Charlotte saw the Captain more or less distinctly before her mind's eye, and so things

[209] Müller-Sievers, *Self-generation*, 162.
[210] Michael Mandelartz M., "Bauen, Erhalten, Zerstören, Versiegeln: Architektur als Kunst in Goethes Wahlverwandtschaften" [Building, Preserving, Destroying, Sealing: Architecture as Art in Goethe's Elective Affinities] in *Erschienen in: Zeitschrift für Deutsche Philologie*, Bd. 118, (1999): 500-517.

present and absent mingled, curiously enough, in the most charming and delightful manner (EA, 147).

In the second part of the novel, Charlotte gives birth to a baby who is christened "Otto," who "could hardly have any other name than that of his father and his father's friend" (EA, 215). The name of the baby and his physical resemblance to other characters has been a focus of debate among scholars. Nemec considered the baby as a "product of imagination and reality," where Goethe sought to transform "the appearance of the conditions into affinity" and the relations into "an image (Otto)" that turn him into an "allegory."[211] Although the baby does not have any blood relationship to the Captain or adopted Ottilie, he shows a physical resemblance to both of them; explained as a product of "double adultery" (EA, 238). Breidbach considered the formal depiction of Otto as an "epigenetic evolution" where "the expression of the forms themselves follows a mechanism that brings unstructured matter in its organic form" under "various external and internal conditions, in which the self-forming organism" through "metamorphosis" or "differentiation" creates "varying structural forms."[212] Otto's lack of parental resemblance relates to an epigenetic model that fails to grow on the landscape. Thadden considered *Elective Affinities* to be "about the universe" and "the whole of nature" in which Goethe's continuing studies on the concept of metamorphosis lead to an

[211] Nemec, *The Economics of Elective Affinities*, 273. "Der Knabe, scheinbares Produkt aus Einbildungskraft und Wirklichkeit, entspricht als Figur aber in Wirklichkeit dem Kunstgriff eines höheren Verstandes, er ist Produkt der Phantasie des Autors, der zum Allgemeinen das Besondere suchte, in welchem die Erscheinung der Verhältnisse (=Tischordnung) in einen Begriff verwandelt wird (=Wahlverwandtschaft) der Begriff in ein Bild (= Otto), "doch so, daß der Begriff im Bilde immer noch begrenzt und vollständig zu halten und zu haben und an demselben auszusprechen" ist; d. h. er ist eine Allegorie."

[212] Breidbach, "*Elective Affinities*," 300. "Variationen in den Randbedingungen einer sich derart explizierenden Naturgestaltung werden es erlauben, die Möglichkeiten solcher Vereinzelungen aufzuweisen und von dorther die Dynamik des Naturalen eingehender zu erfassen. Wird ausgelotet, was an dem Einzelnen in einer bestimmten Ebene der Fall sein kann, so ist die Struktur begriffen, in dem sich dieses Einzelne realisiert. Die Gestalt der Natur ist so in ihrer Metamorphose dargestellt. Goethe sieht denn auch die Natur insgesamt als den Prozess, in dem sie sich selbst entfaltet. Dabei ist diese Ausformung eine Evolution der Epigenesen. Die Ausprägung der Formen selbst geschieht nach einem Mechanismus, der unstrukturierte Materie in ihre organische Form bringt. Der Formierungsprozess des Organismus ist nichts anderes als eine Bündelung solcher Differenzierungsleistungen. Die entstehende Formenvielfalt, die der Systematiker studiert, ist nichts als das Resultat solch eines Differenzierungsprozesses, der unter den verschiedenen äußeren und inneren Bedingungen, in denen der sich ausbildende Organismus befangen ist, die Möglichkeiten der Assimilation variiert und damit innerhalb eines festen Rahmenprogramms variierende Strukturen ausbildet."

understanding of "organism as a genetically interpretable blueprint."[213] Nemec, on the other hand, considered Otto's mixed appearance as "neither a viable nor an image of life" because he did not resemble his biological parents but instead looked like their preferred partners.[214]

Otto's existence on the landscape depends on the affinity among the characters since he fails to show any biological inheritance to his parents. Adler showed that Otto "suggests a form relationship between the four main characters" like a "common chemical element among various substances."[215] Such "symbolism was already present in Bergman's schemes that Goethe studied" which gives Otto a morphogenetic character. Müller-Sievers considered the baby "the total epigenetic child: in not bearing any likeness to his biological parents, he demonstrates the achieved penetration of nature by subjectivity" revealing the affinity of characters by turning them inside out.[216] This makes Ottilie realize Edward's love for her, while Charlotte—in desperation—tries to save her marriage for the baby's sake. The characters' complex relations fail to sustain Otto who dies by drowning in the lake; an "unfathomable element" (EA, 240). Otto's "drowning in water" presents another relation to Schelling's *Naturphilosophie*; considering "the most original product of Nature" as "the fluid" that is "not the absolutely

[213] Elizabeth von Thadden, *Erzählen als Naturverhältnis, "Die Wahlverwandtschaften": zum Problem der Darstellbarkeit von Natur und Gesellschaft seit Goethes Plan eines Roman über das Weltall* (München : W. Fink, 1993): 55."Um so virulenter wird durch die Erforschung der Organismen im Goetheschen Denken die genetische Dimension der Natur, nun in der Manifestation als gesetzhafte Entwicklung der einzelnen Organismen. Der Vorsatz des 'Romans über das Weltall', die ganze Natur, als Prozeß und simultanen Zusammenhang verstanden, übersehbar zu machen, äußert sich nun nicht mehr in einem Plan, den Kosmos darzustellen, sondern bestimmt Anfang der 90ger Jahre Goethes Erforschung der Pflanzenmetamorphose, des Organismus als genetisch zu verstehendem ganzen Bauplan."

[214] Nemec, *The Economics of Elective Affinities*, 58. "Das Ganze des Verhältnisses der vier zeigt sich als Analogon der Tendenz, Leben und Kunst zu vermischen, die die Untersuchung der tableaux des zweiten Teils besonders deutlich zu erkennen geben wird: das Kind Otto ist ein lebendes (Edward-Charlotte) Bild (Hauptmann-Ottilie) und als solches weder lebensfähig noch als Bild von Dauer."

[215] Adler, *An almost Magical Attraction*, 167. "Nur bei dem Kind, das mit allen vier Freunden eine 'Verwandschaft' aufweist, wird es offenkundig. So deutet der Name Otto auf eine Form von 'Verwandtschaft' zwischen den vier Hauptpersonen, die erst im Kinde vollkommen zu Tage tritt. Diese Art Namengebung entspricht der modernen chemischen Nomenklatur, welche die gemeinsamen Bestandteile verschiedener Substanzen veranschaulichen soll. Die Symbolik war auch schon in Bergmans chemischen Schemen angelegt, die Goethe in seinen eigenen Studien übernahm."

[216] Müller-Sievers, *Self-generation*, 160.

formless, but rather that which is *receptive to every form*."[217] Following his Neptunist roots, Goethe uses the lakes as the origin of life from which different vegetative life forms could spur to invade the landscape like Humboldt's migrating plants.[218] When these forms fail to conform to archetypes, they must descend back into a fluid state to find internal equilibrium, necessarily losing their individually flawed form of existence.

Since all the characters are derivatives of this conditioned type, the baby is clearly an epigenetic model, showing how products on the landscape are born, conditioned, grown through metamorphosis, and yield to new productive outcomes under the law of affinity. In contrast, the particular drowning of the child in the lake represents the failure of conditioning that sends forms back to the Absolute. On this transformative role of water, Benjamin stated that "the mythic themes of the novel correspond to those of the novella as themes of redemption" when childhood sweethearts "both dive down into the living current, whose beneficent power appears no less great in this event than the death-dealing power of the still waters in the other."[219] Goethe used the water and lakes as a purifying element that transforms the characters before they return back to the landscape. When Ottilie pulls Otto from water, he returns from this unconditioned [*Unbedingt*] state but fails to find any affinity to condition him. Using the novella as an alternative, Otto could be interpreted as an Urtype [*Urtypus*] within the landscape who descends to being an Untype [*Untypus*]: prototypical, ideal and formless. His death occurs on the lake to show that his disappearance is neither an accident nor fate but the failure of affinity

[217] Schelling, *First Outline of a System of the Philosophy of Nature*, 27.
[218] A discussion of Goethe's interest on Neptunism could be found in W. Scott Baldridge, "The Geological Writings of Goethe: Despite his keen powers of observation, Goethe's ideas ongeology reflected the biases of his time," in *American Scientist*, Vol. 72, No. 2 (March-April 1984): 163-167.
[219] Walter Benjamin, *Selected Writings*, 332-333. Benjamin's analysis of the novella in the second part demonstrates his intention to extract textual clues to critique the novel. He sees the novella as an antithesis of why the characters in the novel suffer such a different fate. Benjamin argues that the characters' relationship to the communities is a direct reflection of their level of freedom. For instance, the characters in the novel are much more free in their actions, but they get subjected to stronger powers of fate.

among four characters. In the novella when the girl is saved from drowning, she recapitulates the *Un* to *Ur* transition, separating her from the betrothal so that she can reunite with her beloved neighbor. This is why she is later dressed in a wedding gown, as "she does not want to 'die in beauty,' be wreathed in death like a sacrifice."[220]

1.6.2 Novella and Elective Affinities

Ottilie's strange death and the ending of the novel was a central topic in Walter Benjamin's seminal essay "Goethe's Elective Affinities," which considered the novel to follow an "aesthetic principle," investigating Goethe's usa of beauty and semblance [*Schein*] in the "mythic forms of life."[221] Benjamin rejects tragic or classical readings of the novel; instead, positing his critique as a way to penetrate the material content of the novel to discover its underlying secret principles. In the first part of his essay, Benjamin focuses on the insignificance of marriage, as "an expression of continuance in love," then shifts focus to the unleashed "forces that arise from its decay."[222] Once the characters realize their freedom, the world around them acquires mythic powers that foreshadow the death brought about by its moral decay. Rather than "resorting to philosophical investigation" in his literary work, Goethe's conflict between "the sphere of perceptible phenomena and that of intuitable archetypes" compelled him to seek a resolution in the novel that still relates to his research in the natural sciences.[223] Instead of defining any formal appearance, the characters in the novel become mythical; feeling passion, affection and subconsciously exerting forces of affinities towards each other.

[220] Ibid., 332.
[221] Ibid., 316.
[222] Ibid., 301
[223] Ibid., 314. Benjamin remarks that Goethe, "Mr.Phenomenon," failed to give any synthesis of this bridge in his scientific work.

Benjamin's second critique on the novel is through the novella—*Die Wunderlichen Nachbarskinder* [The Marvelous Young Neighbours]—that is inserted as a way to provide comparison to the ongoing mythic themes. The description of the events in the novella is more prosaic and the characters "do not obtain their freedom through sacrifice."[224] He considers the characters in the main story to differ from each other less as individuals than as pairs showing a strong contrast presented between the novel and novella. The couple in the novella expresses their actions through decisions "beyond both freedom and fate," whereas in the novel the reunion is not bestowed as Ottilie is "wreathed in death like a sacrifice."[225] Benjamin states that "if in the novel the mythic is considered the thesis, then the antithesis can be seen in the novella," in a sense Goethe provides redemption from the dark forces that lead to a disaster in the novel.[226]

In the final part of his essay, Benjamin uses Ottilie as a "sacrificial object" that "appears most visibly to grow away from the mythic world."[227] Her sexually and intellectually passive state is related to her death. Benjamin considers her appearance in the crèche an "artificial one" that "evokes the semblance of an innocence of natural life."[228] Her visible beauty becomes a formal projection of something beneath semblance [*Schein*] that "spreads itself out with such innocence over her form." However, Benjamin does not consider beauty to be a semblance [*Schein*] nor a veil covering something else. Instead, beautiful becomes "the object in its veil" that "remains essentially identical to

[224] Ibid., 332.
[225] Ibid.
[226] Ibid., 333.
[227] Ibid., 334.
[228] Ibid., 335. Ottilie becomes the sacrificial object that is out of reach for her lover. Ottilie's innocence, virginity and complete silence gives her the morality of the will to die. This does not appear as a decision but rather as a drive that is not sacred. She becomes the "victim of destiny" and sacrifices herself for the expiation of the guilty ones (Edward and Charlotte). As death and love appear as forces originating from nature, only her sacrifice can rescue Ottile and Edward.

itself only when veiled."[229] When unveiled the infinite chaotic forces will make it imperceptible. He confirms that Goethe's use of the "veil" is more than an image that shows a struggle for an "insight for beauty."[230] For Benjamin, the idea of unveiling these appearances is not possible. As a result, he seeks a solution in criticism that will not try to lift the veil but embrace the beauty beneath veil that will "never open itself to so-called empathy." Underlining a "divinely necessary" veiling of things for perception and aesthetic judgment, Benjamin hails the prevailing superiority of Kant's doctrine, which Goethe tried to solve in the character Ottilie.

Benjamin's criticism of the novel shows that "the conjunction of beauty and *Schein* is constitutive of art but at the same time stands as a definitive barrier to any direct manifestation of truth in the work of art."[231] The classical concept of beauty as "beautiful semblance [*schöner Schein*] refers not just to any appearance–let alone mere illusion–but entails the inextricability of object and appearance."[232] The concept of *Schein* was theorized by Goethe's close friend Schiller who considered "sheer appearance or semblance [*Schein*], as a model for artistic creation," that is "independent of physical reality and existing in its own right, and had thus taken the first decisive step from mere visual perception to aesthetic perception, and hence to artistic creation."[233] The perception of virtual objects "helped to reveal the very essence of Art" as *Schein* went "from being merely an optical concept, gradually attained aesthetic connotation."[234] Schiller was a supporter of Kantian aesthetic judgment and considered beauty "a citizen

[229] Ibid., 351.
[230] Ibid., 352.
[231] Alexande Gelley, "Contexts of the Aesthetic in Walter Benjamin," in *MLN*, Vol. 114, No. 5, *Comparative Literature Issue* (Dec., 1999): 954.
[232] Miriam Bratu Hansen, "Benjamin's Aura,"in *Critical Inquiry*, Vol. 34, No. 2 (Winter 2008): 353.
[233] Marie-Luise Waldeck M., "Shadows, Reflexions, Mirror-Images and Virtual 'Objects' in 'Die Künstler' and TheirRelation to Schiller's Concept of 'Schein'," in *The Modern Language Review*, Vol. 58, No. 1 (Jan., 1963): 34.
[234] Ibid., 37.

of two worlds, of the sensuous world by birth, of the rational world by adoption."[235] However, Kantian dichotomy considered nature and human reason to be "diametrically opposed" whereby "only transcendental methods can he attain a satisfying concept of beauty."[236] In this way Schiller "occupies an intermediate position between Kant and Goethe; regarding "the aesthetic judgment as subjective" like Kant as he tries "to maintain beauty as an objective principle" like Goethe.[237]

Both Goethe and Schiller "reject 'gemeine Täuschung' [wicked illusion] as being the wrong kind of illusion and replace it by *Schein*" in the notion of "some kind of illusion, and as something the artist creates, as a property of his work, not just as a way of looking at it, a quality which the appreciating mind projects into it."[238] *Schein* is a property of each and every art, including architecture, lyric poetry and music; its high function is "to articulate the logic of the life within us, which is continuously felt, but only darkly apprehended," representing all aesthetic forms that "liberates perception from all practical purposes" and "enables us to attend to its symbolic significance."[239] This symbolic appearance of *Schein* has been defined by Susanne Langer in *Feeling and Form* as a "direct aesthetic quality" that the "artist tries to reveal for its own sake" where "the emphasis on quality, or essence, is really only a stage in artistic conception," giving the appearance of artwork a "non-discursive but articulate symbol of feeling."[240] As a result, *Schein* could be considered a gateway to understanding human feelings in forms of artwork.

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[235] Elizabeth E. Bohning, "Goethe's and Schiller's Interpretation of Beauty," in *The German Quarterly*, Vol. 22, No. 4, *Goethe Bicentennial Number* (Nov., 1949): 188.
[236] Ibid., 187.
[237] Ibid., 189.
[238] Elizabeth M. Wilkinson, "Schiller's Concept of Schein in the Light of Recent Aesthetics," in *The German Quarterly*, Vol. 28, No. 4 (Nov., 1955): 223.
[239] Ibid., 225.
[240] Susanne K. Langer, *Feeling and Form: a Theory of Art* (New York : Charles Scribner, 1953), 50.

1.6.3 Ottilie and Lucienne

Another expression of polarity among character typologies is expressed through the conflict between Ottilie and Lucienne. Goethe compares their personalities in multiple cases; they show contrasting performances at boarding school (EA, 99) where Lucienne's dominating figure foils Ottilie's passivity (EA, 193). Their respective roles during the *tableaux vivant* [living picture] (EA, 203) scenes have been a point of scholarly debate.[241] During the progression of these pictures, Lucianne's appearance gradually improves until the *Paternal Admonition* scene where she appears "in her greatest glory" (EA, 197). Her "white satin dress" is organized in the "most cunningly natural way" that makes the tableau surpass the original. However her beauty is only visible from behind a veil that hides "the expression on her face." In contrast, in the crèche scene where the architect uses Ottilie as "the mother of God;" everything is dark and light radiates from the painting rather than towards it (EA, 203). Ottilie's visible face shows "the infinite grace to reveal the hidden treasure" (EA, 204). When the architect changes the picture to a daylight scene Ottilie is surrounded with "infinite brightness" as the whole scene is "flooded with light" where "only the colors could be seen" (EA, 205). The discussion of contrasting images, lighting and colors for these scenes have often been attributed to Goethe's work on chromatics. Brodsky draws a close comparison between Goethe's *Theory of Color* and *Elective Affinities*, where in the latter, "the technical identification and theoretical conceptualization of 'colors' are distributed, by poetic analysis, between

[241] A discussion of human body and images in Elective Affinities could be found in Von Mücke, D. "The Power of Images in Goethe's Elective Affinities," in *Studies in Eighteenth Century Culture*, Volume 40 (2011): 63-81. Von Mücke argues that the images in the novel are used as a reaction to mortality and decay to produce three dimensional figures that can produce uniqueness to surpass the original works of art. She also draws attention to the narrative that calls Ottilie's nativity scene no "an image [*Bild*], but an appearance [*Erscheinung*]."

applied rhetoric and aesthetic philosophy respectively."[242] Ottilie's angelic depiction in the living pictures appears as "a phenomenal occurrence like the colors which spot our vision when we attempt to look at the sun." Because of the dynamic nature of the characters their color depictions also show the changing behavior that is "frozen" with the staged pictures. This way Goethe's subjective investigation of color phenomena coincides with "unreconciled aesthetics associated with Classicism and Romanticism" in the late eighteenth century.[243] Helmut Hühn considers "these representations to highlight the other side on the realism of the images" where "the difference and disparity between image and reality" is "reflected in the art and visual theory of the novel" that is against "imagination" hence subjective judgment.[244] These scenes "capture the subjects" that project "their real relationships," while "their own ideas, wishes and feelings are subconsciously moved to the external world."[245] In all the scenes the characters hold their poses in fixed positions that act as a "mechanical operation" that "separates the realm of art from that of the natural presence."[246] By using a literary structure "in contrast to an approach to science that creates a chasm between the world of our conceptions and the

[242] Brodsky, "The Coloring of Relations: Die Wahlverwandtschaften as Farbenlehre," 1150. Brodsky considers the relationship between people and nature in Elective Affinities to take major influence from Goethe's work on color. Goethe's subjective investigation of color phenomena leads to unreconciled aesthetics associated with Classicism and Romanticism. Rather than seeing the novel in a literary form, Brodsky sees the narrative to be turned towards nature's own phenomenality to show how colors appear. In the novel, light substitutes "the character of human being", and "colors" for human "actions" and "deeds". Goethe uses "colors" as non-mimetic conveyors of meaning, or figures.

[243] Ibid.

[244] Hühn, "Truth and Art," 18. "In den erzählten Bildern des Romans treten nicht nur die Sehweise der Bildproduzenten, sondern auch deren Selbstbilder zutage. Die Darstellung hebt andererseits auf den Realitätsgehalt der Bilder ab. Kein einzelnes Bild kann das Ganze der unverfügbaren Wirklichkeit zeigen. Die Differenz und Diskrepanz von Bild und Wirklichkeit muss, das zeigt sich auch im kunst- und bildtheoretischen Diskurs des Romans, festgehalten werden gegen alle In-eins-Bildungen der Einbildungskraft. Sonst sind die Subjekte in ihren Bilderwelten gefangen und es droht die Gefahr, das Bild für die Sache selbst zu nehmen, d.h. Idolatrie. Gefangen sind die Subjekte, wenn ihr Wirklichkeitsverhältnis proj ektivist, wenn eigene Vorstellungen, Wünsche und Gefühle unbewusst in die Außenwelthineinverlegt werden. Die selbstproduzierten Bilder können sich in einer Weise verselbständigen und verfestigen, dass die lebendige Betrachtung der Wirklichkeit und damit die Korrektur der falschen Bilder unmöglich wird. Man kann die Wahlverwandtschaften als eine umfassende Kritik an der »>Eideologisierung<,der verbildlichten Festschreibung der Wirklichkeit«,lesen."

[245] Ibid. "Gefangen sind die Subjekte, wenn ihr Wirklichkeitsverhältnis proj ektiv ist, wenn eigene Vorstellungen, Wünsche und Gefühle unbewusst in die Außenwelt hineinverlegt werden."

[246] Ibid., 227. "Aber Luciane blieb standhaft und kam dem Wunsch nicht nach. Hätte sie sich bewegt, hätte sie das Bild zerstört, zugleich aber dem Wunsch des Publikums nach Schönheit entsprochen. Tournez s'il vous plait bezeichnet exakt den Austritt aus dem Bild in die Wirklichkeit. Die Paradoxie besteht darin, dass das Lebende Bild nur dann funktioniert, wenn es ganz starr bleibt. Jede Bewegung zerstört den Bildcharakter und trennt die Sphäre der Kunst von jener der natürlichen Gegenwart. Goethe verwendet einen anschaulichen Begriff für die Wende, die weit mehr als eine mechanische Operation ausmacht."

world of our perceptions Goethe offers us a science that gives a primacy to the meaningful world given to our senses."[247] He tries to show that "the beauties of nature which appear through perception," do not follow "merely 'subjective phenomena'; they are of nature because we are of nature, and they exist only in a relation between the vacancy of consciousness and the plenitude of being."[248] Thus, rather than using any mediating veil between the onlooker and the object or committing to any type of formalism Goethe points at his primary colors for aesthetic experience. As a result, the living pictures in the novel could be considered archetypal images with suspended intensities that open them up for intuitive perception through colors.

During his collaboration with Schiller on aesthetics Goethe insisted "on necessary and objective ideals of art in an age increasingly preoccupied with reflection upon the subjective, imaginative forces in artistic production."[249] He wanted to develop an aesthetic theory that is rooted in epistemological and scientific investigation. "His ambition to intuit the *Urphänomene* in nature inseparably intertwined with his ambition to intuit the ideal of art" as he tried to establish "ideal archetypes" for the appreciation of art that existed prior to any artwork.[250] Such an ideal could be considered for the characters of *Elective Affinities* where light substitutes "the character of human being", and "colors" for human "actions" and "deeds" as Goethe uses colors as "non-mimetic conveyors of meaning, or figures."[251] For Goethe, colors were defined "as deeds and sufferings of light," where "this interplay of action and reaction" occurred on a "social

[247] Brent Dean Robbins, "New Organs of Perception: Goethean Science as a Cultural Therapeutics," in *Janus Head*, 8(1) (2005): 124.
[248] Ibid., 119.
[249] Joan Steigerwald, "Goethe's Morphology: *Urphänomene* and Aesthetic Appraisal," in *Journal of the History of Biology* 35 (2002): 322.
[250] Ibid., 312.
[251] Brodsky, "The Coloring of Relations," 1154. Brodsky considers the relationship between people and nature in Elective Affinities to take major influence from Goethe's work on color. Rather than seeing the novel in a literary form, Brodsky sees the narrative to be turned towards nature's own phenomenality to show how colors appear.

level."[252] Such polarity is also presented in the novel when Ottilie's dead but still radiating body is placed in the chapel under the vault with polar placement of Otto's coffin and her little chest (EA, 260). Goethe defines such aesthetic appearances in his *Theory of Colors* under "The Sensory and Moral Effects of Color" where colors are able to produce such "impression in their most general elementary character, without relation to the nature of form of the object on whose surface they are apparent."[253] Here the sequential arrangement of the figures could be interpreted as a polarization of three colors where the little chest that contains fabric for Ottilie's "bridal dress" represents yellow as when "applied to dress…as it appears on satin, has a magnificent and noble effect."[254] Due to the tragic events that lead to the death of Otto, his coffin represents the color blue—on which Goethe writes, "we love to contemplate blue, not because it advances to us, but because it draws us after it."[255] In this sense, Ottilie's placement in the middle offers an intensified polarized mixing of yellow and blue to represent red as "the highest of all appearances of color" that "arises from the junction of two contrasted extremes which have gradually prepared themselves for a union."[256] This color is mostly associated with beauty but also "conveys an impression of gravity and dignity, and at the same time grace and attractiveness."[257]

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[252] Stefan Blechschmidt, "… eine Repositur für das Gegenwärtige, ein Archiv für das Vergangene". Wer schafft Ordnung in den *Wahlverwandtschaften*? [A repository of the present, an archive for the past. Who creates order in *Elective Affinities*?] in *Goethes Wahlverwandtschaften: Werk Und Forschung* [*Goethe's Elective Affinities: Work and Research*], ed. Helmut Hühn (Walter de Gruyter: 2010), 392. "Wie Goethe Farben generell als Taten und Leiden des Lichts definiert, so konstatiert er dieses Wechselspiel von Wirkung und Gegenwirkung auch auf sozialer Ebene. Dort wie hier thematisiert Goethe eine Gestalt- bzw. Sichtbarwerdung. Dort ist es das Phänomen der Farbe, das durch 'Taten und Leiden des Lichts' sichtbar wird, hier das 'Bild des Charakters', das durch die Beachtung von 'Handlungen' und 'Taten' aufscheint. Es entstehen Mosaiken von 'Wirkungen' und 'Gegenwirkungen', die Goethe nicht nur in seiner Farbenlehre, sondern zuvor schon in seiner Kunstgeschichtsschreibung über Cellini und Wirrekelmann zu Charakterbildern zusammensetzt."
[253] Johann Wolfgang von Goethe, *Goethe's Color Theory*, arranged and edited by Rupprecht Matthaei (New York: Van Nostrand Reinhold, 1971), 168.
[254] Ibid., 169.
[255] Ibid., 170.
[256] Ibid., 172.
[257] Ibid.

With the contrasting characters, *tableaux vivants*, and inserted Novella, the novel explores a polarity between the images of the dead and the living that follow the same aesthetic ideas. In this sense, Ottilie's death does not happen as a tragic ending to the novel since her "corpse does not seem to decay, and hence can be kept under a glass cover and as such her body has become a lasting true, irreproducible image."[258] The preservation of her beauty at the chapel is a relic of the mystical color hexagram Goethe embraces in his *Theory of Color* that transcends physics of material representation and opens up the path to sensual and aesthetic representations of nature.

1.7 Conclusion: Polarity, Productivity and Prototypes in *Elective Affinities*

Over two hundred years have passed since the first publication of Goethe's *Elective Affinities* in 1809 from a period "with an entirely new radicalism that changed the questions of the world beliefs in a laboratory of classical, romantic and idealistic debates producing philosophy and art."[259] The ideas that were influential from this period are presented in this segment to show the multifaceted complexity of the novel. It is a literary work of organic and dynamic approach where Goethe amalgamates philosophical, aesthetic and scientific ideas to develop dynamic character interactions, epigenetic views on landscape, and aesthetic events that in essence stay primarily morphogenetic and hint at various allegorical meanings.

The philosophical emphasis of the novel can be found in Goethe's focus on the landscape as a hybrid model combining aspects of ecology and philosophy. Seen as a

[258] von Mücke,"The Power of Images in Goethe's Elective Affinities," 72.
[259] Hühn, "Truth and Art," 22. "Er reflektiert mit den Mitteln der Literatur den Übergang von der ständischen zur bürgerlichen Gesellschaft, seine Erzählform basiert auf dem Übergang von der statisch-klassifikatorischen zur genetisch-morphologischen Naturanschauung in der Naturforschung, und er diskutiert-mit ganz neuer Radikalität – die Veränderungen in den Fragen der Weltauffassung, die sich im Laboratorium der klassischen, romantischen und idealistischen Debatten in Philosophie und Kunst abzeichnen."

genetic diagram of constructive character movements Captain's map structures paths, views and projects that give the topographical ground its productive core. These properties of the map could also be compared to biological models such as the "fitness landscape"[260] for the altitudinal relationships of structures and views; and the "epigenetic landscape"[261] for horizontal trajectories and structure of paths. Furthermore, the landscape as a speculative and abstract model shows kinship to Schelling's concept of the ground. The character's movement and projects are part of the "being of the ground" that structures their movement and dynamism on the landscape as the *Ungrund,* "which comes before all ground, thus, the absolute considered merely in itself, the non-ground."[262] Goethe uses the ceremony for the grounding of the summer house as a depiction of how natural products can be produced out of the Absolute. In this regard, the summer house is separated from productive forces through contraction, giving it a stable, fixed foundation. Furthermore, the topographical aspects of the novel combine expansive and contractive paths that either lead to the summit offering a wide view of mountains, or terminate in the combined lakes that represent the pure dynamism of the Absolute leading to formlessness.

Apart from its philosophical aspects, the novel also shows influences of various scientific developments during Romanticism. Goethe's early interest in mystical alchemical texts and later foundation of chemistry as a science dealing with material reactions and compounds is found in the contrasting character typologies and their interactions. This chemical nature not only gives the novel its title, but also transforms Bergman's theory of affinity into a literary technique to structure the dynamic relations

[260] Sewall Wright, "The roles of mutation, inbreeding, crossbreeding, and selection in evolution," in *Proceedings of the Sixth International Congress on Genetics* (1932): 355–366.
[261] Conrad H. Waddington, *The Evolution of an Evolutionist* (Ithaca, N.Y.: Cornell University Press, 1975), 258.
[262] Schelling, *Philosophical Investigations into the Essence of Human Freedom*, 69-70.

among characters. The anthropomorphic discussion of chemical reactions in chapter four foreshadows the human reactions that will take place in the subsequent social scenes. Goethe uses "love as sympathy," like "the driving force behind the motions of the atoms" where the external viewing of the elements or bodies by the characters becomes an opportunity to understand "the condition of internal knowledge" that is based on "similarity."[263] The table settings and the catalyzing effects of the count and the baroness show "the transition from the static-classificatory to genetically-morphological view of nature in natural science."[264] Thus, Goethe accepts the theory of affinity as a physicochemical law; however, he doesn't consider a fixed order for the relations or the reactions that could take place in complex settings.[265] Instead, the theory of affinity is used to introduce dynamism among organic character relations that facilitate their extended walks, coupled activities and cumulative decisions on projects to be built.

After the scientific debate between the epigenesists and preformationists took place in the eighteenth century, Goethe developed morphology as "one of the very fundamental sciences" to be located "within a hiererchy of the other sciences."[266] In his scientific studies Goethe conducted research in osteology, botany, and geology to establish archetypical concepts. In *Metamorphosis of Plants* he conceived the *Urpflanze* as "a morphological concept, a generalized form, a model or pattern" that can be "found by comparison of empirical objects one another, and it embraces both their similarity and

[263] Adler, *An almost Magical Attraction: Goethe's Elective Affinity and the Chemistry of its Time* ,44. "Die Liebe als 'Sympathie' erscheint daher als treibende Kraft hinter den Bewegungen der Atome…Das äußere Anschauen wird zum Anlaß und zur Bedingung innerer Erkenntnis. Das Seinsverständnis überhaupt versteht sich als ein sinnlieber und geistiger Akt ('begreifen'). Sein und Erkenntnis beruhen auf Ähnlichkeit."
[264] Hühn, "Truth and Art," 22. "Er reflektiert mit den Mitteln der Literatur den Übergang von der ständischen zur bürgerlichen Gesellschaft, seine Erzählform basiert auf dem Übergang von der statisch-klassifikatorischen zur genetisch-morphologischen Naturanschauung in der Naturforschung, und er diskutiert-mit ganz neuer Radikalität – die Veränderungen in den Fragen der Weltauffassung, die sich im Laboratorium der klassischen, romantischen und idealistischen Debatten in Philosophie und Kunst abzeichnen."
[265] Jeremy Adler, "Goethe's Use of Chemical Theory in His Elective Affinities," in *Romanticism and the Sciences*, eds. Andrew Cunningham and Nicholas Jardine (Cambridge: Cambridge UP, 1990), 268.
[266] Richards, *The Romantic Conception of Life*, 454.

their variations."[267] A similar morphogenetic role is given to the naming of the baby Otto, showing the influence of Goethe's scientific studies on the conception of the novel.[268] Otto not only ties all characters to a common archetypal origin but also displays changing physiological characteristics that resemble the main four characters in an alternating fashion. In his *Botanical Writings*, Goethe compares this approach to Linnaean taxonomy, which only works through analysis by collecting specimens and organizing them according to their physiological properties. In contrast, by introducing "Otto" to the construction of names for all the characters, Goethe utilizes an epigenetic model to both signal a common archetype among all characters, as well as considers them as gendered deviations from the Urtype–Otto.

Another polarity among characters places the expansive character of Lucianne and the contractive Ottilie in alternating roles during *tableaux vivants* [Living Pictures]. In these scenes, Lucianne takes roles in multiple depictions with increasing intensity. In contrast, Ottilie is depicted through the singular crèche scene representative of her humble character. In these events, Goethe reflects back on his speculations regarding aesthetics in *Theory of Color* that not only uses character appearances as visual experiments combining colors and lighting, but also draws polarity closer to the world of *Schein* as an aesthetic appreciation of beauty. This speculative work shows a resistance to the inability to derive "objective concepts of understanding" nature from the "aesthetic judgment" of Kant, leading Goethe to investigate an alternative aesthetic view of archetypal phenomena in his artistic and scientific work.[269] In the novel, color is utilized

[267] Heinrich Henel, "Type and Proto-Phenomenon in Goethe's Science," *PMLA*, Vol. 71, No. 4 (Sep., 1956): 651-668.
[268] Christina Lupton, "Naming the Baby: Sterne, Goethe, and the Power of the Word," *MLN*, Vol. 118, No. 5, *Comparative Literature Issue* (Dec., 2003): 1213-1236.
[269] Kant, *Critique of Aesthetic Judgement*, 144.

in the various depictions of the living pictures to give insight into the aesthetic perception of form. Without using any formalism or judgment, Goethe points to the polar relationship and sensual effects of colors as a way to perceive things objectively to redefine the aesthetics of his time.

Goethe's *Elective Affinities*, embedded within the scientific and philosophical grounds of the Romantic period, brings forth new ideas on form, growth and ontology for how dynamic relations can be expressed in literary artistic form. Seen in this light, the novel could be read as a memoir of how he viewed his time by placing the science of morphology at a higher vantage point within the landscape of life, providing a wider view than is possible via separated sciences that lack synthesis. With the drawing of new paths, particularly the circumscribing expansive path, Goethe illustrates how dynamic phenomena should be studied by combining analysis with synthesis; grounding morphology as a unified science of life.

CHAPTER 2 POLARITY AND MORPHOGENESIS

2.1 Polarity and Metamorphosis

Metamorphosis of Plants, written in 1790, is Goethe's first scientific treatise, in which he presents a dualist aesthetic theory of plant forms operating under the activity of polar-sexual forces.[270] The work is presented in seventeen sections, composed of one hundred and twenty three paragraphs that articulate observations during the progressive development of annual plants focusing on "particular transformation of structurally similar elements arranged along an axis."[271] The concept of metamorphosis presents an "expanded acceptance of great archetypes of experience such as harmony, polarity and intensification" while taking inspiration from "underlying the images of the Great Chain of Being or the ancient symbolism of alchemy."[272] While polarity in inorganic life finds its theoretical formulation in the concept of "elective affinity,"[273] the concept of metamorphosis extends polarity towards the organic realm by uniting aspects of preformation and epigenesis where "constant qualities can be compared and that those elements with the ability to change can be perfected enters into Goethe's idea of nature as the prerequisite for the construction of nature."[274] The concept of metamorphosis aims to

[270] Johann Wolfgang von Goethe, *Goethe's Botanical Writings*, trans. by Bertha Mueller with an introduction by Charles J. Engard, (Woodbridge, Conn.: Ox Bow Press, 1989). Another version with colored illustrations could be found in Johann Wolfgang von Goethe, *The Metamorphosis of Plants*, intro. and photography by Gordon L. Miller (Cambridge, Mass. : MIT Press, 2009)

[271] Adolf Portman, "Goethe and the Concept of Metamorphosis," in *Goethe and the Sciences: a reappraisal*, eds. Frederick Amrine, Francis J. Zucker and Harvey Wheeler (Boston: D.Reidel., 1987): 133. Portman positions Goethe's work against the modern development of biology as presenting a comprehensive view of nature that drew the interest of Agnes Arber and Wilhelm Troll in the field of botany. He states that "Goethe's powerful longing for synthesis led him to transgress the boundaries that scientific research has set itself in conscious self-limitation."

[272] Ibid.

[273] Adler, "Goethe's Use of Chemical Theory in His Elective Affinities," 275. Adler draws a strong link between Goethe's *Urpflanze* and chemical affinity that should be "understood not as a formula, but as an 'idea'."

[274] Dorothea Kuhn, "Goethe and Theories of Development," in *Goethe and the Sciences: a reappraisal*, eds. Frederick Amrine, Francis J. Zucker and Harvey Wheeler, (Boston: D.Reidel., 1987): 9. Kuhn discusses the role of type within the formulation of structural morphology in Goethean science. She considers type "as the constant in species" and the dynamism as "the law of formation" that "represent as a whole that which has been developed by steps in time", which Goethe called the "ideal whole."

tackle schematic concepts like type [*Urtypus*] with the duality of forces where the "empiricist (originally Nominalist) conception of difference as static and disjunctive is gradually being supplanted by a dynamic and integrative logic of difference as 'transformation'."[275] But Goethe's theory is not on mere transformation of forms or dynamic formless activity, but rests on a duality, that "characterize the *Bildung* of organic life as metamorphosis: 'polarity and intensification' [*Polarität und Steigerung*]."[276] This presents foundational theory for the science of morphology that "studies the forms of organisms by juxtaposing them and evolving, from this juxtaposition, a standard of comparison."[277]As a result, the theory of metamorphosis aims to reformulate the structural laws of organisms that not only enables a Goethean study of organic forms but also establishes a unified science of living forms which he defined as morphology.

2.1.1 Polarity in Metamorphosis of Plants

In *Metamorphosis of Plants* Goethe's main hypothesis is to explain how Nature creates "the most diversified forms through modification of a single organ" which he calls *Urblatt* [Primordial Leaf], that establishes an archetype for plant organs.[278] The transformation and reproduction of this organ is presented with the term "metamorphosis" of which three kinds exist: "regular, irregular and accidental."[279] The first kind, could "be observed at work step by step form the first seed leaves to the final

[275] Thomas Pfau, "All is Leaf': Difference, Metamorphosis, and Goethe's Phenomenology of Knowledge," in *Studies in Romanticism*, 49, (Spring 2010), 6. Pfau discusses the origin of the term metamorphosis in Goethe's early botanical works that "revive ancient models of nature-as-process by subtly amalgamating Platonic form *(eidos)*, Aristotelian teleology, and Ovidian metamorphosis." Thus, Goethe sought to transform the Kantian conception of difference as static form that is grounded by the Newtonian idea of an inert "substance", by mixing it with Schelling's *Naturphilosophie* to gave it dynamism and redefine the difference as metamorphosis. Pfau compares Ovid's poetical works to Goethe's to concludes that "for Ovid no less than for Goethe, it is precisely this coalescence of the phenomenal (ektypal) with the ontological (archetypal) that furnishes the impetus for scientific study and imbues all inquiry into nature with a strong narrative momentum."
[276] Ibid.
[277] Ronal H. Brady, "Form and Cause in Goethe's Morphology," in *Goethe and the Sciences: a reappraisal*, eds. Frederick Amrine, Francis J. Zucker and Harvey Wheeler (Boston: D.Reidel., 1987): 258.
[278] Goethe, *Goethe's Botanical Writings*, 31.
[279] Ibid.

development of the fruit" through the "transmutation of one form into another, as it ascends as though on the rungs of an imaginary ladder to that climax of Nature," is defined as *regular metamorphosis* that displays the "reproduction through two sexes."[280] Although the main focus of the treatise is this progressive development from the first seed-leaves (cotyledons) towards the later forming of the flower and fruit, Goethe also states that the *irregular metamorphosis* reveals some underlying qualities (Fig.2.1.1.1). This type of metamorphosis causes some parts of the plant to appear "in a soft and indeterminate state which is often pleasing to the eye, yet internally impotent and ineffectual."[281] The last kind, *accidental metamorphosis*, is caused by the external activity of insects and other agents causing change in forms. Since this kind fails to explain the intrinsic productivity of Nature, it is quickly discussed and removed from the main focus.

Figure 2.1.1.1 – The annual plant, Goethe's basic model in his discussion of metamorphosis; plant parts, separated for the purpose of illustration, from top to bottom—pistil, stamens, corolla, calyx, stem leaves, cotyledons, and roots. (Reprinted from Goethe, *Metamorphosis of Plants* (2009), 9).

[280] Ibid.
[281] Ibid., 32.

Figure 2.1.1.2 – Young castor bean plant showing its prominent two embryonic leaves (cotyledons) that differ from the adult leaves. The cotyledons (lower) and first stem leaves (upper) show distinguishable complexity of form.

The structure of the essay follows the growth of a flowering annuanl plant that presents a reciprocal relationship between sequential organs produced along its vertical structural axis. This expression is first visible in seed leaves–the cotyledons–that "are always rather undeveloped as compared with the subsequent leaves of the stem."[282] As plant ascends and grows in time, the stem leaves take on a more refined and complex form as "they are entirely green in color; they rest on a visible node; and they bear an undeniable relationship to the following stem leaves, although they are still inferior to them in that their periphery or margins are not yet fully elaborated" (Fig.2.1.1.2). The increasing complexity and articulation of subsequent leaf forms is described as a balance of internal and external factors, the former being guided by changing inner nourishement of the plant, and the latter influenced by environmental conditions of aridity and moisture. These external forces are capable of producing variation of the outer form of the same species in different climatic settings as the plant develops "smoother and less complex leaves when it grows in low, moist-places, and rough, hairy, more delicately

[282] Ibid., 37.

elaborated leaves when transferred to higher regions" (Fig.2.1.1.3).[283] After a hint on the effects of the environment on plant forms, Goethe turns to discuss the internal activity of the plant organs, their exchange of nutrients and role in reproduction.

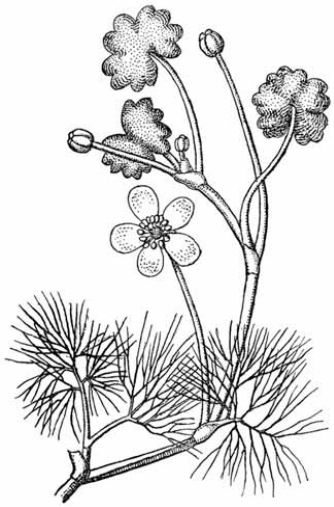

Figure 2.1.1.3 – Drawing of Water buttercup [*Ranunculus aquaticus*] displaying fully formed aerial leaves and threadlike submerged ones along the same stem. (Reprinted from Goethe, *Metamorphosis of Plants* (2009), 21).

For the internal factors guiding metamorphosis, Goethe discusses changing the quality and distribution of nourishment provided to the plant. For instance, the stem leaves and nodes, being the first organs reproduced by the plant, participate in this reproductive process as they produce and filter internal juices transported through the stem. Describing an early account of photosynthesis, Goethe states that the stem leaves first "absorb various types of gas, combining them with their internal moistures" to process and send "purer saps back again to the stem, thereby fostering remarkably the development of the nearby buds."[284] Similarly, in "cereals, grasses, reeds" an upper node is produced along the stem by "obtaining its saps directly through it," while the new

[283] Ibid., 39.
[284] Ibid., 40.

closed node “must necessarily receive these saps in purer and more filtered state and must benefit by the previous action of the leaves” (Fig.2.1.1.4).[285] The constant filtering of fluids drives the plant towards the reproduction of more complex and articulated new organs developed in a sequential order. In return, these organs contribute to the growth process as “cruder fluids are in this manner continually drained off and replaced by purer ones, the plant, step by step, achieves the status prescribed by Nature” to reach the reproductive phase in the production of flower.[286]

Figure 2.1.1.4 – Water Horsetail [*Equisetum fluviatile*] showing the alignment and stacking of closed nodes (Image courtesy of Luc Viator / www.Lucnix.be).

Although the constant purification of the sap drives the plant towards the formation of the flower as its goal, the amount of nourishment can control the timing of this natural process. When the plant is supplied with “excessive nutriment” the preceding “draining operation must be repeated again and again, rendering inflorescence almost impossible.”[287] On the other hand, when the plant “is deprived of nourishment” flowering is “facilitated and curtailed” as “the nodal organs become more refined, the action of the

[285] Ibid.
[286] Ibid.
[287] Ibid., 42.

unadultered saps becomes purer and stronger, and the transformation of the parts is made possible and proceeds irresistibly."[288] This refinement of juices has a major role during the sequential development of the flower organs which follow. For instance, as the first organ before the flower, the calyx is formed "around a single center," where Nature "*connects* several leaves, and consequently several nodes, which she ordinarily would have produced successively and at some distance *apart*, usually in a certain number and order" (Fig.2.1.1.5).[289] The formation of the calyx is described as an example of how the transformation and anastomosis of separate organs is triggered through the activity of nutrients filtered and transported along the plant. As a result, Goethe considers calyx as not a "new organ" but as a configuration of multiple leaves under the effect of refined juices, where nature "combines and modifies organs already known to us, in this way advancing one step nearer towards her goal."[290]

Figure 2.1.1.5 – Calyx of pot marigold [*Calendula offi cinalis*] showing the anastomosis of multiple leaves before the petals of the flower (Reprinted from Goethe, *Metamorphosis of Plants* (2009), 29).

[288] Ibid.
[289] Ibid., 44.
[290] Ibid.

Because of the intensified activity of juices along the stem, the transition between the calyx and corolla often displays cases of *irregular metamorphosis*. For instance, on various tulip stems where there is no calyx, a "leaf-petal" might be produced, that is "half green, and is torn into two parts, the green half which is related to the stem remaining attached to it, and the colored part being lifted up with the corolla" (Fig.2.1.1.6).[291] The coloration and positioning of these parts not only reveals their affinity to other organs along the stem, but also the changing nourishment they received during their formation.

Figure 2.1.1.6 – Watercolor commissioned by Goethe showing the anastomosis of a stem leaf with petals of a flower
(Reprinted from Johann Wolfgang von Goethe and Wilhelm Troll, *Goethes Morphologische Schriften* (1932), Tafel IX).

[291] Ibid., 46.

The petals are “usually larger than the sepals” and they are formed “by the influence of purer saps which have been refiltered through the calyx” where the leaves “that contracted as organs of the calyx can now be observed to expand again and to represent new and entirely different organs” in the petal, because of this “their delicate organization, their color, and their scent would quite obscure their origin.”[292] This expansion of the petal is further balanced “in a highly contracted and, at the same time, highly refined state” in the formation of staminal organs that produce pollens for fertilization.[293] Using expansive and contractive forces as related to the filtering and activity of inner juices of the plant, Goethe describes a formal and polar relationship among the sequential flower organs: calyx, petal and stamina; in the former—calyx to petal—happening through expansion, and in the latter—petal to stamens—as an activity of contraction. A similar relationship is defined for nectarines that appear as “intermediate organs” by alternating “regularly with the stamens, and indeed, already in leaf form.”[294] In reproductive organs, this alternation causes a division of inner forces producing opposite sexual organs: stamens and pistil. The stamens are formed by expansion of “a weak, extremely simple filament” and the contracted pollens that are “merely vessels in which extremely refined sap is stored.”[295] These pollens, sometimes in the form of fluid, facilitate fertilization by attaching to the female organs. Goethe relates the inner polar activity of the plant as an expression of opposite sexual forces that seek their unison in the fertilization.

[292] Ibid.
[293] Ibid., 48.
[294] Ibid., 49.
[295] Ibid., 56.

> If, then, we assume that those vessels which formerly lengthened, expanded, and again sought each other out, are at present in a highly contracted state; if we see the highly developed pollen emerging from them and replacing thorough its activity what the vessels that produce it have lost in ability to expand; if the liberated pollen now seeks out the female parts, which by a similar operation of Nature have been advancing toward the stamens; if the pollen firmly attaches itself to these female parts and transmits its influences to them: then we are disinclined to call the union of the two sexes as idealized anastomosis, and we believe we have brought closer together, for a moment at least, the concepts of growth and generation.[296]

Since "styles and filaments are produced by spiral vessels" Goethe considers both sexual organs to have an equal part in the fertilization, as they "visualize the exact relationship of male and female parts."[297] Their divided roles in flower production manifests itself in their alternation during growth as their activity is manifested as expansive-male and contractive-female forces. This polar description of forces is extended to all other organs of the plant that reveal reciprocal polarity relations.

> From the seed the fullest development of stem leaves we noted first as expansion; thereupon we saw the calyx developing through contraction, the petals through expansion, and the sexual organs again through contraction; and soon we shall become aware of the maximum expansion in the fruit and the maximum

[296] Ibid.
[297] Ibid., 59.

concentration in the seed. In these six steps Nature ceaselessly carries on her eternal work of reproducing the plants by means of two sexes.[298]

Polarity also manifested during vegetative propagation of plants where bud reproduction "occurs in the vicinity of the accompanying leaves, which seem to make provisions for the formation and growth of the buds, and to participate in these processes."[299] While nodes are produced from other nodes followed by "the formation of a leaf at each node with a bud in its vicinity," a single plant is able to reproduce other plants that are connected to it via its stem.[300] A bud receives its nourishment from "the mother plant, which is already completely organized," but if the two are separated then the bud is able to receive its nourishment "from the new plant, if it has been grafted; or from the roots that form immediately, if it has been planted in the earth as a branch."[301] This gives some form of autonomy to the subsequent branches of the plant as they "may be regarded as individual little plants which are set into the mother plant in the same way that the mother plant itself is fastened in the earth."[302]

While the concept of metamorphosis describes the reproduction of new organs through the forces of expansion and contraction that are attributed to a postulated sexual bifurcation in Nature, these forces are restricted to act on leaf-like forms. Both concepts, forces and the leaf form, equally constitute to the laws of metamorphosis. Goethe states that such a law "would have to be manipulated as expertly as algebraic formulae" to develop a morphological understanding for the "formation of genera, species, and

[298] Ibid., 60.
[299] Ibid., 68.
[300] Ibid.
[301] Ibid.
[302] Ibid., 69.

varieties, as well as in the growth of each individual plants."[303] As a result, the concept of metamorphosis becomes a theory of forms, that combines the expression of inner polarity and their variability under changing environmental conditions.

2.1.2 Expansion and Contraction

In *Metamorphosis of Plants* Goethe's description of the progressive development of an annual plant through alternating stages of expansion and contraction presents an aesthetic and formal understanding of forms structured by an organic duality. The concept of metamorphosis as the breathing, pulsating principle of growth and organ transformation becomes "the law of appearance, with the leaf furnishing the enduring *and* concrete substratum for a process of continuous internal differentiation whereby a plant realizes its substantial identity" through expression of antagonistic polar forces.[304] In a short essay titled "Polarity" Goethe describes this principle as a "duality of the phenomenon as opposites" and gives paired examples that extend the concept among multiple domains.[305] For Goethe, the concept of polarity presents a world-view for living forms that not only structures their appearance, but also their experience.

> Whatever appears in the world must itself divide if it is to appear at all. What has been divided seeks itself again, can return to itself and reunite. This happens in a lower sense when it merely intermingles with its opposite, combines with it; here the phenomenon is nullified or at least neutralized. However, the union may occur in a higher sense if what has been divided is first intensified; then the union of the

[303] Ibid., 72.
[304] Thomas Pfau, "All is Leaf': Difference, Metamorphosis, and Goethe's Phenomenology of Knowledge," *Studies in Romanticism*, 49, (Spring 2010), 30.
[305] Johann Wolfgang von Goethe, *Scientific studies*, 155. These pairing are "we and the objects, light and dark, body and soul, two souls, spirit and matter, thought and extension, ideal and real, sensuality and reason, fantasy and practical thought, being and yearning, two halves of the body, right and left, breathing, magnet."

intensified halves will produce a third thing, something new, higher, unexpected.[306]

The origin of Goethe's concept of polarity is often attributed to his early study of "neo-Plantonist writers" and alchemy "where the twin opposites are often designated 'Mercury' and 'Sulphur', and their union is called the Philosophers' Stone."[307] Richards draws a link to Kant's *Metaphysical Foundations of Natural Science* which "reduced the concept of matter ultimately to that of the powers of attraction and repulsion" and inspired Goethe to "develop the concept of the fundamental polarity of all beings, a polarity that penetrates and animates the infinite manifold of appearance."[308] From a philosophical standpoint Goethe's reformulation of the concept as alternating forces of expansion and contraction also shows remarkable similarities to Schelling's *Naturphilosophie* that aims to develop duality as the metaphysical core of Nature where "*that one and the same universal dualism diffuses itself from magnetic polarity on through the electrical phenomena, finally even into chemical heterogeneities, and ultimately crops up again in organic nature*."[309] For Schelling, matter exists within a polar tension and is shaped through constant opposition of forces that appears to be caught within "*infinite metamorphosis*" that cannot "take place *without rule*" and is bounded by its own "limits."[310] Schelling attributes this rule to the expression of polarity inherent in Nature where "productivity is attracted and repelled between opposites; in this alternation of expansion and contraction there necessarily arises a common element, but

[306] Ibid., 156.
[307] Ronald D. Gray, *Goethe: A Critical Introduction* (London, Cambridge University Press, 1967), 117. Gray draws a strong link between Goethe's usage of polarity to Boehme's alchemical formulation of the universe; both showcase a dualist structure. Goethe's literary and scientific work shows signs of similar duality, especially in Faust, Werther, Elective Affinities and Theory of Color.
[308] Robert Richards, *The Romantic Conception of Life,* 429. Richards notes that the similar essay made Schelling develop his philosophical system.
[309] Schelling, *First Outline of a System of the Philosophy of Nature*, 184.
[310] Ibid., 213.

one which exists only *in change*" that "must become fixed."[311] Schelling's notion of metamorphosis divides the unitary force of vitalism into polar materialism that we find in these dynamic forces.

> …if this principle is now called *Life-force*, then I maintain on the contrary that Life-force, taken in this sense, is a completely self-contradictory concept. For we can think of force only as something finite. But no force is finite by *nature* except insofar as it is limited by one opposing it. Where we think of force (as in matter), therefore, we must also presume a force *opposed* to it. Between opposing forces, however, we can only conceive a double relationship. Either they are in relative equilibrium (in absolute equilibrium they would both be completely eliminated); then they are thought of as at rest, as in matter which is therefore said to be inert. Or one thinks of them as in perpetual, never-settled conflict, where each in turn prevails and submits; but then, again, a third must be present which keeps this conflict going and maintains the work of Nature in this conflict of alternately prevailing and submissive forces.[312]

Goethe read Schelling's *Ideas for a Philosophy of Nature* and drew remarks from *Naturphilosophie* on developing a method of aesthetic formulation of forms that could perceive the dynamic productive forces that are invisible.[313] This became a central tenet in his work on natural sciences, particularly fused in *Theory of Color*, where he utilized

[311] Ibid., 219.
[312] Friedrich Wilhelm Joseph von Schelling, *Ideas For A Philosophy Of Nature As Introduction To The Study Of This Science*, trans. Errol E. Harris And Peter Heath, intro. Robert Stern. (New York : Cambridge University Press, 1988), 37.
[313] For discussion on Goethe's influence from Schelling's *Naturphilosophie*, see Gabriel Trop, "Poetry and Morphology: Goethe's "Parabase" and the Intensification of the Morphological Gaze", in *Monatshefte*, Vol. 105, No. 3 (2013): 389-406. On the relationship between Schelling and Goethe, Richards, "Nature is the Poetry of Mind, or How Schelling Solved Goethe's Kantian Problems."

polarity as a way to observe, analyze, study and theorize unified principles that he considered divisible and dual.

> True observers of nature, however they may differ in opinion in other respects, will agree that all which presents itself as appearance, all that we meet with as phenomenon, must either indicate an original division which is capable of union, or an original unity which admits of division, and that the phenomenon will present itself accordingly. To divide the united, to unite the divided, is the life of nature; this is the eternal systole and diastole, the eternal collapsing and expansion, the inspiration and expiration of the world in which we live and move."[314]

Polarity occurs as a recurring theme among many works written by Goethe, particularly presenting the core principle for his work on natural sciences such as botany, osteology and physics (color).[315] In her book *The Will to Create: Goethe's Philosophy of Nature*, Astrade Orle Tantillo considers polarity to be one of the four pillars of Goethe's scientific principles, along with intensification, compensation and competition that are united under "nature's will to create, evolve, struggle, transform and metamorphose."[316] In the first chapter of her book, Tantillo focuses on the principle of polarities stating that they "are not antinomies or logical binaries, but represent opposing forces that often work

[314] Goethe, *Goethe's Color Theory*, 164.
[315] For a discussion of Goethe's formulation of polarity in color see Frederick Burwick, "Goethe's Entoptische Farben and The Problem of Polarity," in *Goethe and the sciences: a reappraisal*, eds. Frederick Amrine, Francis J. Zucker and Harvey Wheeler (Boston: D.Reidel., 1987): 29-43. Polarity in dicotyledonous plant morphology see Peer Schilperoord-Jarke,"The Concept of Morphological Polarity and its Implication on the Concept of the Essential Organs and on the Concept of the Organisation Type of the Dicotyledonous Plant", in *Acta Biotheoretica*, Volume 45, Issue 1 (March, 1997):51–63. Discussion of polarity in animal morphology see Mark Riegner "Horns, Hooves, Spots, and Stripes: Form and Pattern in Mammals," in *Goethe's Way of Science: A Phenomenology of Nature*, eds. David Seamon and Arthur Zajonc (Albany NY: SUNY Press, 1998): 177-212.
[316] Astrida Orle Tantillo, *The Will to Create: Goethe's Philosophy of Nature* (Pittsburgh, Pa.: University of Pittsburgh Press, 2002), 6.

together in order to create."[317] This occurs either through separation or union of oppositions "whose interaction may lead at times to the negation or destruction of one or both elements, polar pairs may also represent reconciliations (such as the magnet) that preclude the concept of negation and permit creativity."[318] Tantillo draws numerous remarks from Goethe's poems, autobiography and works on color to establish polarity as core principle of his works that span from poetry to science. She writes about the creative acts of polarity in Goethe's autobiography, *Poetry and Truth* (*Dichtung und Wahrheit*), and in the poem "Reunion" ("Wiederfinden," 1815) where Goethe discusses creation as he doesn't consider God as "the God of the Judeo-Christian tradition: he is not perfect or even omnipotent, is not involved in human affairs, and does not create the world ex nihilo."[319] Instead God directly "partakes in the polar process of creation" and "becomes a metaphor for nature's creative acts."[320] In order to create the world, the godhead (expansion) creates a polar opposite to himself—Lucifer (contraction), and together their dynamic interplay becomes "the pulse [*der eigentliche Puls*] of both life and creation."[321] Although God initiates the beginning of creation, he doesn't take part in it after the creation process and the opposites that are created fail to attract or repel each other. In his poem "Reunion" Goethe states that God creates "the red light of the dawn" to reunite light and dark as "a reconciliation of opposites" that causes "inanimate matter to attract and repel and organic matter to unite and separate."[322]

[317] Ibid., 14.
[318] Ibid., 17.
[319] Ibid., 20.
[320] Ibid.
[321] Ibid., 21.
[322] Ibid., 25.

2.1.3 Polarity and Intensification

Although polarity establishes a dynamic formula for Goethe's concept of metamorphosis, it alone is not sufficient to express the overall progressive interplay of forces and spatial diversification of organs produced along the stem of a plant. To regulate further change in the material expression of polarity, Goethe adds a secondary principle—intensification—as a non-material property attributed to matter. This unification of the two principles is mentioned in "A Commentary on the Aphoristic Essay 'Nature" published in 1828 where he shows a diversion from an early pantheistic view of nature that considers metamorphosis as formlessness.[323] Instead, polarity and intensification offer a quadruple core that acts as a structure for metamorphosis, and together they define

> two great driving forces in all nature: the concepts of *polarity* and *intensification*, the former a property of matter as we think of it as material, the latter insofar as we think of it as spiritual. Polarity is a state of constant attraction and repulsion, while intensification is a state of ever-striving ascent. Since, however, matter can never exist and act without spirit, nor spirit without matter, matter is also capable of undergoing intensification, and spirit cannot be denied its attraction and repulsion. Similarly, the capacity to think is given only to someone who has made sufficient divisions to bring about a union, and who has united sufficiently to seek further divisions.[324]

Goethe makes similar remarks in relating polarity to intensification in *Theory of Color*, on how the former polarizes the latter, and how the latter induces change in the

[323] Goethe, *Scientific studies*, 6.
[324] Ibid.

former. In his work on physics, colors are defined through the polar opposition of light and dark that yield to two primary colors yellow and blue and their intensified mixtures as green and red.[325] The concept of intensification is mainly introduced in the third didactic part on "Chemical Colors" where it is defined as an "inner pressure, a saturation, a darkening of the hue" that through "a difference of quantity produces a corresponding qualified impression on our senses" through gradual mixing of polarized colors.[326] Intensification relates to a quantitative change in polarity that invokes a qualitative expression on the senses and becomes the inner core of metamorphosis which drives the plant towards coloration. For instance, plants growing underground or in darkness have a tendency towards white coloration and delayed metamorphosis where "the stems between two joints are thus longer than they should be; no side stems are produced, and the metamorphosis of the plant does not take place."[327] In contrast, intensification occurs under light where "the leaves of the stem are only preparations and pre-significations of the instruments of florification and fructification" that exhibit a shift from green to red.[328] This dynamic interiority of organisms also manifests alternating phases of expansion and contraction that are individually expressed in the production of subsequent forms produced along the stem, as well as transcended to overall growth cycles. Thus, intensification appears to be polarized, producing two alternating phases of growth: the first, *vegetative growth*, happens through the "development through stem and leaves" in a succesive manner and produces lower tones of yellow, green and blue, while the second,

[325] Goethe, *Goethe's Color Theory*, 158. Under "General Introspective Veiws" Goethe states color "presents a contrast we call a polarity" and lists various terms in opposition such as yellow-blue, effect-deprivation, light-shadow, brightness-darkness, force-weakness, warmth-coldness, proximity-distance, repulsion-attraction, affinity with acids-affinity with alkalis.
[326] Ibid.,139-140. Goethe gives the example of colored blocks observed under water that attain darker hues with the gradual increase of opacity of the medium.
[327] Ibid., 151.
[328] Ibid., 151. Goethe relates intensification to growth under light.Under darkness the plant shoot gains opposite color (white, yellow) and produces expanded stems. Under light progression towards flowers and fruits are curtailed that produce darker hues from violet to red.

reproductive growth, is "completed in the formation of flower and fruit" that appears sudden and produces intensified colors orange, red and violet.[329] During growth, consistent supply of nourishment tends to dilute the quality of inner juices and delay or abandon intensification—transition to sexual reproduction. When nourishment is curtailed, the plant quickly rushes towards sexual reproduction due to the increased filtering of inner juices by the foliage leaves where an intensification takes place. In some cases, leaves are able to produce higher intensified colors that signal the anticipation of flower and fruit. When plants produce these organs, green color is replaced by proximal gradations of red that appear as darkened hues of primary colors. While polarity attaches a magnetic principle to matter, Goethe considers intensification as its spiritual component as a non-material drive. In "Allegorical, Symbolical, Mystical Application of Color" he introduces this dual state of existence as a divine manifestation.[330]

> When the distinction of yellow and blue is duly comprehended, and especially the intensification into red, by means of which the opposite qualities tend toward each other and become united into a third; then, certainly, an especially mysterious interpretation will suggest itself, since a spiritual meaning may be connected with these facts; and when we find the two separate principles producing green on the one hand and red in their intenser state, we can hardly refrain from thinking in the first case on the earthly, in the last on the heavenly, generation of the Elohim.[331]

The concept of intensification in Goethe's works has been a point of debate that is either considered a teleological drive or a link between subject-object duality that is

[329] Goethe, *Goethe's Botanical Writings*, 76.
[330] Ibid., 190.
[331] Ibid.

related through intuitive perception.[332] In *The Vegetative Soul*, Elaine Miller considers Goethe's concept of intensification to be "a continual process through a sequence of augmenting stages" that cause the "transformation of one shape or form into another such that the end form might not bear any traces of the beginning."[333] Intensification does not determine sexual division as a final end for growth, "Goethe's emphasis is never on the final point, but always on the process", where "fluctuation, an alternation, a rhythm, and the fact that one part metamorphoses out of another means that the two are intimately related as well as equal: one cannot take the other up into itself."[334] Trop considers intensification to be a form of sensory intuition, such as *Anschaaung*, where "the movements of attraction and repulsion—as a "meta-code" that governs the dynamic of observation itself—increase the complexity and indeterminacy of that which is observed and produce a state of permanent semiosis as a form of perceptual intensification."[335] He considers intensified observation to reveal the hidden polarities in the phenomenal world "by virtue of a higher-order polarity that manifests itself in the constitution of the gaze" that relates the object-polarities-expansion and subject-intensification-contraction.[336] Portman considers polarity and intensification a harmonical system for the archetypes that rely "upon sympathetic interpretations from earlier times, such as those underlying the images of the Great Chain of Being or the ancient symbolism of alchemy."[337]Apart from its role in the concept of metamorphosis and theory of color, Goethe's concept of intensification [*Steigerung*] is an active, flexible and dynamic principle that disregards any fixed ends or teleological implications. Tantillo describes this principle as

[332] For
[333] Elaine P. Miller, *The Vegetative Soul: From Philosophy of Nature to Subjectivity in the Feminine* (State University of New York Press, 2002), 60-1.
[334] Ibid., 69.
[335] Trop, "Poetry and Morphology," 390.
[336] Ibid., 392.
[337] Portman, "Goethe and the concept of metamorphosis," 144.

"specialization, augmentation, greater articulation of form, increased freedom of movement, darkened color, or heightened spiritual awareness."[338] The highest expression of intensification in plants leads to the polar division of forces in sexual organs that Goethe considers to be not just about reproduction but also as a yearning "for a former wholeness" representing "a reunion of intensified polar halves, alongside a reunion of their more symbolic characteristic."[339] Intensity makes forms partially transparent as it relates to the ripeness of fruits, change of seasons and smell of flowers. Tantillo interprets this unity as both material and spiritual while expressing an asexual origin of forces.

> This spiritual growing together or anastomosis, is important because it symbolizes the union of polar opposites of spirit and matter and the masculine and feminine, if only for the moment. The reunion of the masculine and the feminine represents the heightened creation that is an androgynous whole and is more significant than the androgynous whole of the seed, which is only a physical manifestation. This heightened reunion also bears two kinds of fruit: the physical one of progeny, and a spiritual one, which represents a wholeness, a completion of former division."[340]

Tantillo lists three main characteristics for the process of intensification that is never frozen in time but a constant ongoing process. Firstly, it gives the ability for parts and wholes to "strive for creativity outside of procreation" and "toward more complex manifestations."[341] Secondly, this creative process "combines the concerns of both matter and spirit."[342] Thirdly, Goethe sees end states as "changing, evolving, creating

[338] Tantillo, *The Will to Create*, 58.
[339] Ibid., 71.
[340] Ibid., 73-4.
[341] Ibid., 96.
[342] Ibid.

themselves anew."[343] Tantillo considers this process to be linear but "the hierarchy that it represents is not static" as "at each 'final' stage' something new may be created.[344] There is no antagonism among polarity and intensification in nature, instead they cooperate on all levels of existence to produce forms as well as to sustain them.

2.2 Polarity and Morphology

Besides his literary genius, Goethe wrote extensively on natural sciences and developed original ideas in botany, meteorology, geology, osteology and color that either still remain undisputed, or are not easily disregarded, making him a contemporary figure in his own right. Goethe's early formulation of the concept of metamorphosis marks the origin of his ideas structured around the concepts of polarity and intensification. Throughout his life, he applied similar concepts and methodology towards the study of other domains in natural sciences in an attempt to develop a cumulative theory of organic forms that are examined within the new science of morphology to offer a coherent and systematic body of work. Presenting a pluralist notion of organisms, morphology unites history of art, knowledge and science, and rests on the knowledge of other subsidiary sciences such as taxonomy that recognizes consistency among different specimens to study the relations of external characteristics and anatomy, focusing on the inner structure of forms. As a theoretical science, morphology shows a reevaluation and bridging of the historical debate between epigenesis and preformation that sought the origin of self-organization in nature, specifically to whether self-organization was a property external to matter given by a divine power or something inherent to it. Goethe sought to bridge

[343] Ibid.
[344] Ibid. Tantillo considers intensification as presenting a form of upward striving that is non-teleological. She also compares this to movement along a cyclic path that can be found in Hartmut R. Schonherr, *Einheit und Werden: Goethes Newton-Polemik als sysematische Konsequenz seiner Naturkonzeption* (Würzburg: Königshausen und Neumann, 1993).

this opposition by formulating a dynamic view of archetypes that not only showed formal consistencies among species as a "comparative" tool, but also allowed him to postulate metamorphosis as a "superlative" theory that brought different life forms together.[345] These archetypes, defined as "One ideal organism—at the most inclusive hierarchical level of the animal archetype—self-differencing into the multifarious species that populate the earth" were foundational in the development of the history of biology and offered stable ground to advance morphology.[346]

2.2.1 Polarity within the Ontogenetic Debate in Eighteenth Century: Preformation and Epigenesis

In the early beginnings of Enlightenment, there was a disagreement among scientists that yielded to two main views on the cause of generation for organisms. In her book *Matter, Life and Generation: Eighteenth-Century Embryology and the Haller-Wolff Debate*, Shirley Roe looks at the opposition between preformationists and epigenesists,in where the former suggested that the embryo "preexists in a miniature form in the egg or spermatozoon," while the latter believed that embryo was produced "through the gradual development from unorganized matter."[347] Among the two views, preformation was adopted by many biologists as it was the dominating theory that gave mechanical explanations to development in accordance to the widely accepted religious world view. A famous advocate of preformation theory was Albrecht von Haller (1708–1777) who

[345] Goethe, *Scientific studies*, 6.
[346] Mark Reigner, "Ancestor of the New Archetypal Biology: Goethe's dynamic typology as a model for contemporary evolutionary developmental biology", in *Studies in History and Philosophy of Biological and Biomedical Sciences* 44 (2013), 735–744.
[347] Shirley A. Roe, *Matter, Life and Generation: Eighteenth-Century Embryology and the Haller-Wolff Debate* (New York: Cambridge University Press, 1981), 1. Roe uses the historical debate to compare different views on the role of mechanism in biological explanation, spontaneous creation, regeneration, hybrids, monsters, god and his Creations. While epigenesis became the widely accepted explanation in the late 18th century through German scientists like Blumenbach, Kielmeyer, Döllinger, Oken, Pander, von Baer, preformation was the dominant theory with its accordance to religious belief in early 18th century.

was an early supporter of epigenesis until he changed his theoretical views. He maintained an extrinsic view of embryogenesis where "development occurs *by means of* forces matter" however, "he was reluctant to allow that these forces *alone* could be responsible for generation."[348] Haller's main conception of the preformation theory stated that "all essential structures of the embryo exist in the female egg," and irritability was granted to these elements by God "even though they cannot be seen."[349]

An opposite view to preformation was given by Caspar Friedrich Wolff (1733–1794) who developed two ideas on embryogenesis, "the ability of plant and animal fluids to solidify, and a force, which he named the *vis essentialis* [essential force]"[350] Wolff pointed out that there exists a "vegetation point" where the internal nourishment of plant guides the formation of various organs that appear as "modified leaves."[351] Roe states that although "new leaves could be found folded up in miniature inside older ones, had frequently been cited as a classic case of preformation" Wolff attributed such feature to epigenetic development relating *vis essentialis* to the solidifying inner nourishment of the plant.[352] With this connection there was "no need to assume the existence of preformed parts in the embryo; everything is formed gradually, through the secretion and solidification of fluids under the guidance of the essential force."[353] Wolff's later work on monsters advanced his views on variation, heredity, the relationship between the environment and form, and the nature of species and the source of embryonic organization. This work reinforced his epigenetic system where "the embryo's initial heterogeneity is of a potential nature, based only on physical factors like solidification

[348] Ibid., 31.
[349] Ibid., 41.
[350] Ibid., 48.
[351] Ibid. Roe states that Wolff's description of "vegetative point" shows similarities to Goethe formulation of *Urpflanze*, while both of them arrived to the same conclusion separately.
[352] Ibid.
[353] Ibid., 49.

and attraction and repulsion, which produce the structures of the organism through a gradual, but automatic, sequence of events."[354] After Kant's conception of *archetype* that considered natural forms as "variations of a limited number of ideal types," early versions of "the biogenetic law were developed by Kielmeyer, Oken, Meckel and others."[355] The biogenetic law stated that the development of an organism "requires an active mechanism that pushes previously adult features into progressively earlier stages of descendent ontogenies–that is, it requires a change of developmental timing."[356] This was confronted by the ideas of Caspar Friedrich Wolff who considered organisms "not as a gradual unfolding of preformed germs, but, in conformity visible in all of nature, as an actual production of something new."[357] He disagreed with preformationism and its teleological view of organisms, and considered a dynamic developmental process for nature. Reill also defined a polarity between the two concepts, where preformation as "the physiological embodiment of the great chain of being" provides a teleological purpose associated to it, while epigenesis "posited the existence of leaps in nature and cited the leap from inert to organic matter as a prime example."[358] However, the former had problems with explaining monstrosities, while the latter couldn't postulate "the source of its eventual organization", the "origin", as well as a "destination."[359]

Another version of epigenesis was introduced by Johann Friedrich Blumenbach (1752–1840) who developed a comprehensive theory of a vital force defined as *Bildungstrieb* [formative drive] that "was responsible for reproduction, nourishment,

[354] Ibid., 147. Roe states that Wolff's system does not start from "a state of absolute homogeneity" but instead presents an initial "simple heterogeneity" that gradually becomes more complex.
[355] Ibid., 153.
[356] Stephen J. Gould, *Ontogeny and Phylogeny* (Cambridge MA: Belknap Press of Harvard University Press, 1977), 3.
[357] Müller-Sievers, *Self-Generation*, 38.
[358] Hanns Peter Reill, "Bildung, Urtyp and Polarity: Goethe and Eighteenth-Century Physiology," in *Goethe Yearbook Volume 3*, (1986): 143.
[359] Ibid.

and restoration of parts" as modifications of the same principle.[360] This activity existed during the lifetime of organisms as "an independent vital agency" that organized "the architectonic articulations of living matter" and "directed the formation of anatomical structures and the operations of physiological processes of the organism so that various parts would come into existence and function interactively to achieve the ends of the species."[361] *Bildungstrieb* had both vitalist and teleological attributes and aimed at arriving at a synthesis of preformation and epigenesis, by seeking consistency of the former in a life force that existed inside matter and by considering a drive for the unorganized matter as a characteristic of the latter. This principle became highly attractive to Kant who included the concept in his *Critique of Judgment* and considered it "a self-maintaining purposiveness" and a "*principle* of an *original* organization" that Blumenbach defined as "*formative impulse*."[362] Huneman considered Kant's approach "a *moderate* epigeneticism rather than the *radical* epigeneticism" where the latter "implied spontaneous generation" which Kant "absolutely rejected."[363] Kant maintained that organisms had archetype [*Urbilde*] which "could only be understood by us as the crafted products of an intentional being" and mechanical forces alone fail to explain the purposiveness of nature, thus the source of organization had to be teleological.[364] Kant extended this mechanistic approach to evolution as the gradual biological development of animal forms and their continued transformation into the multitude of species but he denied a transition from inorganic to organic that radical epigeneticism advocated. He admitted that animal species, despite their variety, seemed to display common patterns or

[360] Richards, *The Romantic Conception of Life*, 219.
[361] Ibid., 220.
[362] Kant, *Critique of Teleological Judgement*, 205. Kant discusses Bildungstrieb under the "Methodology of the Teleological Judgment" in paragraph §81.
[363] Huneman, "Naturalising Purpose," 655. Huneman also states that the radical epigeneticism removed the epistemological boundary "*between organized and unorganized beings*; and the *boundary between species"* that supported spontaneous generation.
[364] Richards, *Romantic Conception of Life*, 233.

archetypes. In this respect, we could imagine a mechanical transformation of an archetypical pattern that would produce various species which could explain the natural phenomena. In contrast, Blumenbach's loose principle was conceived as teleologically equal to the mechanical principles that drove organization. Richards states that although Kant "found Blumenbach's principle of the *Bildungstrieb* so attractive" he misinterpreted it, by stating that "ultimately only organized matter could causally produce organized matter."[365] However Blumenbach's goal was to identify "the origin of organization in the first place."[366]

In *The Strategy of Life*, Timothy Lenoir revisits the historical development of natural sciences in nineteenth century German biology that aimed at uniting all natural sciences, under a teleo-mechanistic program called "vital materialism" which "assume in some form or other the existence of an agent which actively selects and arranges matter in the organism" that "may be a rational soul" existing "separately from matter and that organism is in a healthy, functional state so long as the vital agent remains in control."[367] In the first chapter of his book, Lenoir revisits the theoretical arguments of Blumenbach's *Bildungstrieb* that presents two main features. The first property of this principle is that it acts as a "teleological agent" that "did not exist apart from its material constituents, but it could not be explained in terms of those elements" or reduced to parts while it had to be conceived as an "emergent property" of the whole generative fluid.[368] The second property is functional adaptation that gave "the organism an ability to make slight modifications in its structure in order to adapt to its environment" under "the law of

[365] Ibid.
[366] Ibid., 235.
[367] Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth Century German Biology* (Chicago: University of Chicago Press, 1982), 9.
[368] Ibid., 21.

homogeneity, a correlative variation in other parts of the organism" that was triggered by the environment and nutrition.[369] According to Kant, this principle satisfied the regulative principle to investigate mechanical causes for generation in organic realm, but "the teleological explanations demanded by biology require an active, productive principle which transcends any form of causal (natural-physical) explanation available to human reason."[370] Lenoir states that "Romantic theories, their employment of concepts such as polarity, unity, metamorphosis, and ideal types, as well as the structure of the system of nature constructed from them, were determined by their stand with respect to this Kantian problem and its solution" that set limits for the investigation of organization in organisms.[371] An example of these theories was found in the work of Johann Christian Reil (1759–1813) who considered a causal link between the inorganic and organic realm through the concept of *Lebenskraft* that pointed towards the "pre-existence of some already organized body which transmutes the affinities of the inorganic realm to those more complex affinities characteristic of the organic realm."[372] The theoretical developments of vital materialism gave way to a teleomechanistic program, formulating a "developmental morphology" that aimed at investigating "special internal biological laws governing morphogeneis," and "improving the criteria for specifying the morphotype."[373] Therein, the goal was to find homologous structures and common organizations among organisms.

Kant's support of Blumenbach's *Bildungstrieb* in *Critique of Judgment* had great influence among *Naturphilosophen*. Goethe also commented on the theory in a short

[369] Ibid., 22.
[370] Ibid., 26.
[371] Ibid., 27.
[372] Ibid., 36.
[373] Ibid., 54.

fragment titled “Formative Impulse” where he revisited ideas on epigenesis to give insight on his position within the ontogenetic debate.[374] In his essay he reviews Caspar Friedrich Wolff’s essential force [*vis essentialis*] that is defined as “a force adapted to all that was generated” and “nourished every being destined for life as an organism.”[375] However Goethe finds such force to be incongruent with the “material quality about such an organic substance” since “force means something purely physical, even mechanical” that poses an obscure and insoluable problem. He states that Blumenbach is able to solve this dilemma by antropomorhizing the concept and calling it “a *nisus formativus*, an impulse, a surge of action which was supposed to cause the formation.”[376] Following this idea Goethe considers the formative impulse to be equivalent or omnipresent within the material character of the organism, as “the two forever present at one and the same time.” In considering the material quality of formation in organisms Goethe considers a middle path that can connect preformation and epigenesis.

> If we now return to philosophy and reconsider evolution and epigenesis, they will strike us as terms which only avoid the issue. Admittedly, the theory of encasement quickly becomes unacceptable to the well-educated. Nonetheless, any theory of accommodation and adaptation will have to presuppose something which adapts and something to which it adapts; if we want to avoid the concept of preformation we will arrive at a concept of predelineation, predetermination,

[374] Goethe, *Scientific Studies*, 35.
[375] Ibid.
[376] Ibid.

> prestabilization, or whatever we wish to call the process which would have to occur before we could perceive a thing.[377]

Rather than resorting to either side of the ontogenetic debate Goethe suggests that "when an organism manifests itself we cannot grasp the unity and freedom of its formative impulse without the concept of metamorphosis."[378] Reill states that while Goethe likened Blumenbach's *Bildungstrieb* which considered a teleological drive for formation, he considered this drive to be anchored to "the polarities of matter and form; between them Goethe discerned a continuum of elements linking the two extremes."[379] But this model still failed to explain an origin and a continuous goal for the production of form. Thus, he used the concept of metamorphosis and amalgamated some aspects of preformation to incorporate a "physiological concept, that of inherent idea or prototype."[380] Metamorphosis became the variation of this physiological prototype using polar forces of expansion and contraction.

Richards considers Goethe's position within the debate to be a form of consolidation where "his theory could show the merits of and thereby subsume both points of view" since "organic development had to be governed by an unchanging law or power that was realized in empirically variable phenomena."[381] Tantillo draws a similar conclusion focusing on Goethe's work on plants that combines "emphasis on the form of the leaf would place him on the side of the preformationists, while his emphasis on the metamorphosis of form would place him among the epigenesists."[382] As a unifying concept, metamorphosis offers a synthesis of epigenesis and preformation by considering

[377] Ibid., 36.
[378] Ibid.
[379] Reill, "Bildung, Urtyp and Polarity," 144.
[380] Ibid.
[381] Richards, *The Romantic Conception of Life*, 416.
[382] Tantillo, *The Will to Create*, 77.

the latter as not predetermining development from the beginning but acting as a stabilizing principle throughout growth working within the concept of metamorphosis.

2.2.2 Urpflanze: Polarity and Botany

From 1786 to 1788 Goethe went on a trip to Italy to experience the landscape, people and art while carrying the works of "Linnaeus with (him) and his terminology firmly stamped on (his) mind."[383] He was seeking physical evidence for his hypothesis "to derive all plant forms from one original plant" that would enable him to define the species and genera exactly.[384] Goethe came closer to formulating this idea in Silicy during his visit at the Botanical Gardens in Palermo, where he was able to recognize a whole series of transformations from which plant leaves acquired their complex form. All plants appeared to him as a transformation of the same underlying model. This allowed him to conceptualize an archetypal plant [*Urpflanze*] which could be the progenitor of all plant forms. In a diary entry from the *Italian Journey* in April 17, 1787 he wrote:

> Here, where instead of being grown in pots under glass as they are with us, plants are allowed to grow freely in the open fresh air and fulfill their natural destiny, they become more intelligible. Seeing such a variety of new and renewed forms, my old fancy suddenly came back to mind: Among this multitude might I not discover the Primal Plant? There certainly must be one. Otherwise how could I recognize that this or that form was a plant if all were not built on the same model?[385]

[383] Goethe, *Italian Journey*, 33.
[384] Ibid., 71.
[385] Ibid., 258-9.

Goethe's formulation and description of the archetypal plant [*Urpflanze*] has been a point of scholarly debate that found theoretical explanations mostly rooted in phenomenology. In an essay titled "Form and Cause in Goethe's Morphology", Ronald H. Brady discusses the archetype as "an important advance in the phenomenology of organic form."[386] While Goethe "did not produce a schema for his *leaf*, nor did he trace the identity of the organs mentioned by means of position and composition," the archetype shows a lack of homology to other plant organs.[387] Since the leaf itself doesn't present any fixity in a physical manifestation Brady considers it to be a vague organ, hence a formless, non-topological entity.

> But if this is homology, it is neither 'special' nor 'general' homology, for it makes no use of their criteria. Goethe's common organ, or *leaf*: is not a simplification of foliar members. All empirical forms are, for him, equally particularized, and his general organ can be general only by lacking such particularity. His *leaf* accomplishes this requirement *by having no form at all*.[388]

To find the presence of the archetype among its manifestations, Brady uses a sequence of Buttercup leaves to trace the continuous movement along the form and pattern transformations of a single leaf, where any missing particulars among the series could be added, if necessary (Fig.2.2.1.1). This way, phenomenology is directed towards the study of the archetype within the overall transformation observed in a temporal sequence of forms that enables the observer to imagine missing gaps by looking at the progression among neighboring parts of the plant.

[386] Brady, "Form and Cause in Goethe's Morphology," 257.
[387] Ibid., 271.
[388] Ibid., 272.

Thus the movement is not itself a product of the forms from which it is detected, but rather the unity of those forms, from which unity any form belonging to the series can be generated. Individual forms are in this sense 'governed' by the movement of the series in which they are found–their shape and position in that series are both functions of the overall transformation.[389]

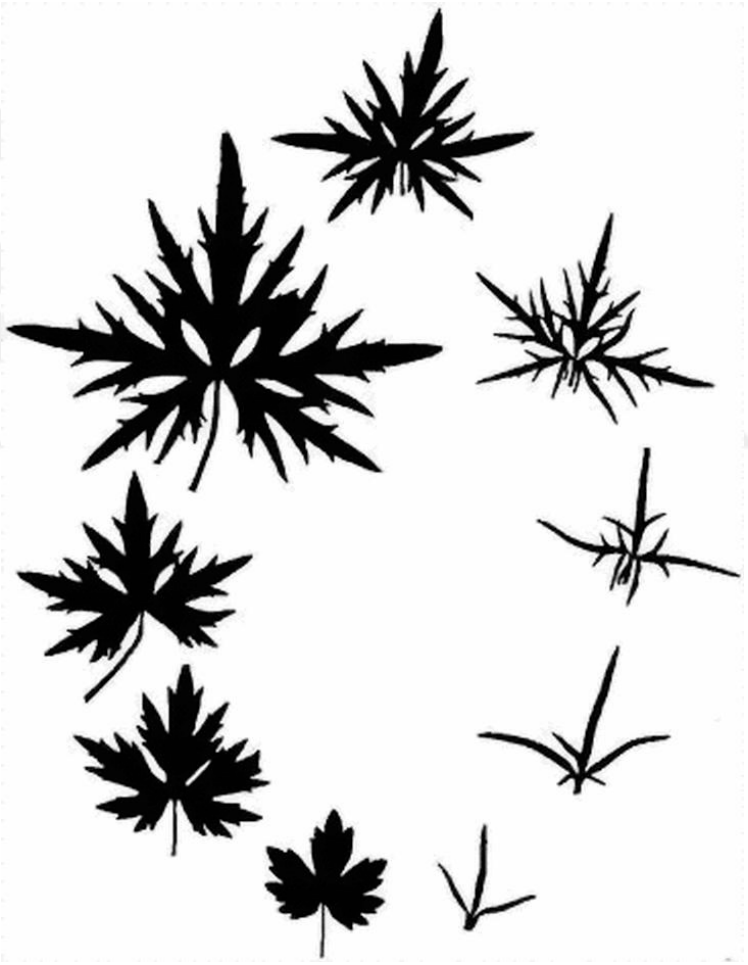

Figure 2.2.2.1 – Ronald Brady's Buttercup leaf sequence (Reprinted from Ronald H. Brady, "The idea in nature: rereading Goethe's organics," in *Goethe's Way of Science: A Phenomenology of Nature* (1998), 94).

[389] Ibid., 279.

As long as there is observable movement among the physical manifestations in a formal series, "the Type, as Goethe explained, designates potential rather than actual forms."[390] For Brady, the archetype remains more of a potential than an actual, by lacking any particularity or fixity in time, the identity of the archetype "remains obscure," as "the only explanatory principle that remains" is "change," while there is "no space for the question of law."[391] Goethe "attempts to reconcile the notions of the static and the dynamic" in *Urpflanze* as "a morphological concept, a generalized form, a model or pattern" that can be "found by comparison of empirical objects one another, and it embraces both their similarity and their variations."[392] Although "it includes the idea of change," it's not a "phylogenetic concept" that considers "change as linear progress or evolution in history."[393]

In *Wholeness of Nature*, Henri Bortoft reviews Goethe's scientific works and methodology to designate him "as a *phenomenologist* of nature" since his work developed "the kind of theory which attempted to explain phenomenon by some kind of hidden mechanism."[394] In reviewing Goethe's work on metamorphosis in botany, Bortoft warns against drawing a material-physiological link between different organs of a plant through the concept of *Urpflanze*; instead he states that "the *urorgan* is neither internally subjective (a mental abstraction) nor externally objective (a primitive organ)."[395] Similar to Brady, he considers this to be a conceptual construct, "as an omnipotential form and

[390] Ibid., 298.
[391] Ibid.
[392] Henel, "Type and Proto-Phenomenon in Goethe's Science," 654.
[393] Ibid.
[394] Henri Bortoft, *The Wholeness of Nature: Goethe's way of science* (Edinburgh: Floris Books, 1996), 21.
[395] Ibid., 79.

not as a particular physical leaf" that is only perceivable with a holistic-synthetic mode of consciousness when the plant is seen as whole.[396]

The phenomenological formulation of the archetype, postulated by Brady, has been reviewed by the evolutionary biologist Gerry Webster who described Goethe's "perceptual-aesthetic synthesis in which a set of forms, for example, the sequence of leaves along the axis of a plant, is grasped intuitively as an 'animated totality'."[397] Webster finds two problems with the phenomenological formulation of metamorphosis, particularly described by Brady. Firstly, "one mature leaf does not actually produce, or change into, the next in series; the 'generative relation' or 'dynamic' is purely epistemic"; and secondly, "temporal order plays no significant or essential part in our experience of the set of leaves as a transformation series" since the sequence of complete leaves are arranged on a space after growth is terminated.[398] For Webster, the unification of descriptive methods and experience embededed in "Goethean phenomenology seems applicable only to continuously varying forms; that is a series of forms must be such that a continuous, uninterrupted 'movement' can be experienced" and ignores discontinuous variation advocated by Bateson.[399] Thus, phenomenology only considers the archetype to be observable in continuous metamorphosis that reveals relations among sequential forms, but not the metamorphosis among multiple organs that happen discontinuously, such as the formation of fruit and flower.

Another view of the archetype is presented by Pfau who distinguishes the phenomenological engagement with the archetype as not a mere "seeing" but as an

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[396] Ibid., 80.
[397] Garry Webster and Brian C. Goodwin, *Form and Transformation: Generative and Relational Principles in Biology* (New York: Cambridge University Press, 1996), 110.
[398] Ibid., 112.
[399] Ibid., 115. Webster here refers to Bateson's Materials for the Study of Variation (1894) that draws a distinction between "meristic" and "substantive" variation among forms.

"event" of seeing where the construction of "the archetypal plant is neither an abstraction from the empirical processes of plant development nor a hypothesis ventured prior to the actual observation of organic growth."[400] This phenomenological "event" is essentially "a radically deductive and inductive process", going through an analysis-synthesis cycle, where the appearances of "the differential form of a plant points to its archetype or, rather, makes that archetype (Urbild, Urpflanze) more than the 'idea'" of itself.[401] Thus, metamorphosis becomes the "law of appearance" as the plant undergoes a "process of continuous internal differentiation" to realize "its substantial identity."[402] Pfau states that this identity could not be directly revealed, instead the archetype produces a "particular formal mode of appearance" as it "can only appear in some concrete guise or *Gestalt*."[403]

In *The Natural Philosophy of Plant Form*, botanist Agnes Arber revisits Goethean concepts on types and metamorphosis to develop a partial-shoot theory of the leaf akin to *Urpflanze* to aid the study of plant morphology.[404] She considers Goethe's formulation of the type as prototypical, *Urpflanze* is the "common idea [*Begriff*]" or "a concept, from which the concepts of existing plant forms could be derived mentally; it carried no phylogenetic implications, and did not to him any notion of an ancestral stock."[405] She considers the archetypal plant to be more virtual than actual, "as a supersensible conception" that might lead someone "into the error of thinking about it pictorially, while believing oneself to be approaching it abstractly."[406] In this regard, any typological approach to reduce *Urpflanze* to certain physical manifestations becomes erroneous. For instance, she considers the early attempts to capture the archetype through pictorial

[400] Pfau, "All is Leaf," 24.
[401] Ibid., 35.
[402] Ibid., 30.
[403] Ibid., 39.
[404] Agnes Arber, *The Natural Philosophy of Plant Form* (Cambridge : Cambridge university press, 1950).
[405] Ibid., 59.
[406] Ibid., 61.

depictions, like Turpin's archetypal drawings as "a botanist's nightmare, in which features, which could not possibly coexist, are forced into the crudest juxtaposition" (Fig.2.2.2.2).[407] Instead, the concept remains as an idea, "which in his mind had a timeless quality, was thus transferred to some specific period of the past, as the Ancestral Plant; and it was imaged as something which would have been visible and tangible, if mankind had been there to see and handle."[408] Arber draws a parallel between the partial-shoot theory and Goethe's conceptual approach and states that the leaf has similar characteristics to a generic phyllome from which all organs develop. She doesn't consider this concept to denote a predetermined productive capacity or sequence of products for plants, considering flowers to be a modification of foliage leaves or existing prior to reproduction. Instead, she considers the concept of metamorphosis to associate separate organs "in both directions" where it is "legitimate to call a foliage-leaf an expanded sepal, as to call a sepal a contracted foliage-leaf; this reversibility obviously precludes the idea of historic derivation."[409]

> The metamorphosis theory, as Goethe himself understood it, thus means that the generally recognized relationship between the different appendicular members arises out of the fact that they are all manifestations of one type-phyllome, non-historic in character. This idea has a number of obvious advantages as a working hypothesis; but the question remains whether it is to be received as an ultimate dictum, or whether, in present-day thought, some further and more satisfying generalization can be developed out of it.[410]

[407] Ibid., 62.
[408] Ibid., 63.
[409] Ibid., 68.
[410] Ibid., 68-9.

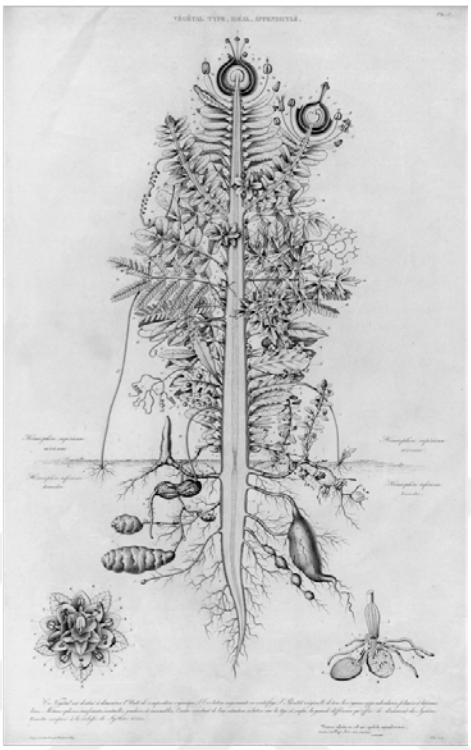

Figure 2.2.2.2 – The plant archetype by P.J.F. Turpin appeared in an 1837 edition of Goethe's works on Natural History published in France (Johann Wolfgang von Goethe, *Oeuvres d'Histoire Naturelle de Goethe*, translated and annotated by C.F. Martins (Paris: A.B. Cherbuliez, 1837). Image courtesy of the Houghton Library of Harvard University).

Goethe sought this generalization to the archetype through the concept of polarity that is provided in supplementary essays to his botanical writings. In an early draft of the metamorphosis essay titled "Organic Duality" Goethe draws similar remarks to Schelling on establishing a dualist core for nature, but ascribes this duality to the inner structure of the archetype [*Urpflanze*] that not only transforms it to produce various plant organs, but also becomes the internal drive of nature that produce new and perfected forms.

> These ideal archetypal bodies, even though we may picture them in our minds as simply as possible, we must nevertheless imagine as disunited in their interiors,

> for no third developing body can be imagined without previous division of the original body.
>
> These ideal archetypal bodies, which already have an inherent tendency towards duality, we shall allow to rest for the present in the womb of Nature.
>
> We shall only remark here that the atomistic and dynamic concepts are opposed at the very outset to developmental and formational procedures.[411]

This dual structure of the archetype presents antagonistic relationships and expressions for various plant organs such as the root and the leaf, that are "by origin opposed to each other" where the former "require moisture and darkness to develop" and the latter "light and aridity" that become polar influences of the environment for a plant.[412] Under these external forces, the plant can either produce simple forms, in the case of the root, that appears "merely a combination without diversity", or complex forms achieved by the metamorphosis of the "leaf embryo" that "develops most diversely, and step by step approaches perfection."[413] Thus, the duality of forces manifest themselves in the expression of forms, that either "foster elaboration" in the case of expansion, or "retard it" as in contraction until "we reach the climax of organic duality in the division of two sexes."[414] This diametric opposition is also present among subsequent organs produced in an ascending order that have alternating relations to each other as these forms take on expansive or contractive expressions until their differentiation into the sexual reproductive organs of the flower.

[411] Goethe, *Goethe's Botanical Writings*, 94.
[412] Ibid., 95.
[413] Ibid.
[414] Ibid., 95-96.

Before the conception of his work on plant metamorphosis Goethe believed that "a law governing the structures of all plants had to exist, for otherwise we could not recognize something *as* a plant—a quasi-Platonic principle that carried enormous weight with him."[415] Richards considers the archetpye as a "transcendental leaf" which is already present in the seed before the development of the plant occurs.[416] This "idea" connects all plant organs that display a similar physiology back to an underlying generative origin–"not as a static form" but as "a Proteus" that could not only relate different plant organs to each other, but also explain how it "would give rise to endless varieties of plants."[417] However, Richards states that before considering this unifying principle, Goethe "only adopted a common word, "leaf" [*Blatt*] to designate the organ that metamorphosed into the variety of forms assumed by different parts of the plant."[418] Thus, Richards doesn't consider any archetypal significance for the physiology of the leaf, and states that Goethe understood the *Urpflanze* "symbolically" that "represented a unitary dynamic force beneath the multiple transformations to which it gave rise."[419] Richards speculates two main reasons behind choosing the leaf as a symbolic element. Firstly, each plant organ goes through an epigenetic development through "leaflike transformations"; secondly, the leaf offers a "veined structure" that shows a "comparable network of veins in the sexual organs of plants."[420] It is through these veins that the transportation of varied juices and the alternating forces of expansion and contraction cause metamorphosis and produce all individual plant organs. Furthermore, Goethe's view on evolution shows that "individual organisms are composed, as it were, of other

[415] Richards, *The Romantic Conception of Life*, 416.
[416] Ibid.
[417] Ibid.
[418] Ibid., 418.
[419] Ibid., 396.
[420] Ibid.

individuals" which presents a theory of subordination as organisms move towards more complexity and perfection.[421] In a flowering plant "subdivided leaves represent a striving to become nearer complete" as "each leaf tried to become a branch" while "comparable reduction" could occur "in the individual members of a compound leaf" producing a reciprocal relationship among parts.[422] This transformation in plant parts followed an "internal economy" where "the blueprint, basic model, or type determines the range of variations and the range of coordination between the different organs and their shapes."[423] This way various sequential organs of the plant could also be labeled as transformed reproductions of their antecedent and subsequent neighbors as they are related by polar forces in affinity. At the end of *Metamorphosis of Plants*, Goethe explains why he chose "the leaf" as a motivic template for the expression of polarity in plant forms.

> It is self-evident that we ought to have a general term with which to designate this diversely metamorphosed organ and with which to compare all manifestations of its form. At present we must be content to train ourselves to bring these manifestations into relationship in opposing directions, backward and forward. For we might equally as well say that a stamen is a contracted petal, as that a petal is a stamen in a state of expansion; or that a sepal is a contracted stem leaf approaching a certain stage of development, as that a stem leaf is a sepal expanded by the influx of cruder saps.[424]

[421] Ibid., 477.
[422] Vera L. Ryder, "On the Morphology of Leaves," *Botanical Review*, Vol. 20, No. 4 (Apr., 1954): 267.
[423] Dorothea von Mücke, "Goethe's Metamorphosis: Changing Forms in Nature, the Life Sciences, and Authorship," *Representations*, 95, No. 1 (2006): 36.
[424] Goethe, *Goethe's Botanical Writings*, 77 (Paragraph 120).

Since the transcendental and phenomenological formulation of the archetype fails to physiologically anchor the alternating forces of expansion and contraction and how this manifests metamorphosis on matter, it is possible to attribute polarity as both actual and virtual in the construction of the archetype. Tantillo considers this central role of polarity among Goethe's botanical works where metamorphosis "indicates a shift away from focusing upon a static form and toward a malleable one" where the concept transforms the raw, undeveloped juices into specialized organs.[425] For Tantillo the leaf doesn't anticipate "the existence of one archetypal form for the plant, but for an archetypal organ" that has the "ability to change and transform through the process of intensification."[426] While Goethe tries to combine static formal constructions with dynamic nature, Tantillo doesn't consider the archetype to carry any physiological attribute for the expression of polarity and instead "the leaf becomes an example of fluidity of nature in general as well as of one organ in particular" thus extending the topology of the leaf towards formlessness.[427] Bloch also drew a similar idealist formulation where the archetype is not "an element of geometric or static character" or "a fixed relationship within a specific organ;" on the contrary, it's "an "idea" of nature, a symbol of her innermost principle of permanence in the midst of change" that is "seen morphologically, of ever changing forms in time."[428]

2.2.3 Zwischenkiefer: Polarity and Osteology

Goethe's early work on morphology starts with osteology, particularly investigating common structural elements for all animal forms and developing a vertebral origin for the

[425] Tantillo, *The Will to Create*, 66.
[426] Ibid.
[427] Ibid., 67.
[428] Robert Bloch, "Goethe, Idealistic Morphology, and Science," in *American Scientist*, Vol. 40, No. 2 (April, 1952): 316.

skull while attending Justus Ferdinand Christian Loder's (1753 –1832) lectures on anatomy in 1781 at the University of Jena. In 1784, he worked on the intermaxillary bone [*Zwischenkiefer*] to investigate whether human beings possess this bone like all other animals in order to establish a common developmental pattern among vertebrates. During that period contemporary authorities like Camper, Sömmerring and Blumenbach "denied the existence of a *Zwischenkiefer* in human beings" considering "this bone as a natural sign of man's radical separation from the animals."[429] When Goethe continued his research with animal skulls which he borrowed from Sömmerring, he eventually "found the presence of the bone in human embryo and believed he could trace its faint residue in an adult skull" (Fig.2.2.3.1).[430]

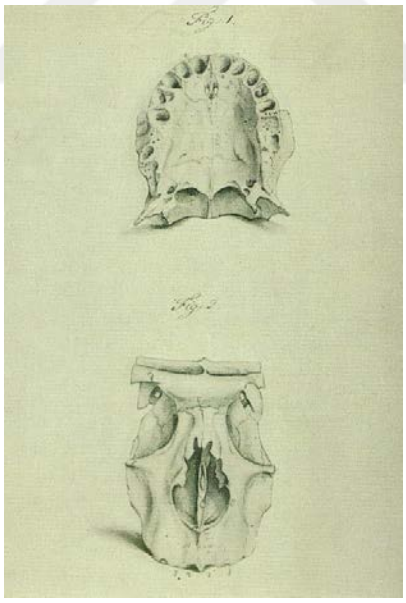

Figure 2.2.3.1 – The intermaxillary bone in man, from Goethe's essay in 1784 "Dem Menschen wie den Tieren ist ein Zwischenknochen der odem Kinnlade zuzuschreiben" [An Intermaxillary Bone is Present in the Upper Jaw of Man as well as in Animals] (Reprinted from *Scientific Studies,* Color Plate II).

[429] Richards, *The Romantic Conception of Life*, 368–370. Goethe's findings influenced his friend Herder's work in finding a uniform structure and a principal form [*Hauptform*] evident in living creatures on earth. Although Herder did not give credit to Goethe in his works, Goethe was later able to publish his findings on the subject in 1820 in *Zur Morphologie*.
[430] Ibid., 369.

Goethe was particularly "impressed by the underlying similarity between all vertebrates, and did not explain it by alleging that they have common ancestors, but rather supposed that nature used a single archetype in constructing them, and that the task of the biologist is, from comparison of a large number of animal forms, to form a clear idea of this archetype."[431] Proving the existence of this bone in man had both morphological and teleological consequences.

When Goethe wrote "An Intermaxillary Bone Is Present in the Upper Jaw of Man As Well As in Animals" in 1786, he argued for the presence of this bone in man by comparing the upper jaw bones from skulls of a horse, walrus, ox, fox, lion and ape that show the intermaxillary bone is "inserted between the two main bones of the upper jaw" and "is made up of two bones which meet in the middle of the face."[432] For instance, in walrus this bone is inserted into the upper jaw, similar to man, but it is not fused with the upper jawbone. In his illustration Goethe used "an upper jaw from a broken human skull" with "two front teeth missing" that "makes it possible to see the *os intermaxillare* without obstruction."[433] The comparison of this illustration to the lion and ape bones proves that "this bone is present in man as well as in animal," however, "only some of its edges can be located because the others have grown together and fused with the upper jaw."[434] Goethe further added that the bone "is reduced in man to a very small size" because "the growing teeth exert such pressure on these parts … that the full force of nature is required

[431] George A. Wells, "Goethe and the Intermaxillary Bone," in *The British Journal for the History of Science*, Vol. 3, No. 4 (Dec., 1967): 357. Wells discusses a similarity between Aristotle's law of compensation, and Goethe's consideration of polarity between horns and teeth in the skull. This view presented Goethe's opposition to a teleological cause for the shaping of the archetype that produced only functional structures.
[432] Goethe, *Scientific studies*, 111.
[433] Ibid., 114.
[434] Ibid., 115.

to weave these bones together."[435] In animal skulls the opposite is the case, where the size of the bone is related to the expansion of the incisor teeth that "are shifted quite far forward, thus putting less pressure on each other or on the canine tooth" where "this bone is partially or completely fused" that allows a "step-by-step comparison of many animals to progress from the simples to the most complex."[436] By comparing all the animal skulls, he aimed to describe all parts of the skull found among tetrapods since "human being cannot serve as the archetype for the animal, nor the animal for the human being."[437] In his assessment regarding the origin of the bone, Goethe followed a developmental approach to the problem rather than agreeing with the teleological assumptions of his contemporaries that denied the existence of this bone in man and therefore gave man a higher position in the animal realm.

Goethe was not the only scientist to discover the intermaxillary bone at the end of eighteenth century. "Prior to him, Coiter (1573), Broussonet (1779) and finally Vicq d'Azyr (1780) observed and/or described this structure in the human."[438] The intermaxillary bone played a major role in Goethe's theories on morphology. "After he had returned from Italy, with a flush of enthusiasm, he began outlining a theory of the *Urtypus* of the vertebrate skeleton," later developing a "vertebral composition of the skull."[439] However, he did not publish his findings until the collection of his morphological works from 1817 to 1820. This caused a dispute with Lorenz Oken (1779–1851) who also discovered and published his findings in 1807. In "Skullduggery: Goethe and Oken, Natural Philosophy and Freedom of the Press" Müller-Sievers revisited this

[435] Ibid.
[436] Ibid.
[437] Ibid.,124.
[438] Klaus J. Barteczko and Monika Jacob, "A re-evaluation of the premaxillary bone in humans," in *Anatomical Embryology* 207 (2004): 434.
[439] Richards, *The Romantic Conception of Life*, 421.

controversy by drawing a contrast between the two; "while Goethe extends the model of literary authorship to the realm of sciences," he "always withholds something in publication" in order to preserve his individual ideas; in contrast, Oken aims to build a forum among scientists and publish everything to discuss the discoveries of his time where "the relation of scientific discovery to discoverer, the claim to scientific universality and individual timeliness, is linked … to the time of publication."[440] Apart from the differences among them in terms of scientific authorship, both Goethe and Oken arrived at similar morphological conclusions regarding the intermaxillary bone. With the discovery of this bone "diachronicity between the species" was complete leading to a vertebral theory of the skull that "would introduce correspondences and repetitions into the skeletal structure itself" where the skull "was composed of metamorphosed vertebrae" thus integrating it to the "totality of the skeleton."[441] Although Goethe felt "misunderstood and neglected by the scientific community," his findings became central to his research on morphology.[442]

Goethe aimed at extending the identification of all bones in the animal skeletal system to derive an archetypal construct for comparative studies. However, he did not consider this archetype to be reductive, becoming a mere listing of bones as in the case of typology; instead, he aimed at extending his concept of metamorphosis towards bones to develop polarized relationships among parts. Goethe arrived at reformulating the skull through polarity after his publication of the intermaxillary essay. In "Significant Help

[440] Helmut Müller-Sievers, "Skullduggery: Goethe and Oken, Natural Philosophy and Freedom of the Press," in *Modern Language Quarterly*, 59, No.2, (1998): 249. Müller-Sievers compares Goethe's efforts to define hermeneutic standards for individual works in science and literary authorship to Oken's resistance to such hermeneutics and censorship while he struggles to publish his works extensively in his publication *Isis*. While Goethe tries to establish the importance of individual accomplishments, Oken tries to build a forum to publish extensively causing a debate for the authorship of Intermaxillary bone. Also see Richards, *The Romantic Conception of Life*, 497-8. Richards showed that Goethe had made such discovery earlier than Oken as can be seen in his personal letter. However, Oken independently arrived to the same conclusion much later.
[441] Ibid., 240.
[442] Ibid., 250.

Given by an Ingenious Turn of Phrase," Goethe describes how he discovered a polar relationship among the posterior and anterior parts of a skull through an evidence of metamorphosis akin to his work on plants.[443]

> This is also true of my concept that the skull is composed of vertebral bones. I had early recognized the three posterior bones. But it was not until 1790 that I picked up a broken sheep's skull from the dunelike sands of the Jewish cemetery in Venice, and saw right away that the facial bones could also be traced back to vertebrae, for the transition was clear from the anterior sphenoid bone to the ethmoid bone and the nasal conchae.[444]

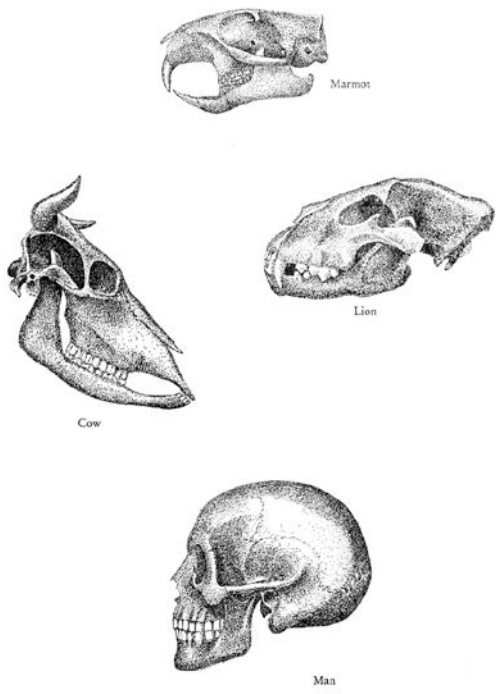

Figure 2.2.3.2 – Skulls of various animals showing polarity between the skull and jaw (Reprinted from Schad, *Man and Mammals*, 35).

[443] Goethe, *Scientific studies*, 39.
[444] Ibid., 40.

Recent investigation on the intermaxillary bone confirms Goethe's discovery where "premaxilla acts as a stabilizing element within the facial skeleton comparable with a keystone in a Roman arch" where "the formation of the human face is characterized by the simultaneous extension of the head and the outgrowth of the facial skull."[445] In *Man and Mammals*, Wolfgang Schad extends this polarized relationship and growth among the anterior and posterior parts of the skulls towards a threefold classification of animals that demonstrates polarized skull formations among three groups: rodents, carnivores and ungulates.[446] Schad relates the dietary and habitual activities of vertebrates to have an effect on their morphology, particularly on their skulls and teeth formations (Fig.2.2.3.2). The teeth are categorized in three groups: incisors, canines and molars; where "in the anterior part, the conscious nerve-sense pole is predominant; in the rhythmic chewing and tasting, the middle system prevails; in the unconscious throat area, the metabolic system predominates."[447] In rodents, such as mice, rats, hamsters, there is "highly specialized development of the anterior incisors" while "canines are lacking" and there are "very few molars"[448] In carnivores, such as lions, fur seals, the "canines are predominant" while "incisors are rather small" and molars "take on some of the characteristics of the canines."[449] On the other hand, in ungulates such as "horses, rhinoceroses, pigs, hippopotami, camels, giraffes, deer, sheep, and cattle," "molars are particularly well developed" "nerve-sense and rhythmic systems are so completely dominated by the forces of digestion that the cow's upper jaw has no incisors

[445] Barteczko and Jacob, "A re-evaluation of the premaxillary bone in humans," 435.
[446] Wolfgang Schad, *Man and Mammals: Toward a Biology of Form* (Garden City, NY: Waldorf Press, 1977), 33.
[447] Ibid., 33.
[448] Ibid.
[449] Ibid., 34.

or canines at all!"[450] Schad relates each animal group to a particular polarity group associated to the dominant teeth in the jaw, rodents with incisors, carnivores with canines, and ungulates with molars. In revisiting Schad's threefold classification, Riegner draws conclusions on polarity; compared to the human teeth that are "relatively unspecialized" the three animal groups show that "rodents are polar to ungulates, with carnivores occupying an intermediate position."[451]

Goethe's work anatomy and osteology was not limited to the skull of animals but aimed at developing a cumulative understanding of the animal archetype that can be compared through polar relationships of forms. Reigner states that establishing these archetypes offers a dynamic typological view connecting similar organisms where "these discoveries of profound relatedness among markedly diverse animals are consistent with the notion of the *One ideal organism*—at the most inclusive hierarchical level of the animal archetype—self-differencing into the multifarious species that populate the earth."[452]

In *Goethe as a Scientist*, Rudolf Magnus gives a comprehensive review of Goethe's scientific works focusing on botany, osteology, color, geology, mineralogy and meteorology.[453] With his further studies on osteology in 1790, Goethe thought that the skull was the continuation of the spine in the form of a transformed vertebra "under the influence of powerfully developed sense organs of sight, hearing and smell."[454] He considered the vertebra an osteological building block that underwent metamorphosis during the development of an organism. However, there was great "difficulty in

[450] Ibid.
[451] Riegner, "Horns, Hooves, Spots, and Stripes," : Form and Pattern in Mammals," in *Goethe's Way of Science: A Phenomenology of Nature*, edited by David Seamon and Arthur Zajonc (Albany NY: SUNY Press, 1998): 181.
[452] Reigner, "Ancestor of the new archetypal biology," 739.
[453] Rudolf Magnus, *Goethe as a scientist*, Translated by Heinz Norden (New York: H. Schuman, 1949).
[454] Ibid., 91.

establishing the general type for an entire class" because "nature can produce her genera and species only because the type, prescribed to her by eternal laws, is so protean" that excludes any reductive or limiting classification restrictive to the vertebra.[455] However, Goethe was able to develop "a general scheme of animal structure, applying primarily to the vertebrates, but also involving higher invertebrates, such as the insects, crustaceans and worms."[456] This model was organized as a threefold by the sensous head, locomotive torso and reproductive sexual organs. He also included a typical skeleton to aid in comparative studies since some "structures may be ossified which in others are present only in the cartilaginous or fibrous form" and because "certain bones may be fused, while in others they are separate" as it was in the case of the skull.[457] Rather than documenting variations of each bone as taxonomy, he sought to find the overall structure of a common type by looking at its expressions in individual forms. He posited two circumstantial forces, an internal force guiding formation and an external influencing the development of these individual forms due to environmental factors. This way "the law of the correlation of parts intervenes to regulate matters, seeing to it that the animal as a whole is harmoniously formed;" however, Goethe offers a different correlation between form and function where the "mode of life and habitat alter animal form in a mechanical sense, but the inner laws of integration see it that form retains organic cogency."[458] Goethe found the teleological concept of how animal forms were created for man to be unscientific. He doesn't find any purposive argument for the causes of natural phenomenon. Magnus states that the type concept acts a bridge between the two, where

[455] Ibid., 94.
[456] Ibid., 98.
[457] Ibid., 99.
[458] Ibid., 106.

"external factors determine its specific modifications" and "the law of correlation keeps the whole in harmony."[459]

2.2.4 Farbenlehre: Polarity and Color

As a cumulative and consistent body of work, *Farbenlehre* marks the culmination of Goethe's theoretical formulations on natural laws by extending polarity into the realm of physics. What differentiates the work on color from other natural sciences is not its discoveries but its method that offers a new way of combining the experimenter with the experiment. This attitude stems from Goethe's early interests on color and his dissatisfaction with Newtonian experiments using prisms in a white painted room. This is summarized in an epilogue titled "Confessions of the Author" where he thought "through instinct, that Newtonian theory was erroneous."[460] In *Opticks*, Newton's experiments rely on the "analysis of white light (sunlight) into lights of different colors, separated in the visible spectrum according to their different refrangibilities" and formulated an asymmetrical color wheel "combining primary colors, of which he named seven."[461] Goethe rejected the "explanation for the appearance of colors when white light is passed through a prism" considering Newton's colors to appear "from the point of view of the theory of refraction, which was not derived from nature herself, but from an artificial hypothesis."[462] "He reverted to the ancient idea that colors arise from a combination of

[459] Ibid., 107.
[460] Goethe, *Goethe's Color Theory*, 199. In this essay, Goethe writes that he received the necessary equipment from Privy Councillor Büttner in Jena to conduct prismatic experiments. When the prisms were asked to be returned, he hastily made some observations in a white painted room expecting to see colors. However, he notes that rather than seeing colors the room appears white: "As I held the prism before my eyes I expected, keeping Newtonian theory in mind, that the entire wall would be fradated into different colors, since the light retuning to the eye would be seen shattered in just so many colored lights." Colors were only observed when a bordering edge of light and dark were present as "only where there was something dark did a more or less distinct color show."
[461] Eric Temple Bell, "Newton After Three Centuries," *The American Mathematical Monthly*, Vol. 49, No. 9 (Nov., 1942): 556. Isaac Newton, *Opticks; or, A Treatise of the Reflections, Refractions, Inflections & Colours of Light* (London: G.Bell & Sons, 1931, orig. 1704) 134. Newton mentions the construction of asymmetrical color wheel in Book I, Part II, Proposition VI, Problem 2.
[462] Myles W. Jackson, "A Spectrum of Belief: Goethe's 'Republic' versus Newtonian 'Despotism'," in *Social Studies of Science*, Vol. 24, No. 4 (Nov., 1994): 686.

light and darkness," that can be "effected with the aid of a turbid medium."[463] During his observations with the prism, Goethe experienced that "the wall remained white unless there was some type of contrast that introduced a boundary between white and darkness."[464] He became highly critical of Newton's experiments due to their "highly complex" and "deliberately difficult" methods that made it hard to verify their universal validity.[465] Following this experience, he defines an alternative approach for the study of color through polarity.

> Then that first recognition aided me to a new theoretical road, a road that occurred in decisive separating steps, antitheticals, assignations, and differentiations. Or whatever it is to be called, whatever occurs among prismatic color manifestations, something that I summarized for myself in the rule of polarity. I was convinced of this, as well as that this could also be applied to the remaining color phenomena.[466]

Goethe considered the colors to be of "fleeting appearances" that "are not accidental but are dependent upon definite laws."[467] The *Farbenlehre* presents two main bodies of work. The first is the "Contributions to optics" published in 1791 that outlines sequential experiments which overlap with experiences to aid in the formulation of a polarized theory on color. The second main body of work is didactic in nature, published in 1808 and structured in two main parts. The first part is analytic, relying on experiments focusing on the "first physiological, the second physical, the third chemical colors,"

[463] George A. Wells, "Goethe's Qualitative Optics," in *Journal of the History of Ideas*, Vol. 32, No. 4 (Oct.-Dec., 1971): 617.
[464] James A. Marcum, "The Nature of Light and Color: Goethe's "Der Versuch als Vermittler" versus Newton's Experimentum Crucis," *Perspectives on Science*, vol.17, no.4 (2009): 462.
[465] Magnus, *Goethe as a Scientist*, 179.
[466] Goethe, *Goethe's Color Theory*, 200.
[467] Ibid., 14.

where “the first are fleeting and not to be arrested; the next are passing, but still for a while enduring; the last may be made permanent for any length of time.”[468] In the second synthetic part, the aim is to consolidate the former listed experiments and observations into a cumulative view of color, intending to develop an aesthetic system. This goal is briefly summarized to give an outline of how polarity structures colors. Their mixing begins by making a distinction of light and dark which produces yellow and blue and their purest mix produces green. However, yellow and blue are also capable of producing a darker or concentrated hue that can culminate into the production of “the intensest and purest red” when “two extremes of the yellow-red and blue-red are united.”[469] Thus, Goethe extends the duality into a triad by considering two triangles that form a color wheel through their opposing relations.

> But we can also assume an existing red in addition to the definite existing blue and yellow, and we can produce contrariwise, by mixing, what we directly produced by augmentation or deepening. These three or six colors, which may be conveniently included in a circle, are the sole concern of the elementary doctrine of colors.[470]

In *Contributions to Optics* [*Beiträge zur optic*], Goethe first defines two modes of studying color. The first is through the “surfaces of objects” that are “fixed, *body colors*” which “besides their won characteristics that we recognize by touch, an additional one that is usually not attributable to touch” is called “color.”[471] The second is “not fixed upon the surface of an object but can be seen only under special circumstances” which

[468] Ibid., 74.
[469] Ibid., 75.
[470] Ibid., 75.
[471] Ibid.

are called “absolute colors.”[472] Goethe names only two colors that are pure. These are yellow and blue and “they have a particular quality in producing a third color by intermixing, namely green.”[473] On the other hand, “red is not known in a pure state, since it leans either to yellow or to blue.”[474] These initial statements are followed by prismatic experiments that are arranged sequentially to determine how color could be studied through polarity through the observation of various black and white patterned cards that are observed under an equilateral prism. Goethe uses 18 cards and records the color orders that are produced along contrasting borders between black and white edges. For each experiment instructions are provided on how to position the cards and the prism as well as the specific distance of observation that yields certain color production through the refraction of light. In one of these, Goethe observes a horizontal black and white border under the prism that is kept parallel to the border. In paragraphs §47-49, the experiment is defined by using a black top and white bottom card where the observer sees “a red and a yellow band without a trace of blue, green, or violet.”[475] Reversing black and white in the card produces “blue and violet bands.”[476] These experiments are complemented in §50, where the black and white patches are joined side by side and “the concept of reversal is becoming clearer.”[477] By using the prism and refraction of light, color sequences are observed and noted leading to further experimentation always taking place in a dual fashion, by comparing cards that yield to opposing color sequences (Fig.2.2.4.1).

[472] Ibid.
[473] Ibid.
[474] Ibid.
[475] Ibid., 27.
[476] Ibid., 27.
[477] Ibid., 28.

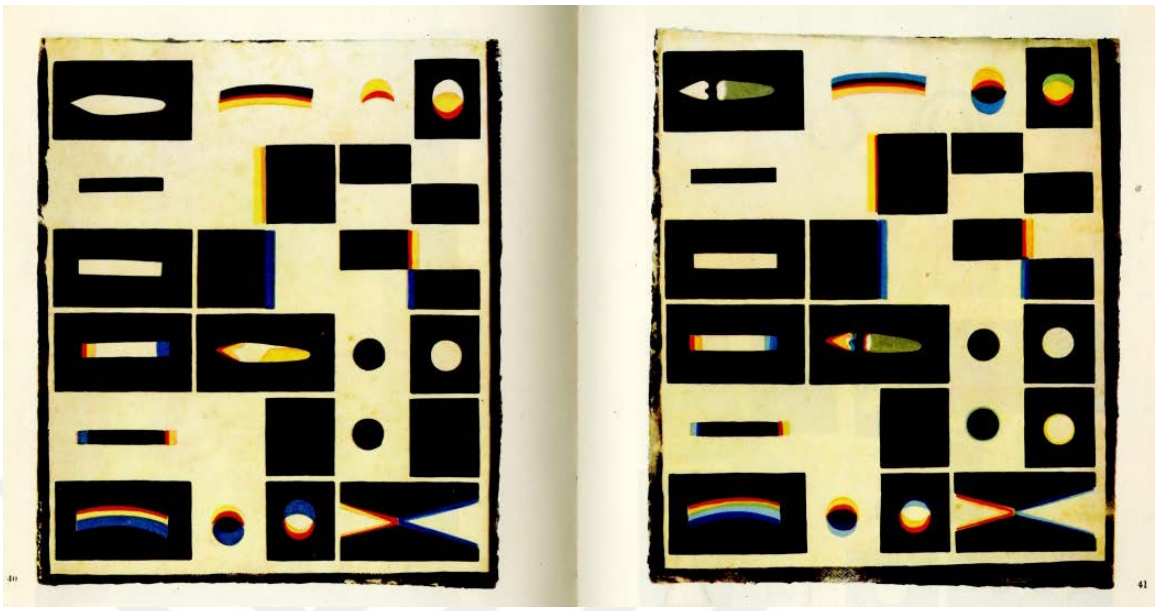

Figure 2.2.4.1 – Documented prismatic experiments using the eighteen black and white cards (In D.Kuhn, *Corpus der Goethezeichnungen*, Band VA, NR.1-390, *Die Zeichnungen Zur Farbenlehre*, Leipzig, 1963, plates 40-41).

In the following experiments, Goethe aims to document the flexible zone between borders using the prism. The refraction produced by the prism is used dynamically to observe how polarity between contrasting edges of black and white produce alternating color sequences which are complementary. He states that "the prism does not show that colors follow sequentially, rather in opposition to each other" and "since everything is based on this principle, it is necessary to repeat relevant experiments."[478] A key experiment is narrated in paragraph §59 which describes how the angle of refraction could be manipulated to overlap separate colors produced along the white and black horizontal zones on cards. The color schemes observed under the prism are indicated below and the symbol "†††" denotes the white or black spaces that have no color.[479]

[478] Ibid, 30.
[479] Ibid., 31.

Card 1 - White on black	Card 2 - Black on White
Red	Blue
Yellow	Violet
†††	†††
Blue	Red
Violet	Yellow

During this experiment when "radiation is increased by distance" it replaces the white and black areas on cards with green and peach blossom respectively.[480] Goethe defines "the phenomena of colors as they appear through the prism and when the occurring edges are definitely black on white" and the middle colors that emerge through higher radiation as mixtures.[481]

Card 1 - White on black	Card 2 - Black on White
Red	Blue
Yellow	Violet
Green	Peach Blossom
Blue	Red
Violet	Yellow

Jackson considered this experiment to oppose Newton's argument of diverse refrangibility that concluded green was "homogeneous;" in contrast, Goethe argued that "the color green emerges as a compound color, produced by the mixing of blue and

[480] Ibid.
[481] Ibid., 33.

yellow."[482] Currie considered a more scientific view of these experiments and related the mixing to addition and subtraction of wavelengths; for instance, "green emerges by subtraction of wavelengths as the light of the white strip gives way to darkness, while magenta emerges by addition of wavelengths as the darkness of the black strip gives way to light."[483] Since boundary colors blue and yellow are complementary to each other in terms of wavelengths, Goethe is correct to consider them "building blocks for all color mixing."[484] Rupprecht Matthaei, the editor of *Theory of Colors*, also reviewed these experiments and noted that the colors occur in a crosswise fashion where warm colors are on the black-over-white edge, and the cool colors on the white-over-black edge. Goethe called these two opposing ordering of color sequences "border spectra" where the "light-valued color is adjacent to white, and the dark-valued is adjacent to black."[485] Goethe called the colors observed over black background "the principal spectrum colors that Newton analyzed" and defined the ones on the white background as complementary "Goethe-colors." [486] Goethe identified yellow and blue to be primary colors and red as an intensified mixture of them. These three colors define the corners of an equilateral triangle where red has "highest of all appearances of color."[487] He gave equal rank to the reversed spectrum where the colors appeared in harmony and contrast. When viewed at a greater distance, the colors on the left converge to black while Goethe colors converge to white. These six colors became the foundation for Goethe's color wheel (Figs.2.2.4.2-3).

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[482] Myles W. Jackson, "Putting the Subject back into Color: Accessibility in Goethe's Zur Farbenlehre," in *Perspectives on Science*, Vol.16, No.4, (2008): 383.
[483] Pamela Currie , "Goethe's Green: The "Mixed" Boundary Colors in Zur Farbenlehre," in *Goethe Yearbook*, Volume 17 (2010): 270. Currie also shows schematic diagrams of how colors mix through their refrangibility.
[484] Ibid.
[485] Goethe, *Goethe's Color Theory*, 42.
[486] Ibid., 43.
[487] Ibid., 172. Goethe designates a whole chapter on the sensual and moral effects of color. He gives further descriptions on primary colors as well as their intermediaries. He considers red to give "an impression of gravity and dignity, and at the same time of grace and attractiveness." He defines two types of states of red which can be observed. The first is a "dark deep state", the latter is under "light" to represent the "dignity of age and the amiableness of youth." He also writes of the jealousy of sovereigns with regard to the quality of red

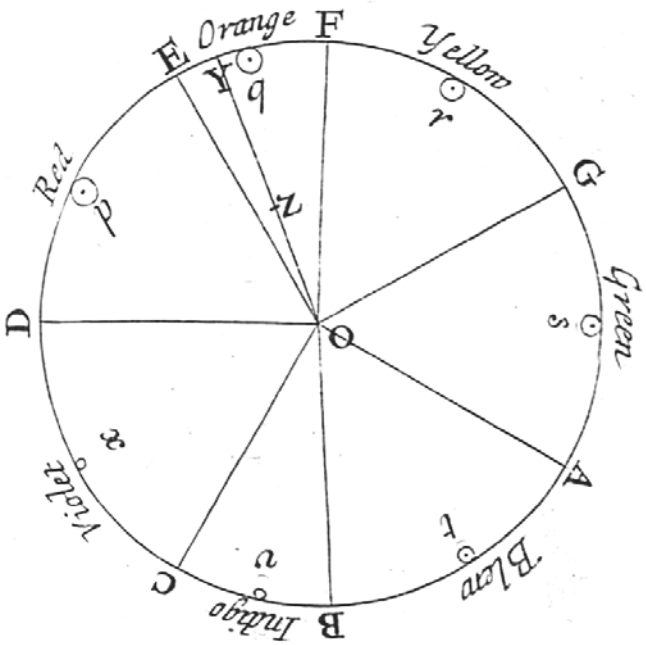

Figure 2.2.4.2 – Newtons asymmetrical color wheel showing the division of colors according to their wavelengths that bounds their regions on the spectra (Reprinted from Newton, *Opticks*, 1704).

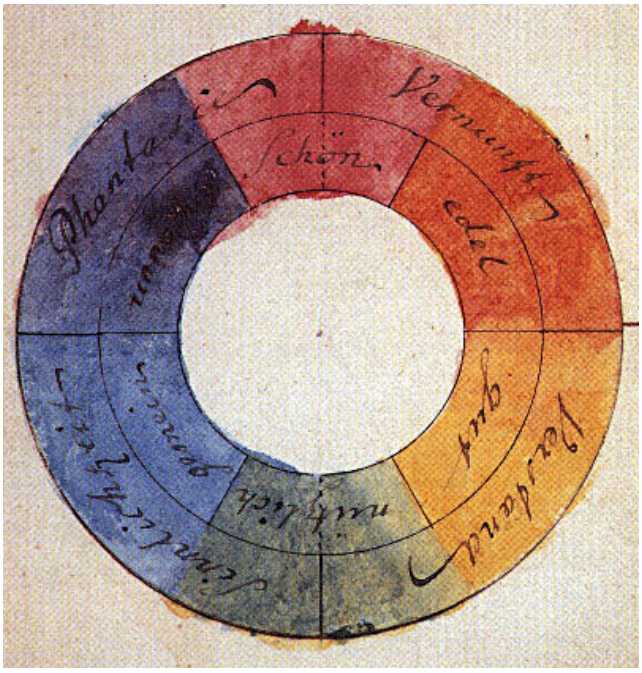

Figure 2.2.4.3 – Goethe's symmetrical color wheel showing the placement of colors in opposition. Watercolors enable mixing and intensification (Reprinted from Goethe, Theory of Colors, 1809).

The experiments with prism and monochromatic cards were incorporated into the first section of *Theory of Colors* published in 1808 where polarity is further extended into three analytical parts. The first part is on physiological colors, focusing on the polarity that exist in the organ of perception, "the sound eye" that provides "the necessary conditions of vision; the active oscillation is thus plainly indicated with reference to external objects and a principle within it."[488] Goethe first describes how the retina is structured through polarity by discussing its relationship to the environment and to the presence or absence of light as well as citing pathological cases. Key observations are presented by looking at either bright colorless objects or general colorless brightness to cause the eye to produce afterimages and compare results. For instance, when the crossing wooden support of a window is seen under light, it produces an afterimage where the cross appears lit, and the glass planes black, producing the opposite of the initial picture imprinted on the retina. This principle produces contrasting results for the perception of gray surfaces, where "a gray image on black ground appears much brighter than the same image on a white ground" that presents "a proof of the great excitability of the retina."[489] For Goethe, the retina and the image operate in a polarized relationship.

> Thus inhalation already presupposes expiration; thus every systole its diastole. It is the universal formula of life which manifests itself in this as in all other cases. When darkness is presented to the eye it demands brightness, and *vice versa*: it shows its vital energy, its fitness to receive the impression of the object, precisely by spontaneously tending to an opposite state.[490]

[488] Ibid., 78.
[489] Ibid.
[490] Ibid., 81.

Goethe also draws conclusions on the variability of the eye and how it may produce slightly different results for individuals. For instance, he describes an experiment where one first looks at a white lit circle produced in a dark room from a small opening by the window and then the opening is closed and the observer looks at the darkest corner of the room. The bright circular afterimage is compared after longer durations staring at the initial bright circle that first appears bright, colorless or yellowish, then bluish red, then blue, and finally colorless.[491] Goethe relates this transformation to the radial movement of the colors around a circle which he aims to produce.

> for the colors diametrically opposed to each other in this diagram are those reciprocally evoke each other in the eye. Thus, yellow demands purple; orange, blue; red, green, and *vice versa*: thus again all intermediate gradations reciprocally evoke each other; the simpler color demanding the compound, and *vice versa*.[492]

The second didactic part focuses on physical colors that are produced by "certain material mediums: these mediums, however, have no color themselves, and may be either transparent, semitransparent yet transmitting light, or altogether opaque."[493] Three types of physical colors are defined: "catoptrical" when light "flashes back from the surface of a medium," "perioptical" or "paroptical" when light "passes by the edge of a medium", and "dioptrical" when light "passes through either a merely light-transmitting or an

[491] Ibid., 82. Goethe relates this transition to the dynamic transformation of the receptors of the eye that first produces a bluish afterimage after seeing light and gradually changes it to dark: "After a time this bluish red, increasing toward the center, covers the whole circle, and at last the bright central point. No sooner, however is the whole circle bluish red than the edge begins to be blue, and the blue gradually encroaches inward on the bluish-red. When the whole is blue the edge becomes dark and colorless. This darker edge again slowly encroaches on the blue till the whole circle appears colorless. The image then becomes gradually fainter, and at the same time diminishes in size. Here again we see how the retina recovers itself bit by bit a succession of oscillations after the powerful external impression it received." He also repeats this experiment with durations to see how intensity of the perceived brightness effects the colors of the afterimage.
[492] Ibid., 83.
[493] Ibid., 96.

actually transparent body."[494] A fourth one is called "epoptical," where the "phenomena exhibit themselves on the colorless surface of bodies under various conditions, without prior revelation."[495] While catoptical colors are related to physiological, paroptical are independent, dioptrical are strictly physical, and epoptical show a transition to chemical colors. Goethe considers physical colors to combine polarity within different types of turbid media, akin to the prism, by joining "on the one side light, brightness; on the other darkness, obscurity: we bring the semitransparent medium between the two, and from these contrasts and this medium the colors develop themselves, contrasted, in like manner, but soon, through a reciprocal relation, directly tending again to a point of union."[496] This union is discussed under an addendum with entoptic colors that repeat similar experiments to cards; but, in the case of physical colors, black mirror pieces are arranged on a ground facing clear blue sky that produces polarized afterimages on the eye. In these experiments, Goethe attributes the appearance of color to the gradated blending of light and dark as the expression of polarity.

> Darkness and light have eternally opposed each other, one alien to the other. Only objects that are in between both have a lighted and darkened side, if they are opaque. Shadow asserts itself by a weak reflection. If these materials are transparent, then if half-light, in murkiness, something happens to the eye which is called color.
>
> These manifestations, like light and dark, are in general polarized contrasts. They can be eliminated, neutralized, so that both seem to disappear. But this can also be

[494] Ibid., 96.
[495] Ibid., 96.
[496] Ibid., 101

> reversed, a reversal that with each polarity is in general the most fragile thing in the world. Plus can be turned into minus, minus into plus at the slightest condition. The same is also true of entoptic appearances. The white cross is turned into the black cross, the black into the white, at the slightest change, and the accompanying colors are similarly reversed into their complement.[497]

The third part focusing on chemical colors discusses the fixed appearance of color with natural forms as a way to relate colors to morphological manifestations "which we can produce, and more of less fix, in certain bodies; which we can render more intense, which we can again take away and communicate to other bodies, and to which, therefore, we ascribe a certain permanency: longevity their main characteristic."[498] While physical colors are more "fluctuating and transient" chemical colors appear to be "gradually fixed."[499] Chemical colors show apparent contrasts and relation to chemicals, such as "yellow and yellow-red affect the acids, the blue and blue-red the alkalis."[500] The last section of chemical colors is devoted to morphological discussions, on how color appears in organic bodies, such as plants and animals. Plants are the first type of organisms that produce color through mixing, whereas in animals, the production of color is related to internal fluids and light in the environment. Animals growing in dark or deep sea appear to lack coloration. The term that Goethe uses is "concoction," which refers to this ancient idea that defines a rule for color in form.[501]

[497] Ibid., 126.
[498] Ibid., 137.
[499] Ibid., 137.
[500] Ibid., 137.
[501] Ibid., 151.

> All the elementary colors, as well as the combined and secondary hues, appear on the surface of organic productions, while on the other hand, the interior, if not colorless, appears, strictly speaking, negative when brought to the light.[502]

The next three sections of *Farbenlehre* aim to synthesize the aforementioned experiments in different classes of color and extend the theory towards other domains of investigation such as aesthetic perception. Part four titled "General Introspective Views" provides some consolidation on the previous three sections and presents a general hypothesis on color as it relates to duality: "a contrast which we call a polarity, and which we may fitly designate by the expressions *plus* and *minus*."[503] Goethe gives coupled examples that are manifested in color: yellow-blue, effect-deprivation, light-shadow, brightness-darkness, force-weakness, warmth-coldness, proximity-distance, repulsion-attraction, affinity with acids-affinity with alkalis. The *Theory of Colors* focuses on the middle ground between these oppositions—"if two opposite phenomena springing from the same source do not destroy each other when combined, but in their union present a third appreciable and pleasing appearance, this result at once indicates their harmonious relation."[504] This also marks the dynamic and temporal nature of color that never stays fixed within its manifestations. Such gradual transition is observed through the transition from physiological and physical colors that first appear transient and later become fixed.

> All that has been adverted to as subsequent to the rapid excitation and definition of color, immixture, intensification, combination, separation, not forgetting the

[502] Ibid., 151.
[503] Ibid., 158.
[504] Ibid., 160.

law of compensatory harmony, all takes place with the greatest rapidity and facility; but with equal quickness color again altogether disappears."[505]

In the fifth part titled "Adjacent Relationships," Goethe considers this color theory in its relation to other sciences such as philosophy, mathematics, physiology, physics and music. While not claiming to have an expertise in any of these fields, he considers them to be useful to provide extensions or improvements to the theory. He discusses the general terminology used throughout the work, and "the application of the term polarity, which is borrowed from the magnet to electricity, etc." that provides a suitable language to discuss the dynamic properties and appearances of color."[506]

The last part "Sensual and Moral Effects of Color" is related to the aesthetic perception of color invoked on the observed which "are associated with the emotions of the mind."[507] These sensations bring an effect on the mind that "in combination they may produce a harmonious, characteristic, often even an inharmonious effect on the eye, by means of which they act on the mind; producing this impression in their most general elementary character, without relation to the nature or form of the object on whose surface they are apparent."[508] The relation of color and feelings are investigated by perceiving only one color in a room or by looking through a colored glass. Polarity is observed between warm and cool colors that appear on the plus or minus side, where the former defined by yellow, orange and red "the feelings they excite are quick, lively, aspiring" compared to others that produce calm or repose.[509] Goethe looks at relationship among the color pairings along the wheel. The fundamental law of harmony of color

[505] Ibid., 160.
[506] Ibid., 167.
[507] Ibid., 168.
[508] Ibid., 168.
[509] Ibid., 168.

states shows that when eye sees a color, it immediately seeks its opposite (physiological colors). These first types are called complementary colors and three pairs are presented: red-green, yellow-violet, blue-orange. These invoke the most polarity when paired. The second type shows harmonious relations called "characteristic" that "excite a definite impression; an impression, however which does not altogether satisfy."[510] These color combinations are determined "not by diameters, but by chord, in such a manner that an intermediate color is passed over."[511] These are yellow-blue, yellow-red, blue-red, and orange-violet. The third type are unsatisfying contrasts in the case of adjacent pairings that are called "noncharacteristic" because the "colors are too nearly alike for their impression to be significant."[512] While colors are arranged in a polarized manner producing a circumscribed wheel, their radial spacing shows intensified relations, that when seen together produce gradations of aesthetic appreciation. Towards the last section, Goethe extends the sensual effects of color towards painting and refers to an essay sent to him by Philip Otto Runge. Here, supplementary notes and information on color and pigment mixing for painters are provided.

During his investigations, Goethe sought to "experience the *quality* of the colors so that he could understand them in a creational sense" rather than seeking out to "quantify the phenomenon" like Newton.[513] Although he received great satisfaction as a poet from the outside world, his work *Farbenlehre* received nothing but censure and disapproval due to the "non-objective" character of his experiments. However, he declared himself proud to be "the only one in (his) century who knows the truth about the

[510] Ibid., 177.
[511] Ibid., 177.
[512] Ibid., 178.
[513] Jim Platt, "Newton, Goethe and the process of perception: an approach to design,"in *Optics & Laser Technology 38,* (2006): 207.

difficult science of color."[514] By using comparable experiments, he not only showed affinity among optimal and intermediate colors through their adjacency and opposition on the geometric construction, but also their sensual and aesthetic effects on the mind. His color hexagram using prismatic colors later became influential to the work of many philosophers like Schopenhauer, Steiner and Wittgenstein and to painters like Philipp Otto Runge and J.M.W. Turner who embraced his color theory.

2.2.5 Goethean Morphology as a Unifying Science

Throughout his lifetime Goethe produced various works on different branches of natural sciences starting with an essay on the existence of the intermaxillary bone in human skull published in 1786, followed by a complete dissertation on plant metamorphosis in 1795, and a speculative work on color in 1809. Goethe consolidated all of his works on various natural sciences into the science of morphology that was published between 1817 and 1824. In "Observation on Morphology in General" Goethe defines this new science that "may be viewed as a theory in and of itself; or as a science in the service of biology" while also drawing knowledge from other subsidiary sciences such as physiology, physics and chemistry without producing conflicting ideas with them.[515] "Through its limitations" this new science offers a comprehensive theory of form based on "a specialized set of principles" that present a structural understanding and metamorphosis of organic bodies.[516]

[514] Johann P. Eckermann and Johann Wolfgang von Goethe, *Conversations with Goethe*, intro. Hans Kohn, trans. Gisela C. O'Brien (New York: Ungar, 1964): 149
[515] Goethe, *Scientific Studies*, 57. In this essay Goethe gives information about the definition, content and method of morphology while describing its relation to other sciences.
[516] Ibid.

> Morphology may be said to include the principles of structured form and the formation and transformation of organic bodies; thus it belongs to a particular group of sciences, each of which has its own purpose.[517]

Among these particular sciences Goethe finds numerous contributions and limitations. He defines natural history as related to taxonomy in that it "shows a certain consistency" that "not only records the bodily structures known to it, but arranges them, sometimes in groups and sometimes in sequence, according to the forms that are observed and the characteristics that are sought out and recognized."[518] In doing this, Goethe considers natural history to concentrate "on the surface appearance of forms and views them as a whole" in contrast to anatomy that "requires a knowledge of the inner structure" that is essential to understand formative principles; however, the work in this field is "so scattered, so incomplete and even so erroneous in many cases, that the collection of material remains almost useless to the scientific researcher."[519] Considering the science of physics Goethe mentions its focus on mechanical principles and forces as posing a limitation for the study of organisms that are dynamic; because "the less applicable mechanical principles become, the more an organism grows in perfection."[520] Similarly chemistry avoids any structural discussion and instead "observes the character of materials and how they form compounds."[521] Due to lack of unifying principles in all these sciences, Goethe calls for establishing a unified "physical-chemical biology in the course of time" that potentially could become a new science.[522] This task is granted to the biologist who has to consolidate the extensive work in all other fields while

[517] Ibid.
[518] Ibid.
[519] Ibid., 58.
[520] Ibid.
[521] Ibid.
[522] Ibid.

acknowledging the accomplishment of others in order to arrive at the new science of morphology that

> must prove its legitimacy as an independent science by choosing a subject other sciences deal with only in passing, by drawing together what lies scattered among them and establishing a new standpoint from which the things of nature may be readily observed. The adventures of morphology are that it is made up of widely recognized elements, it does not conflict with any theory, it does not need to displace something else to make room for itself, and it deals with extremely significant phenomena. Its arrangement of phenomena calls upon activities of the mind so in harmony with human nature, and so pleasant, that even its failures may prove both useful and charming.[523]

As a theory-laden science, morphology shows a reevaluation and bridging among the historical debate between preformation and epigenesis by combining the aspects of common types or Bauplan and the transformation of organisms under the concept of metamorphoiss as a core principle. While Goethe's "primary interest was in representing the formal constraints upon these forces, ideal types abstracted from experience through a disciplined perception" he formulated morphology as "a methodology for realizing that intuition objectively" to perceive the whole.[524] In "The Purpose Set Forth" Goethe defines this approach by comparing *Gestalt* [structured form], which excludes "what is changeable and assume(s) that an interrelated whole is identified, defined, and fixed in character" to *Bildung* [formation] which describes "the end product and what is in

[523] Ibid., 59-60.
[524] Steigerwald, "Goethe's Morphology," 303. Steigerwald draws a strong link between Goethe's scientific epistemology and aesthetic views that aid the formulation of intuitive principles of perception for the study of archetypes.

process of production."[525] For morphology, he reduces the use of *Gestalt* "only in reference to the idea, the concept" while *Bildung* finds its expression in the dynamic concept of metamorphosis; to study the relationships of parts within a whole as "when something has acquired a form it metamorphoses immediately to a new one."[526] But, rather than focusing on the continuous flux of changing forms, Goethe directs attention to the study of parts within a whole through a duality, which mainfests antagonistic proximal relationships to produce either similar or dissimilar forms.

> No living thing is unitary in nature; every such thing is a plurality. Even the organism which appears to us as individual exists as a collection of independent living entities. Although alike in idea and predisposition, these entities, as they materialize, grow to become alike or similar, unalike or dissimilar. In part these entities are joined from the outset, in part they find their way together to form a union. They diverge and then seek each other again; everywhere and in every way they thus work to produce a chain of creation without end.[527]

While describing polar relationships among parts of an organism becomes the purpose of morphology, Goethe uses the notion of a Chain of Being not in a linear hierarchical process, but but instead considers it to be cyclic, that still perfects the forms thorugh the activity of polarity and intensification.[528] Thus, morphology aims to

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[525] Goethe, *Scientific Studies*, 63. Ronald H. Brady, "The idea in nature: rereading Goethe's organics", in *Goethe's Way of Science: A Phenomenology of Nature*, eds. David Seamon and Arthur Zajonc (Albany, NY: State University of New York Press, 1998), 102. Brady considers Goethe's ideal types a "continuous connection to an antecedent unity," where "form is never viewed as Gestalt [Form], fixed and cut off from the process of production" but "its form is understood dynamically, as *Bildung* [Formation]."
[526] Ibid.
[527] Ibid., 64.
[528] Tantillo, *The Will to Create*, 98.Tantillo relates this chain of creation to intensification [Steigerung] that is formulated in opposition to teleology as a determinative end to creation. This gives the organisms the ability to metamorphose and evolve. She writes "First, Steigerung arises within the organism itself; second, organisms through Steigerung may not only take outside elements into account, but they may even use these elements as an impetus to change and develop." Richards, *The Romantic Conception of Life*, 445. Richards denotes similar remarks on how Goethe replaced teleology with his concept of metamorphosis where "he replaced divine teleology with natural causality, though a causality that reatined a telic feature."

restructure homology through polarity which is "no longer seen as a multiplicity of relationships that express the unity of form, but rather as scenarios that infer direct paths of descent."[529] But noticing this relationship among parts through polarity is not sufficient, as a second comparison using intensification establishes a counterweight among parts with the whole that express similarity or dissimilarity of forms.

In his work titled *The Structure of Evolutionary Theory*, Stephen Jay Gould revisits Goethe's concepts of metamorphosis and states that the archetype of plant forms could not be reduced to "serial diversity to the actual form of a stem leaf" since this will contradict with "the Platonic character of archetypes in formalist theory."[530] The leaf should then be viewed as an "abstract generative principle" that combines alternating stages of expansion and contraction that lead the complexity of development, by constantly refining the raw juices in the plant until the division of the forces in sexual organs. Still, morphology falls under a "vision of formalism" that combines three principles–"the archetypal leaf, progressive refinement of sap up the stem, and three expansion–contraction cycles of vegetation, blossoming, and bearing fruit and the vast botanical diversity of our planet."[531] These "internal and formalist principles" define primary laws of morphology while "external fit, though of great importance, can only be regarded as secondary."[532] Gould reserves a higher respect for Goethe's archetypal concept, while considering the formulations for an overall encompassing morphological view as a fruitful avenue of investigation.

[529] Ebach, "Anschauung and the Archetype," 255-6. Ebach considers Goethean scientific to be holistic, where multiplicity in unity could be perceived intuitively as a way to repair comparative biology.
[530] Stephen J. Gould, *The Structure of Evolutionary Theory* (Cambridge, Mass.: Belknap Press of Harvard University Press, 2002), 285.
[531] Ibid., 288.
[532] Ibid., 289.

In "Bildung, Urtyp and Polarity: Goethe and Eighteenth-Century Physiology," Reill considers Goethe's "mature concept of morphology" to be formulated by "concepts of polarity, Bildung, Urtyp, and metamorphosis," offering an "economy of nature" structured between opposite views of his time.[533] While Goethe "displayed an ambivalence towards the concept of type" as its ontological status was undecided, he agreed with Kant that it was "an intellectual construct, an idea" but became an active, generative, principle that is both regulative and determinative.[534] This type is structured by the concept of polarity that defines a "language of nature" and relate to "the act of breathing" while Goethe's morphological writings present a duality of tensions "between inner force and environment, between preformation and epigenesis, between *Idee* and appearance, between law and individuality."[535] Thus, morphology, guided by the formulation of type, provides a middle ground separated by polarity and offers a method for the study of form.

2.3 *Bildebewegungen*: Polarity in the work of Jochen Bockemühl

A botanical study of metamorphosis focusing on leaf morphology and polarity could be found in the work of botanist Jochen Bockemühl whose work has had a long lasting influence on Goethean science community with its discovery of bi-polar regulative rhythms acting through leaf transformation series.[536] After studying zoology, botany, chemistry, and geology, Bockemühl became a resident botanist in Research Institute at

[533] Reill, "Bildung, Urtyp and Polarity," 141-2.
[534] Ibid., 145.
[535] Ibid., 142.
[536] The main contributions of Bockemühl could be found in three papers published in 1960s looking at leaf morphogenesis through the polar relationships within a series of forms: "Bildebewegungen im Laubblattbereich hoherer Pflanzen," in *Elemente der Naturwissenschaft 4* (1966) 7-23, "Der Pflanzentypus als Bewegungsgestalt," in *Elemente der Naturwissenschaft 2* (1964): 3-11 and "Äusserungen des Zeitleibes in den Bildebewegungen der Pflanzen," in *Elemente der Naturwissenschaft 7*, (1967), 25–30. These papers are consolidated into one essay in "The Formative Movements of Plants" in *Towards a Phenomenology of the Etheric World*, (N.Y.: Antroposophic Press, 1977).

the Goetheanum in Dornach, Switzerland since 1956, running the Natural Science Section from 1970 to 1996. Amrine states that Bockemühl's work in botany, particularly on leaf morphogenesis, "is rigorous, subtle, and meets all the requirements of a 'Goethean' methodology -including that of being highly aesthetic" while "it also offers a unique, contemporary perspective on Goethe's morphology."[537] The main premise of this work is to reconsider a plant's foliage leaf through two antagonistic growth rhythms that run counter to each other. The first is the development of individual leaves that define the embryogenetic sequences which are continuous. The second is the overall development of all foliage leaves, the ontogenetic sequence, which are produced from the first cotyledons until flowering and are discontinuous but show an overall rhythm or movement. Brady states that in this approach the study of form creates a move away from *Gestalt* towards the more generative *Bildung*, "from the static product to the transformation which leads to and from the product, and thus eventually to a consideration, not of the products, but of the generative field of movement."[538] While Bockemühl's body of work has esoteric and holistic dimensions,[539] his pressed leaf sequences with original terminology extending metamorphosis to polarity allows a technical discussion that will be investigated in this section.

2.3.1 Form and Pattern Transformations [Bildebewegungen]

A discussion of leaf morphogenesis through polar formative principles can be found in "Transformations in the Foliage Leaves of Higher Plants," where Bockemühl describes

[537] Frederick Amrine, "Goethean Method in the Work of Jochen Bockemühl," in *Goethe and the Sciences: A reappraisal*, eds. Frederick Amrine, Francis J. Zucker and Harvey Wheeler, (Boston: D.Reidel., 1987), 301.
[538] Brady, "Form and Cause in Goethe's Morphology," 280-1.
[539] An example of esoteric discussion of metamorphosis could be found in Jochen Bockemühl, "Elements and Ethers: Modes of Observing the World" in *Towards a Phenomenology of the Etheric World* (N.Y.: Antroposophic Press, 1977): 1-67.

"form and pattern transformations [*Bildebewegungen*]" as a way to study the metamorphosis of leaf forms that evolve around an initial hypothesis: "a complete series of fully developed foliage leaves mirror's the plant's development and says much about its archetype."[540] The study presents two alternative approaches for the study of leaf morphology, that either approaches them in a quantitative way focusing on the Cartesian measurements of "leaf's length, breath, and thickness as it grows," or presents a qualitative description of forms where one can "avoid abstract scientific terminology" and rather focus on the "leaf appearances as much as possible in their own terms."[541] For the study of *Bildebewegungen*, the latter approach is followed and exemplified through leaf sequences that focus not on "individual leaf forms" but rather within the "generative movements *between* them".[542] To perceive this movement we have to "become aware of formative tendencies, or activities [*Tatigkeiten*]" and "bring a mobility and flow into our own thinking" to observe ongoing progressive metamorphosis.[543] This method is achieved through observation, where the movement that is internal to the plant, is reciprocated in the scientists' mental activity that "can derive the first leaf of the plant from the last or the last from the first, but in the plant the direction of the sequence of forms is fixed."[544] However, this movement appears to be discontinous; it "does not take place in the outer sense world; each leaf has arisen separately form the plant and has not developed through a physical transformation of the previous leaf," but instead "represents an ideal relationship between the separate phenomena" that is attributed to Goethe's

[540] Jochen Bockemühl, "Transformations in the Foliage Leaves of Higher Plants," in *Goethe's way of Science: a phenomenology of nature*, ed.David Seamon and Arthur Zajonc (Albany, NY: State University of New York Press, 1998), 115.
[541] Ibid.
[542] Ibid.
[543] Ibid., 116.
[544] Bockemühl, "The Formative Movements of Plants," 132.

concept of metamorphosis and polarity (expansion-contraction).[545] In order to study how this archetype manifests itself throughout metamorphosis, the study compares the production of individual leaves along a stem—embryogenesis—and the larger development of the plant—ontogenesis—by relating them in a polar manner.

2.3.2 Polarity and Embryogenesis of Foliage Leaves

The first type of movement that occurs in leaf morphology is embryogenesis which focuses on the growth of a single stem leaf. By looking at various stages of growth of *Cardamine hirsuta* (Hairy Bittercress), key aspects of development and formative activities are described through parts of a leaf (Fig.2.3.2.1). This leaf initially grows with a small spike that moves away from the base and then multiplies into five distinct points that develop into the blade. As the blade grows it bulges outwards in between the points that are held back like a knot, while the stalk extends itself in the opposite direction.

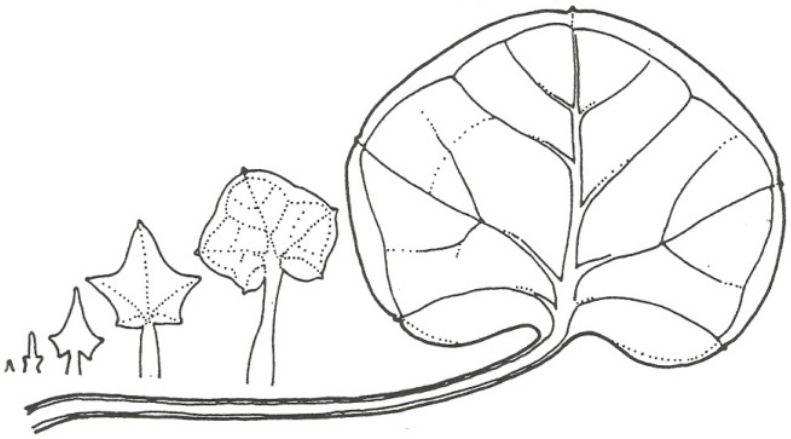

Figure 2.3.2.1 – Development of one of the first leaves of Hairy Bittercress [*Cardamine hirsuta*] (Reprinted after Bockemühl, *Toward a Phenomenology of the Etheric World*, 1977, 139).

[545] Ibid.

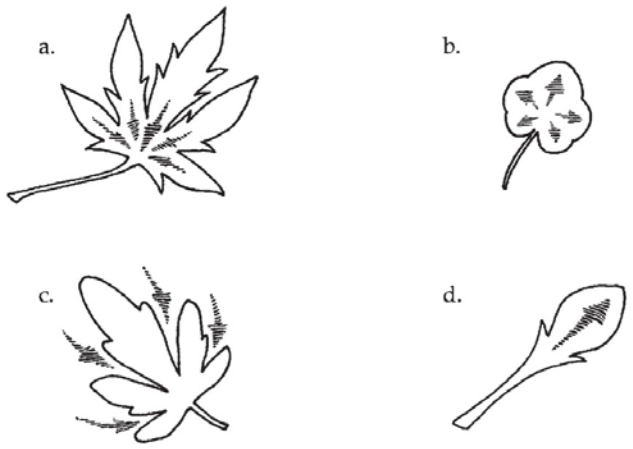

Figure 2.3.2.2 – An attempt to diagram the four formative activities after Miller, 2009: (a) stemming, (b) spreading, (c) segmenting, (d) shooting (The diagram is taken from the appendix: Generative Method in Goethe, *The Metamorphosis of Plants*, 2009).

Although this process is described through the occurance of different parts of a leaf such as spikes, blade, petiole (stalk)…etc., Bockemühl states that the production of these forms could be attributed to four different formative activities that underlie the development: *sprouting* [Spriessen]–"a spike forms and grows out in a specific direction", *segmenting* [Gliedern]–when the leaf divides and the amount of spikes multiply, *spreading* [Spreiten]–"the activity which gives rise to extended leaf surfaces," and *stemming* [Stielen]–"the activity whereby the region near the base of the leaf lengthens and consolidates to a stem".[546] During the early phase of development, sprouting dominates and is then advanced by segmenting which gives way to five distinct points. In the later phase, the leaf surface begins to expand due to spreading and the sprouting activity reduces. In the final phase, stemming extends the leaf in the opposite direction producing a separated stalk. As a result, the development of the contour and

[546] Ibid., 139-140.

organization of the leaf occurs as "a function of the intensity, timing and duration" of sprouting, segmenting, spreading and stemming.[547] These four activities define quantifiable variables that give each leaf form a dynamic character and guide its formation through metamorphosis (Fig.2.3.2.2).

During embryogenesis the four formative activities are expressed in different regions of the leaf that gives them a polar identity while the overall development appears continuous and linear as it takes place along the form of a single leaf. While Bockemühl does not attribute polarity to the four formative activities, he describes them through oppositions that give them antagonistic roles during growth. Among these, sprouting and stemming show clear opposition as the former "is characterized by the growth of points or spikes" and "the tendency is to ray out from a center," while the latter "arises through intercalary growth (mainly at the leaf base), which pushes the leaf outward."[548] Both forces bring an elongation to the central axis of the leaf; however, they guide growth in opposite directions. In contrast to axial growth, spreading expands the blade on to a plane in between the created spikes, increasing surface area and contour length. On the other hand, segmenting either adds more divisions attached to the midrib pulling the blade towards a center or creating lobed blade contours. Segmenting also curtails repetition of similar blade patterns in the formation of leaflets that are part of a larger compound leaf. Although the four forces act as formative activities overlap during growth, they complement each other as opposites, coupling sprouting with stemming and segmenting with spreading along the leaf axis.[549] While these forces are relegated to different regions

[547] Bockemühl, "Transformations in the Foliage Leaves of Higher Plants," 116.
[548] Jochen Bockemühl, "The Formative Movements of Plants," 148.
[549] Another diagram of the four forces could be found in Margaret Colquhoun and Axel Ewald, *New Eyes for Plants: A Workbook for Observing and Drawing Plants* (Stroud : Hawthorn Press, 1996), 82. Mainly dwelling on the work of Bockemühl, Colquhoun

around the leaf which is organized by its symmetrical topology, its internal organization and axiality could be multiplied by segmenting giving the leaf both a diagrammatic and dynamic character.

2.3.3 Polarity and Ontogenesis of Mature Leaf Sequences

The second type of in leaf morphogenesis focuses on the overall development of a plant—ontogenesis—expressing two polar phases of metamorphosis that show opposite tendencies. This development is observed through the entire mature leaf sequence of a plant beginning with the first cotyledons and ending with the leaves formed before the flower. In these serial forms, Bockemühl's main interest is not on individual leaves but on highlighting formal tendencies where the activities that describe the embryonic sequence appears in the reverse order. This way, the ontogenesis is called an *inverse embryonic sequence*, describing an antecedent polarity between them.

Using Common Sow Thistle as an example, ontogenetic development is shown by arranging subsequent leaf forms around a loop arrangement where the sequence "begins with smaller, simpler forms, progresses to more complicated ones, and then near the flower passes back again to simpler forms" (Fig.2.3.3.1).[550] For the ontogenesis of leaves, Bockemühl attributes the change in the proportion and complexity of leaf forms to "a movement" produced by polarity "symbolized by a curve such as a loop or a lemniscate" where "the least expanded and the most contracted leaves both appear near the ideal zero-

considers four types of forces: stemming, spreading, differentiating and pointing. Stemming and spreading are depicted with arrows facing upward (expansion), while pointing and differentiating are represented with arrows facing downward (contraction) along the leaf. In addition, Colquhoun considers contractive forces located outside of the blade acting inwards while expansive forces are located inside acting outwards.

[550] Bockemühl, "The Formative Movements of Plants," 132.

point."[551] This arrangement presents polar formal characteristics during ontogenesis that are organized by expansion (left half) where "the plant's development tends towards the periphery" as "the stem of the leaf lengthens and the parts near the top of the leaf become ever more richly differentiated" and contraction (right half) where the "direction shifts" and "a formative tendency polar to the tendency during the phase of expansion" appears.[552]

Figure 2.3.3.1 – Complete mature leaf sequence of a Sow Thistle [*Sonchus oleraceus*] arranged in a loop. (Reprinted from Bockemühl, 1977, 135).

This shift also shows antagonistic leaf morphology by producing convex-rounded forms during expansion and concave-pointy forms during contraction. During contraction, the parts closer to the base of the leaf (axil) become broader, showing

[551] Ibid, 132-3.
[552] Ibid.

similarity to the peripheral development in expansion, and in complimentary fashion the distal parts become thinner. This process also shortens the whole central leaf axis producing smaller forms. Bockemühl states that this shifting of the direction "during the phase of contraction is not simply the reversal of the phase of expansion" as it would have led to a symmetrical leaf sequence; instead, the sequence appears as the result of an "inner shift" that can also be "read from the changing proportions of the forms."[553] While each leaf internally transfers the location of formative activities from its tip to the base, the sequence becomes a physical index of the changing internal dynamism of the plant by giving it a formal representation among the sequence as well as switching roles of expansive and contractive forces.

Figure 2.3.3.2 – Mature leaf sequence of Corn Salad [*Valerianella locusta*] (Reprinted from Bockemühl, 1977, 145).

[553] Ibid.

The ontogenetic development also presents four types of regulative rhythms: separating/interpenetrating and fusing/inversion that control how expansion and contraction mix with each other. In *Valerianella locusta* (corn salad) the series shows that "during the phase of expansion, stemming and spreading are largely *separate"* producing forms with distinguishable stalks and blades, "whereas during contraction they are *merged* with one another" wherein the stalk progressively disappears and remains a part of the blade (Fig.2.3.3.2).[554] These two activities interpenetrate during the transition between expansive and contractive phases producing variations of the leaf outline. While separating causes formative activities to be relegated to different poles along the main leaf axis, towards contraction these activities start interpenetrating until they merge with each other, distributing stemming activity towards the tip of the leaf and producing smaller elongated blades.

Figure 2.3.3.3 – Mature leaf sequence of Hairy Bittercress, from seed leaf to flower (Reprinted from Bockemühl, 1977, 147).

[554] Ibid.,144.

In the ontogenetic sequence of *Cardamine hirsuta* segmenting dominates throughout the series by producing different amounts of leaflets distributed along the main axis. While separation between spreading and stemming is maintained throughout the sequence as a motif, segmentation during early stages of growth allows "the stemming activity to reach up into the individual segments" (Fig.2.3.3.3).[555] While early expansive leaves are shaped by only stemming and spreading, the later contractive leaves show activity of segmenting on individual leaflets until they are taken over by shooting towards the end. Comparing the individual sequences (Fig.2.3.2.1) with the foliage leaves (Fig.2.3.3.3) shows a reversal of the embryonic sequence in mature leaves of the same species that produces polarized tendencies for the production of forms.

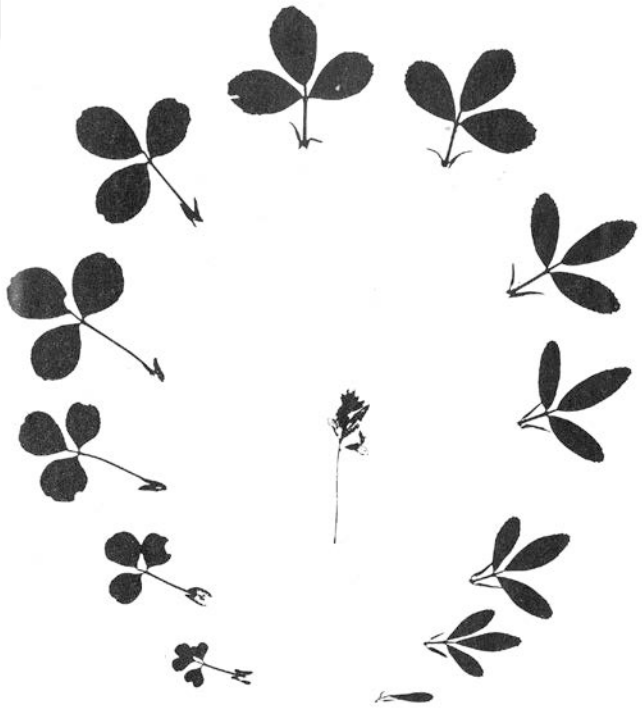

Figure 2.3.3.4 – Mature leaf sequence of Alfalfa [*Medicago sativa*] (Reprinted from Bockemühl, 1977, 149).

[555] Ibid.

A formal expression of polarity during ontogenesis is found in the mature leaves of Alfaalfa where towards the end the of sequence "elements of form can arise which have a polar relationship to the initial forms" (Fig.2.3.3.4).[556] Bockemühl looks at the contrasting relationship between the early leaves in the sequence to the rest, where the "indentations at the distal ends of the early leaves are later replaced by rounded points" showing similarity to the embryogenesis of Hairy Bittercress where the leaf blade bulges outward between contractive points (Fig.2.3.2.1).[557] In Alfaalfa, early leaves show similar contracted points are overtaken by spreading, producing heart-like shapes (obcordate); whereas, in later forms these points become expanded along more oval shaped blades (elliptic) producing polar forms within the series.

The ontogenetic sequences present a spatial distribution of the activity of polar forces and they show alternating roles within the series. While the phase of expansion "is dominated by stemming and spreading" and "sprouting and segmenting are held back," during contraction "sprouting dominates and stemming is held back."[558] If stemming and spreading are still evident during contraction "they are confined more and more to the base of the leaf" which also shifts the location of these forces along the axis of the leaf.[559] The transfer of polarized activities causes them to interpenetrate and merge in various ways during the contractive phase of development. Among these, segmenting acquires a distinct role, as with its absence the forces can only produce a simple blade shape. This also relates segmenting to separating. While the former "leads to a repetition of the same whereas separating–as a subordinated law–has to do with qualitatively different

[556] Ibid.,146.
[557] Ibid.
[558] Ibid.
[559] Ibid., 150.

tendencies (separating relegates stemming and spreading to separate regions)."[560] Thus, during expansion, separating enables the expression of duality through the division of the leaf axis which takes the form of the contrasting coupled relationship of the stem and the blade, while during contraction these two parts merge the stem remains hidden within the blade.

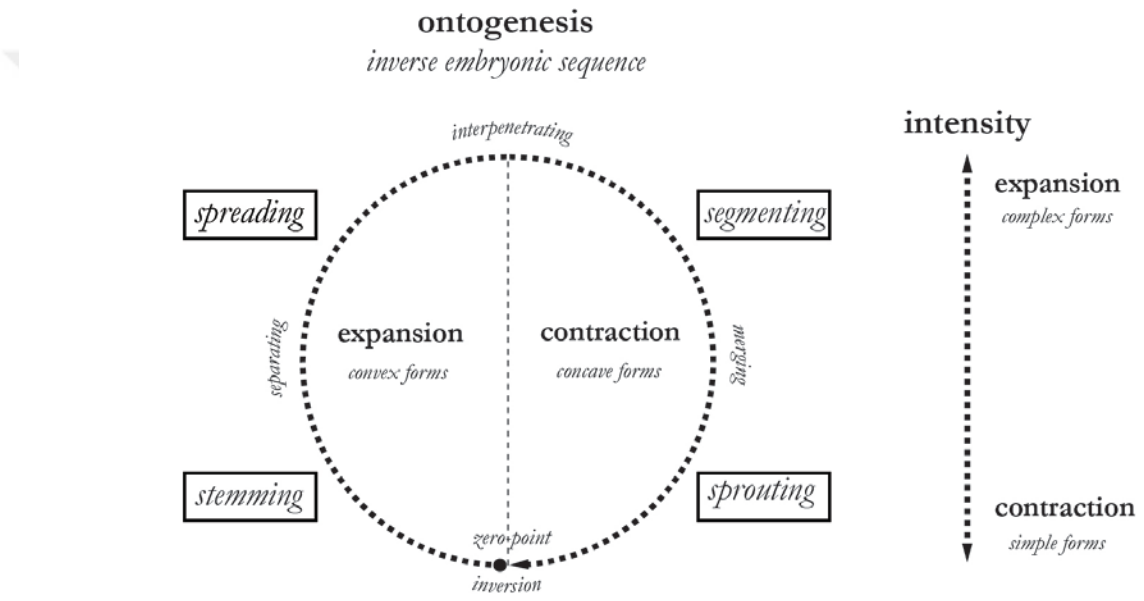

Figure 2.3.3.5 – Diagram showing the formative activities during ontogenesis organized as a loop. The activities of separating, interpenetrating, merging and inversion relate these forces to each other. The loop closes at a lower "zero-point" that repeats the whole process during vegetative growth of the plant. Inversion appears to be the transition of the cycle to a new rhythm or the opposite.

For Bockemühl, ontogenesis expresses the polar forces of metamorphosis by combining formative and regulative activities during the development of the plant where each leaf passes "rhythmically between two poles—expansion and contraction, separating and merging."[561] Although this development appears *discontinuous but cyclic*, the

[560] Ibid., 150
[561] Ibid., 150.

continual transformation of formative activities within the sequences leads to relatable leaf forms as the plant strives to complete its vegetative phase (Fig.2.3.3.5). This aspect defines to two rules for metamorphosis. Firstly, each leaf within the series expresses a certain distribution of the four activities between expansion and contraction, fixing how their embryogenesis will be expressed. Secondly, each plant species presents a "characteristic motif, which determines the interplay of the forces so that an actual *form* can emerge."[562] This motif offers some form of fixity, not for comparing typical forms within the sequence for their identification, but by establishing a formative rhythm fixated for ontogenesis that can only be seen along a transforming series belonging to the same plant. Thus, this characteristic motif, as a spatio-temporal pattern, becomes an expression of metamorphosis that is not only limited to ontogenesis but also regulates the expression of four formative activities during embryogenesis.

2.3.4 Polarity in Overall Development of a Plant

The transformative capacity of plant morphogenesis could be studied through a comparison of multiple samples from the same species. This kind of comparative study reveals how ontogeny relates to embryogeny, where Bockemühl discusses multiple leaf sequences gathered from a number of plants of nipplewort that are germinated at the same time and place but harvested at different times (Fig.2.3.4.1). The amount of vegetative reproduction among these plants produces a weakening effect while the overall growth rhythm is noticable among samples as the overall movement mimics the forms of horizontal leaf blade. In these sequences the polar opposition and merging of expansive and contractive phases of growth show how the intensity of inverse embryonic sequence

[562] Ibid., 151.

produces different rhythms among the harvested plants that is “intense and full in the lower but weakened in the upper: a wavelike pattern moves to the right and exhibit a smaller relative amplitude as one moves vertically from series to series.”[563]

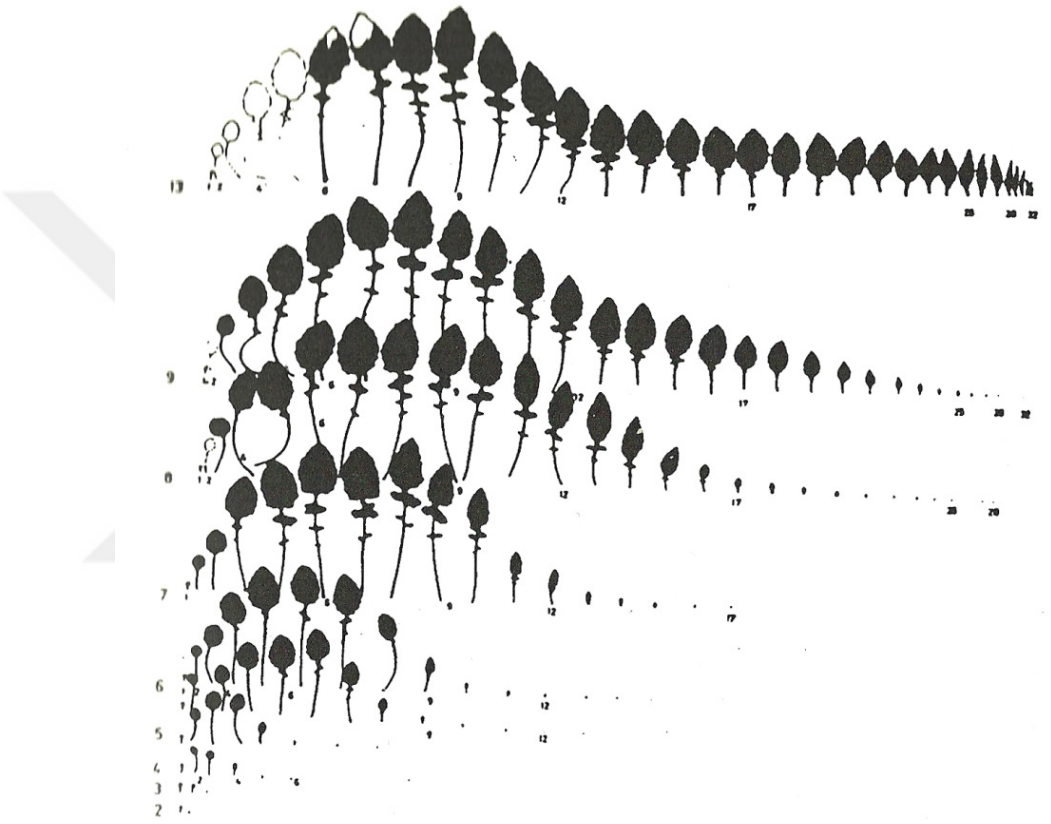

Figure 2.3.4.1 – Leaf series of Nipplewort [*Lapsana communis*] showing change of intensity during ontogenesis – “the wave.” Mature leaf sequences from several plants that are harvested at weekly intervals for during thirteen weeks. Vertical numbers [2-13 weeks] show the time of harvesting, horizontal numbers [1-32] show the order of individual leaves
(Reprinted from Bockemühl, *Goethe’s way of Science,* 1998*, 123).*

The sequences also displays the temporal variation expressed during ontogenesis of a plant where contractive forces, anticipating flowering, weaken expansive vegetative propagation of the plant. The last sequence taken from a plant grown in 13 weeks

[563] Bockemühl, “Transformations in the Foliage Leaves of Higher Plants,” 122-123.

presents a wave outline that resembles a leaf contour formed by the *separation* and *merging* of the stemming and spreading activities observed previously on individual leaves (Fig.2.3.3.1-4). While "the wave" as an open version of the loop highlights the changing intensities during ontogenesis, its movement still produces a leaf contour among discontinuous sequences that reveals the polarity of the whole plant. Thus, the weakening along the sequence is an expression of the contraction that accelerates the filtering of raw fluids by the flower organs and causes the sequence to be limited to contractive forms by the time leaf #12 is reached.

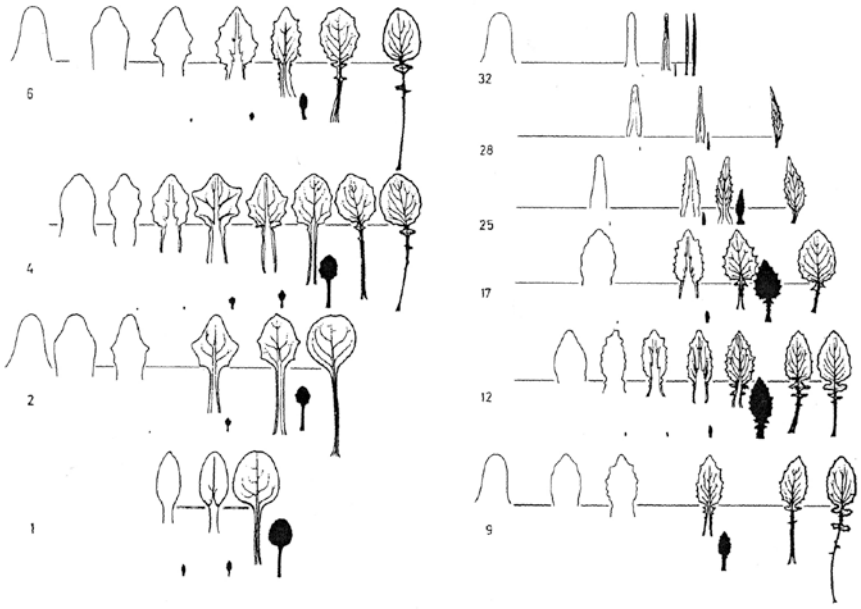

Figure 2.3.4.2 – The embryonic development of individual leaves for nipplewort. Each row represents the development of a selected leaf. The numbers at the left of each row are those of the individual leaf's place within the entire foliar development (Reprinted from Bockemühl, *Goethe's Way of Science,* 1998, 125).

The series is further analyzed using individual nipplewort leaves selected from the sequences to reveal how the weakening effects the embryogenetic sequence (Fig.2.3.4.2). With the exception of first and last leaves among the sequence that show no signs of

segmenting, the rest of the sample leaves show all four activities in changing configurations. Among these, Bockemühl remarks that the weakening of spreading after leaf 2, which is "no longer able to either 'round out' completely the apices created by articulating or to halt the multiplication of leaf forms" that "is accentuated even more strongly in" leaf 12.[564] Towards the end of the sequence when leaves 25 to 30 are reached, "not only spreading but also segmenting (articulating) and stemming have nearly disappeared" showing the inverse embryonic sequence of formative activities.[565] For Bockemühl the last leaf in the sequence, leaf 32, represents "the 'confluence' of these two inverse streams, the place where the micro- and macro-developments intersect" where *inversion* as a regulative polarity switch occurs.[566] Thus the ontogenetic sequence ends with the "first activity of the embryonic sequence, shooting" where individual leaves as parts appear in a polarized relationship to the overall plant development as a whole.[567]

To visualize the interrelationship of polarized growth sequences of embryogenesis and ontogenesis Bockemühl produces a diagrammatic layout of the overall development of Nipplewort leaves (Fig.2.4.4.3). This arrangement is shown around a semi-lemniscate using three types of arrows representing formative movements among the series. The outer curving arrows and leaf forms placed around the periphery from lower left to lower right represent the leaf forms produced during vegetative growth until flowering. These depict ontogenesis—*inverse embryonic sequence* (Fig.2.3.3.1-4). The spiraling radii show the "embryonic forms of the leaves at intervals proportional to their proximity to the shape of the fully developed leaf" corresponding to embryogenesis—*embryonic*

[564] Ibid.
[565] Ibid., 124.
[566] Ibid.
[567] Ibid.

sequence (Fig.2.3.2.1).[568] The straight lines radiating from the center "connect forms in which the four activities stand in approximately the same relationship to each other."[569] For example the third and fourth rays in clockwise order show predominant activity of spreading, while sixth ray shows segmenting. The forms arranged along the radiating straight lines express the same activity that is attributed to inorganic growth –"if the plant grew linearly, like a crystal, the growth of each leaf form would follow the straight radii", however, each leaf form "represents a nexus or confluence of complex growth rhythms" thus bending the trajectory of each leaf growth backwards.[570] This counter activity is more visible in the early leaves towards the left, where the initial activity of sprouting has almost disappeared. However, on the right side, sprouting fully overlaps with its reversal, producing an almost linear trajectory as the plant approaches flowering. Bockemühl attributes this principle to the two polar stages of growth.

> Where the inner spiral movement meets the counter movement of the periphery, there stands a mature leaf. Every leaf originates as the product of these two movements. If the path along the outer loop is short, then the path along the spiral is long and strongly curved. A leaf that emerges after the plant has undergone much development–in other words, one that one reaches on the outer loop only after traveling far to the right- passes through only minor changes of form in its development and has a path that is weakly curved, approaching a straight line.[571]

[568] Ibid., 124.
[569] Ibid.
[570] Ibid.
[571] Bockemühl, "The Formative Movements of Plants," 158.

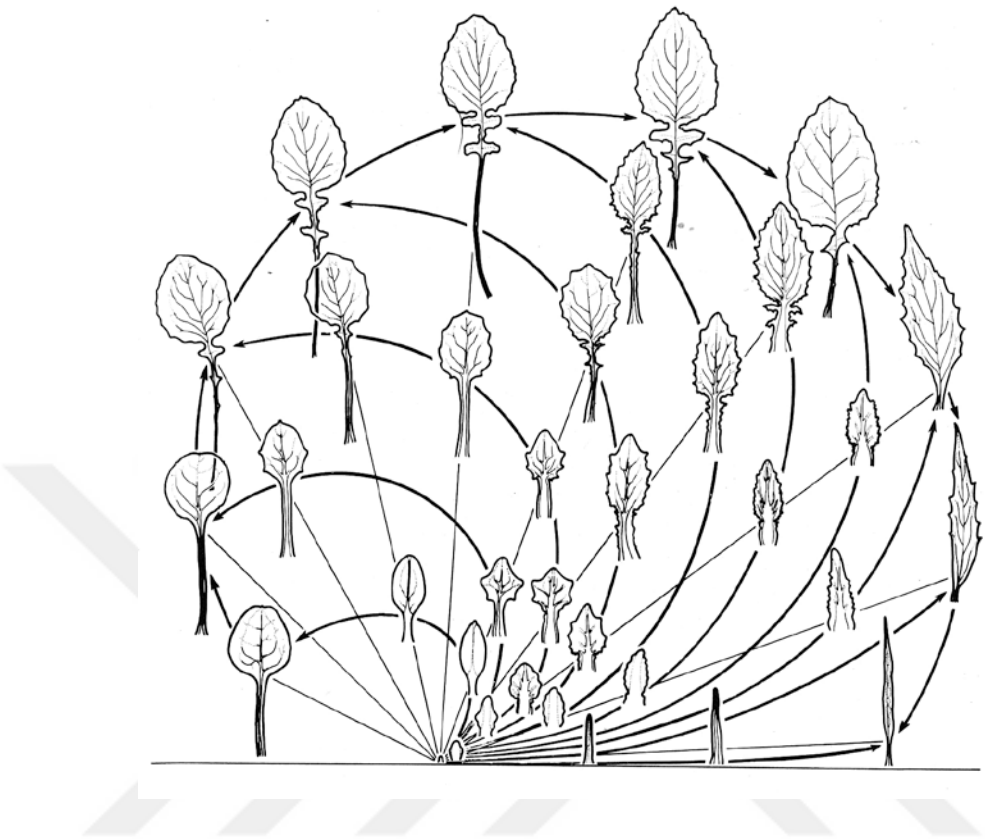

Figure 2.3.4.3 – Developmental movement of the leaves of nipplewort. The drawing shows the relation between the changes of form during the growth of individual leaves from growing point to mature leaf (arrows radiating counterclockwise from center) and the changes of form in the sequence of mature leaves from the seed leaf to the highest leaf (outermost arrows clockwise) (Reprinted after Bockemühl (1977), 155).

From this diagram, two conclusions can be made. Firstly, as the streams overlap more with the presence of contraction, the expression of the inner polarity of the leaf becomes more perfected, the juices get more refined, producing only a single activity, shooting, rather than several that mix with each other. Secondly, expansion tends to retard embryonic development as it counters contraction and rounds out forms by bending linear trajectories (crystalline growth) into an organic one (spiraling growth). This diagram shows that the organization of the outermost leaves not only correspond to two cyclic streams that meet in the production of each leaf, but it also explains the full

picture of variability of a plant achieved in a spatio-temporal domain. The embryonic sequence marked by continuous production of forms in a spatial domain is counter balanced by discontinuous forms produced along the stem, while still presenting a continuous wave expressing the consistency of underlying forces. Bockemühl considers there to be polarity between the dual dimensions of form, space and time, where the latter "is not exhausted by the sequential appearance of things in space."[572] Similar contrast is developed between ontogenesis and embryogenesis, where the former as "an *ideal* movement underlying the plant's development" is countered by the latter as "the *real* (substantial) transformations of the leaf pass through the tendencies of this ideal movemnet in opposite direction."[573]

2.3.5 Reversed Biogenesis: Polar Relationship of Phylogenesis and Ontogenesis

Bockemühl's discovery of polarized relationship between ontogeny and embryogeny has been influential in reconsidering the biogenetic law, whether there could also be a polarized relationship between ontogeny and phylogeny. Historically, ontogeny has been mainly developed through taxonomy and adaptation à la Darwin, which placed type as a schematic construct that gradually transform under the influence of external factors. Throughout the development of biology, phylogenesis has been reconsidered in new terms, such as fetalization or retardation, that attempted to correlate "extended and slowed down development" to various allometric effects, while ontogeny took place through a polar relationship between related organs which defined "hypermorphosis (over formation)" where "as the development progresses the retarded organs (the latecomers)

[572] Ibid., 159.
[573] Ibid.

continue to grow for a long time still, whilst the growth of the propulsive organs (the forerunners) decreases."[574] In arms, the hypermorphosis presents such a polarized relationship between the hand and the upper arm where the former grows first while the latter remains retarded. In this way the arm as an appendage to the main body shows similarity to leaf morphogenesis, where it "develops in accordance with *a distalproximal gradient* (from hand to shoulder)" until "sometime later in the embryogenesis, deviates from it through a specialization."[575] This process mimics the embryogenetic sequence described above that alternates between the blade (hand) and the stem (arm) through polarity switching.

In *Ontogeny and Phylogeny*, Gould revisits some ideas in evolutionary theory that aimed at bridging the two aspects of development by comparing the biogenetic law–ontogeny recapitulates phylogeny–as advocated by Haeckel and its opposition in von Baer.[576] In recapitulation, two main mechanisms are described that are accepted among evolutionary biologist and define a linear and polarized trajectory for development. The first term "'terminal addition'—evolutionary change proceeds by adding stages to the end of ancestral ontogeny" which expand the development of an organism for further complexity; this is countered by the second term "condensation" where "development is accelerated as ancestral features are pushed back to earlier stages of descendent embryos."[577] Gould relates these two aspects to the acceleration and retardation of paedomorphism, reconsidering Bolk's theory of fetalization that defines a peadomorphic

[574] Trond Skaftnesmo, "Goethe's Phenomenology of Nature: A Juvenilization of Science" in *Rivista di Biologia/Biology Forum*, May-Aug;102(2) (2009): 190.
[575] Ibid., 194 "The stretching of the gibbon-arms implies a deviation from the generalized vertebrate growth pattern, while the stretching of the legs of man is a direct expression of this growth pattern. Both structures serve their function. In this very restricted sense they are both adaptive. But only the first structure is a specialization. The second structure is what we get when a specialization is *not* taking place. We should not fail to recognize how this insight changes our picture of the evolution of man, indeed of evolution on the whole."
[576] Gould, *Ontogeny and Phylogeny*.
[577] Ibid., 7.

origin for human evolution where adult forms, as they evolve, retain juvenile features. Following the strong evidence presented in Bolk's theory, Gould considered human beings to be "essentially neotenous", where "a *general, temporal retardation of development has clearly characterized human evolution" and "this retardation established a matrix within which all trends in the evolution of human morphology must be assessed*."[578] Among these features the increase in brain size and the loss of rotation of the big toe are given as examples that show how reverting back to an early plastic stage of ontogeny can induce further morphological change. Thus, neoteny could offer a polarized mechanism for retardation of development where the trajectory is bent backwards toward "a storehouse of potential adaptation" that can carry early dynamic structures and shapes "forward to later ontogenetic stages."[579]

Another discussion of neoteny that particularly focuses on the phylogenesis of plant morphology is provided by biologist Andreas Suchantke, who considers the polarized relationship between ontogenesis and embryogenesis, presenting a paradoxical observation, where "*in the course of its ripening, the plant, in growing older, arrives at ever more juvenile stages.*"[580] Suchantke extends the concept of metamorphosis towards the biogenetic law and discusses formative tendencies described by Bockemühl by looking at the paleontological record of land plants. He states the polarized growth is not limited to ontogeny and embryogeny, but is extended towards phylogeny as well, where metamorphosis runs counter to phylogenesis that defines a "*reversed biogenetic law*."[581] The paleonotlogical record shows that early land plants show only shoots or highly segmented leaves that are then replaced by bladed leaves as the species evolves

[578] Ibid., 365.
[579] Ibid., 375.
[580] Bockemühl et al., *The Metamorphosis of plants*, 52.
[581] Ibid., 54.

(Fig.2.3.5.1). This transition shows similarity to the embryonic sequence where the similarity between the parts and the whole of a plant are reduced and the former are "subordinated" under the latter during phylogenesis until the whole leaves appear divided and differentiated under polarity.[582] Suchantke relates this tendency to the reproductive phase of the plants that "reverses the formative sequence of phylogenesis," thus "the 'reversed Biogenetic Law' is an expression of the flowering-impulse."[583] In herbaceous plants the metamorphosis of leaf forms only occurs in flowering plants. The non-flowering ones, on the other hand, produce only the last stage of phylogenetic development as the inverse stream seems transfixed.

Figure 2.3.5.1 – Phylogenesis of the Ginkgo leaf (Reprinted from Bockemühl et al., *The Metamorphosis of plants, 56-57.* Original image source: Krausel 1953 and Magdefrau 1968).

Although there is a repetitive relation between ontogenegy and phylogeny, recapitulation does not appear to be linear due to the involvement of time, but it presents cycles of development. As forms evolve, they tend to express younger traits in their ontogenesis as if evolution is working backwords on forms that are rapidly produced. Suchantke describes this as the "*juvenilization"* or "*neoteny*" that could be the key to understand morphological constraints and how polarity acts on a larger scale to reverse

[582] Ibid., 55. Suchantke quotes Goethe's morphological writings on subordination of parts: "The less perfect the creation, the more its parts are alike or similar and the more they resemble the whole. The more perfect the creation the less similar its parts become. In the first instance the whole is like its parts to a degree, in the second the whole is unlike its parts. The more similar the parts, the less they will be subordinated to one another. Subordination of parts indicates a more perfect creation."
[583] Ibid.,58.

morphic movements which "signifies a return to the origin, in the sense of a state in which all possibilities are still (or once again) open."[584] While variation in ontogeny is expressed through growth and aging, phylogeny shows morphological tendencies expressed among species under changing spatial conditions such as climate and geography that are still effected under the dynamic rubric of ideal productivity of nature– the archetype.

2.4 Polarity and Leaf Morphology

In this section the concept of polarity will be explored by looking at leaf morphogenesis from a digital perspective using algorithms. This approach will consider Bockemühl's rules for ontogenesis and embryogenesis through simple formal principles of expansion and contraction that will remain generative, diagrammatic and abstract. In his botanical writings, Goethe suggests such an algebraic approach to investigate the generative capacity of the archetypes.[585] Although polarity mainly expresses a spiraling tendency in nature that produces rotational symmetry radiating from an axis, in leaves, this radial capacity is restricted to a plane that mainly establishes bi-lateral symmetry and an axis for each leaf.[586] By considering the left and right halves of an organism to be complementary, polarity could be studied by developing simple geometric rules of

[584] Ibid.,63. Suchantke also finds evidence to such formulation in paleontological records where animal and plant evolutionary records points to a form of "neoteny (= foetalisation: the preservation of juvenile traits in maturity." In animals, this causes the exoskeleton to be gradually reduced and in plants this relates to the origin of Monocotyledons that preserves juvenile traits such as reduced axial activity, less developed roots and undifferentiated leaves that resemble the incompletely developed leaves of Dicotyledons.

[585] Goethe, *Italian Journey*, 310. In his entry on May 17, 1787 in Naples Goethe defines the generative capacity of the archetype: **"**With this model and the key to it, it will be possible to go on forever inventing plants and know that their existence is logical; that is to say, if they do not actually exist, they could, for they are not the shadow phantoms of imagination, but possess an inner necessity and truth. The same law will be applicable to all other living organisms." Goethe also mentions the algebraic applicability of polarity in *Botanical Writings*, 102. "…the conceptions established above-of expansion and contraction, compression and anastomosis-would have to be manipulated as expertly as algebraic formulae, and would have to be applied in the right places."

[586] On the orign of radial symmetry and its fractalized expression in plants see Roger V. Jean, "On the Origins of Spiral Symmetry in Plants," in *Spiral Symmetry*, eds.István Hargittai and Clifford A Pickover (Singapore : World Scientific, 2000): 323 – 351. Jean argues for the existence of a phyllotactic pattern of plant growth that shows kinship to dendrites and fractals found in crystals. He considers a consistent proportional rhythm that generates similar forms in plants that could also be visualized using L-systems. For the relationship between radial and bilateral symmetry see Mark Q. Martindale and Jonathan Q Henry, "The Development of Radial and Biradial Symmetry: The Evolution of Bilaterality," in *American Zoologist* Vol. 38, No. 4 (Sep., 1998): 672-684.

expansion and contraction that articulate growth from a magnetic axis by recursively adding new charged points to the forms. This draws polarity closer to symmetry, where the latter becomes an expression of how polar-magnetic forces act on forms.[587] Thus, Bockemühl's discoveries could be reevaluated and extended using algorithms that can generate leaf forms to test the existence of morphological constraints of growth. This will position polarity as a generative model of growth that can unravel secrets of symmetry and potentially aid in the development of new computational tools for the study of form.

2.4.1 Diagramming Leaf Polarity

Prior to developing an algorithmic approach for the study of polarity in leaves, it is necessary to develop a diagrammatic understanding of leaf morphology that is based on a bi-polar axis. The justification for this hypothesis is found in both Goethe's writings on animal archetype and in Bockemühl's essays on leaf development. In his morphological writings on the animal archetype, Goethe describes a linear organization for the animal archetype that aligns sensory, locomotive and reproductive systems along a body axis.[588] In his supplementary texts on plant growth, he also develops an axial basis for plants that combines vertical and spiraling tendencies to facilitate vegetative and reproductive growth.[589] Bockemühl also describes an axial tendency in leaf morphology where the poles are capable of switching direction of growth.[590] Although Goethe does not attribute a direct axial basis for the structuring of leaves, various examples provided by

[587] On the relationship of polarity and symmetry and sexual forces see Werner Hahn, *Symmetry as a Developmental Principle in Nature and Art* (Singapore: World Scientific, 1998), 190. In chapter 10 titled "Causes and Processes of Morphological Evolution. Facts and Interpretations," Hahn develops his "molecular theory of symmetrization" which utilizes "presumably different, mobile opposite and complementary 'charges' and which presumably produce together by bonds the particles of matter (biomolecules): exchange of charges positive-negative/left-right/female-male."
[588] Goethe, *Scientific studies*, 119-120. On this issue see also Schad, *Man and mammals.*
[589] Goethe, *Goethe's Botanical Writings*, 128.
[590] Bockemühl, "The Formative Movements of Plants," 132.

Bockemühl show that polarity acts as a magnetic principle for leaf morphogenesis where "actual formative movement passes rhythmically between two poles—expansion and contraction."[591] Thus organic forms appear fixated on a magnetic polar axis that regulates their growth and differentiation (Fig.2.4.1.1).

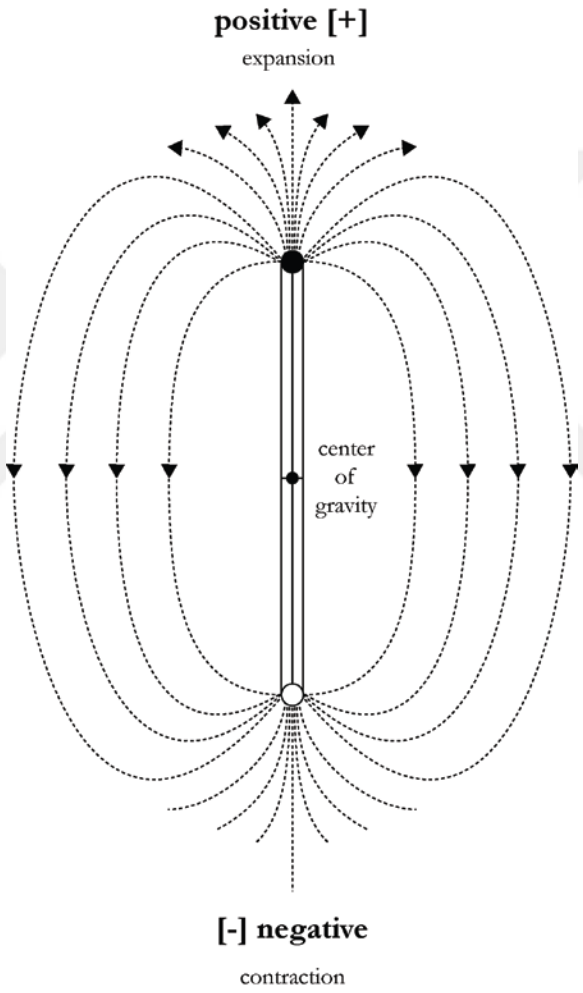

Figure 2.4.1.1 – Polarity axis in between magnetic poles. Expansive pole grows with shooting and spreading, while contractive pole grows with segmenting and stemming.

[591] Ibid., 150.

Figure 2.4.1.2 – First leaf from Brady's buttercup sequence.

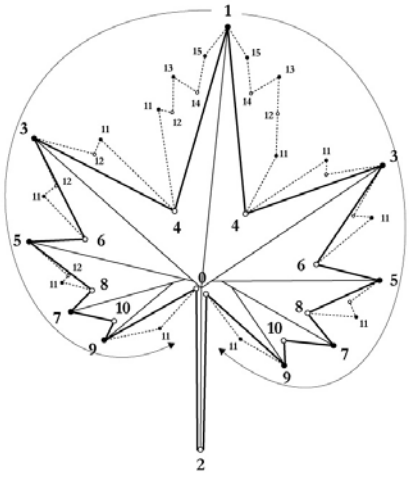

Figure 2.4.1.3 – Polarity diagram diagram of the leaf showing expansive points with odd numbers (black) and contractive points with even numbers (white) showing their order of generation.

A common feature of this magnetic axis is its alignment with the leaf midrib that introduces a plane of symmetry for growth. However there are many other examples that do not show a predominant central axis such as ginkgo where this morphological principle may remain hidden. When the midrib of a leaf is considered a magnetic axis, it is possible to diagram the polarity of any leaf by placing expansive and contractive points

along its formal outline. Using the first leaf from Ronald Brady's buttercup sequence, these polarized points could be distributed along the leaf blade to reveal an inherent sequential order that complements metamorphosis (Figs.2.4.1.2-3). In Buttercups, the axis initially grows through radial symmetry during its contractive cycle, producing nine conjoined shoots. During expansion, each partial shoot further grows linearly by producing single or double branches that increase the amount of points along the blade. These partial shoots partake the activity of metamorphosis that governs the plant as a whole, wherein "*the leaf is a partial-shoot, arising laterally from a parent whole-shoot"* which defines the embryogenesis of each leaf.[592] Thus, polarity manifests itself during all growth phases of a plant where it transcends between ontogenesis of the whole plant, embryogenesis of each individual shoot, and the topological information distributed along the blade.

The center where the stem is attached to the blade of each individual leaf marks a special point for metamorphosis that not only separates the contractive stem from the expansive blade but also acts as the center of gravity pulling contractive points towards it. In contrast, the expansive points spawned from the new outlines formed between expansive and contractive edges constantly break the geometry of the leaf into complementary polar halves. Seen in this way, the leaf looks like a mechanical clock that moves in polar radial directions, adding partial shoots at odd numbers, and contractive points that pull the form towards the center at even numbers. The two counter streams work in opposition, the first moving from the expansive pole towards the contractive one through radial symmetry, and the latter, moving from each contractive lobe of the partial shoot towards its tip (Fig.2.4.1.2-3).

[592] Arber, *The Natural Philosophy of Plant Form,* 74.

Figure 2.4.1.4 – Coconut palm leaf.

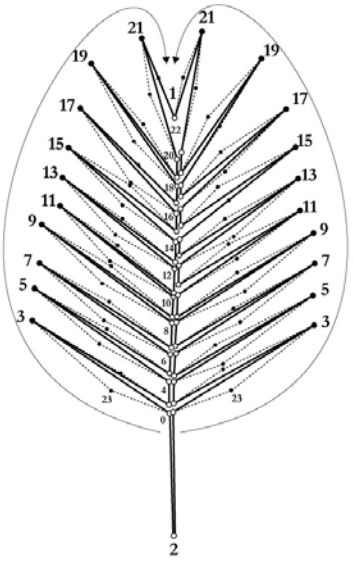

Figure 2.4.1.5 – Polarity diagram of the leaf showing expansive points with odd numbers (black) and contractive points with even numbers (white) showing their order of generation.

This diagram shows that expansion and contraction effects the direction of new points that will be added to the leaf, increasing the amount of information along the blade bounded by two magnetic poles. In this sense, polarity also produces two overall

directions for formal growth. If this movement is contractive, the points move towards the contractive pole via negative radial symmetry. In the case of expansive movement the point sequencing is reversed, where the points are generated towards the tip of each partial axis producing positive radial symmetry. When this expansive movement is balanced with contraction then the leaf often turns into a compound leaf. When contraction is lacking, the leaf performs a counter radial movement producing a heart shape, opposite of contractive movement. This type of expansive movement can be seen in the diagram of a coconut palm leaf which shows the clocklike movement in the opposite direction moving from the contractive pole towards the expansive one (Fig.2.4.1.4-5). The overall direction of growth between expansive points along the blade shows polarity to the contractive movement observed in buttercup leaf.

These expansive and contractive movements happening in positive and negative directions along the blade also highlight four types of physiological tendencies for leaf morphology. Apart from leaves that are primarily produced during vegetative growth, these tendencies occur at all levels of generation including flower organs and fruits that produce infinitely variable expressions and intermediate blends of polarized forms (Fig.2.4.1.6). These diagrams primarily show the topological proportions of the overall movements happening along expansive points of the blade. While contractive points mainly produce lobes, serrations and compound expressions with subordinated leaflets could also follow this overall prescribed movement. Various examples could be given for each type. The expansive-contractive leaf, also known as obcordate or heart shaped, is mostly expressed in the production of petals, while it can also occur in vegetative forms such as ginkgo biloba and hop. The contractive-contractive leaves are normally called

elliptic due to their blade curvature and produce the most common leaf forms such as magnolia and citrus while also appearing in sepals. The expansive-expansive or the oblong type is mostly encountered on fruits as well as the in the production of male sexual organs (stamen) in flowers. The contractive-expansive or the cordate type can be found among fig, sycamore, tulip and ivy leaves that exhibit different proportions of blades and stems as well as in the female reproductive organs (pistil). This particular form can also occur towards the end of vegetative sequence, as previously shown in sow thistle, due to the dominating contractive tendency of the plant as it approaches sexual production of flower (Fig.2.3.3.1). As a result, metamorphosis could be considered operating primarily along a polarity axis; as the leaf expands and contracts in an alternating fashion it distributes polarized points as remnants of its internal rhythm, producing a particular morphological motif.

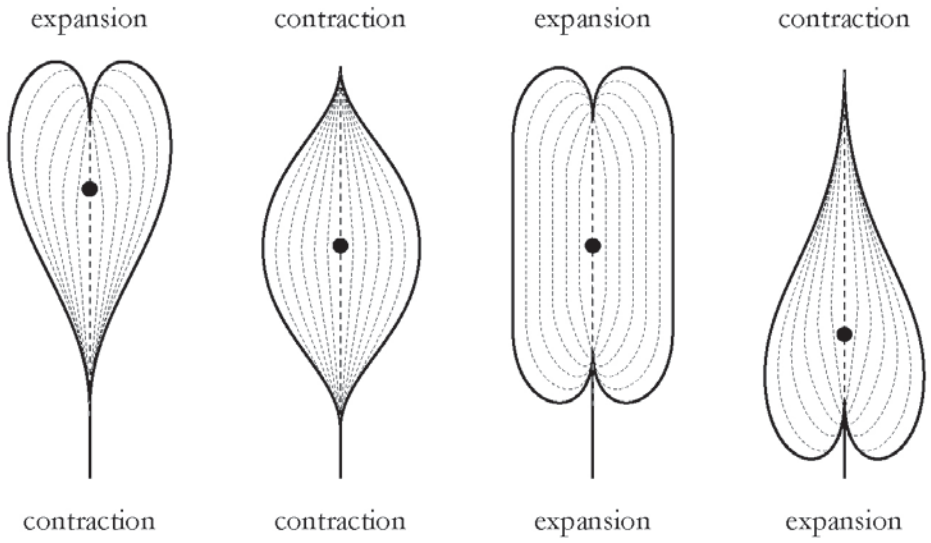

Figure 2.4.1.6 – Diagram showing magnetic form tendencies based on the relationship of poles. The point along the axis marks the center of gravity of the leaf. These forms could occur on all kinds of embryogenesis throughout development in both vegetative and reproductive organs.

2.4.2 Polarity and Generative Leaf Embryogenesis

Among the many theories on leaf growth, perhaps the most prevailing and convincing hypothesis is on the activity of growth hormone auxin proposed by Tsvi Sachs in *Pattern Formation in Plant Tissues.*[593] Auxin's primary role has been defined as a guiding mechanism for the flow of nutrients through the leaf form, influencing the development of leaf venation and blade outline. As Sachs states, "polarity is both induced and expressed by the oriented flow of auxin" where this hormone is produced along the leaf contour and acts as a catalyzer for cell polarization and canalization.[594] Current research in developmental biology conforms to the activity of homeobox genes and production of growth hormones along the margins of the leaf blade that regulate the polarization of cell tissue, guiding development of morphological traits.[595] The auxin hypothesis has been influential to many generative applications which study variability of leaf venations, leaf contours and volumetric tree generation.[596] Another avenue has been pursued using Prusinkiwicz's L-systems which suggests algorithmic substitution rules for the generation of branching systems that are applicable to compound leaves and trees.[597] While these systems have offered a foundation for the study of botanical forms using recursion, this

[593] Tsvi Sachs, *Pattern Formation in Plant Tissues* (New York : Cambridge University Press, 1991), 52-88. In chapters five and six, Sachs develops the canalization hypothesis that rests on the idea of the auxin hormone populated throughout the plant as a guiding mechanism in its development, redirecting cell polarity and influences vein development.
[594] Ibid., 67.
[595] On the activity of genes regulating leaflet initiation on tomato see Yael Berger et al., "The NAC-domain transcription factor GOBLET specifies leaflet boundaries in compound tomato leaves," in *Development* (2009, Mar), 136(5): 823-32. On the genetic relationship between Arabidopsis thaliana and the compound *Cardamine hirsuta* see Daniela Vlad et al.,"Leaf shape evolution through duplication, regulatory diversification, and loss of a homeobox gene," in *Science*, (2014, Feb 14); 343(6172):780-3.
[596]An example of auxin based leaf venation algorithm can be found in Adam Runions et al., "Modeling and visualization of leaf venation patterns" *ACM Transactions on Graphics* 24(3), (2005): 702-711. For an overall application see Adam Runions, "*Modeling Biological Patterns With a Space Colonization Algorithm."* PhD diss., *University of Calgary*, 2008.
[597] A discussion of L-systems and their application for plant growth can be found in Przemysław Prusinkiewicz and Aristid Lindenmayer, *The Algorithmic Beauty of Plants* (Springer-Verla, 1990). Another application is also provided in Stephen Wolfram, A New Kind of Science (Champaign, IL : Wolfram Media, 2002), 400-406.

chapter will present an alternative recursive approach based entirely on Goethe's concept of metamorphosis.

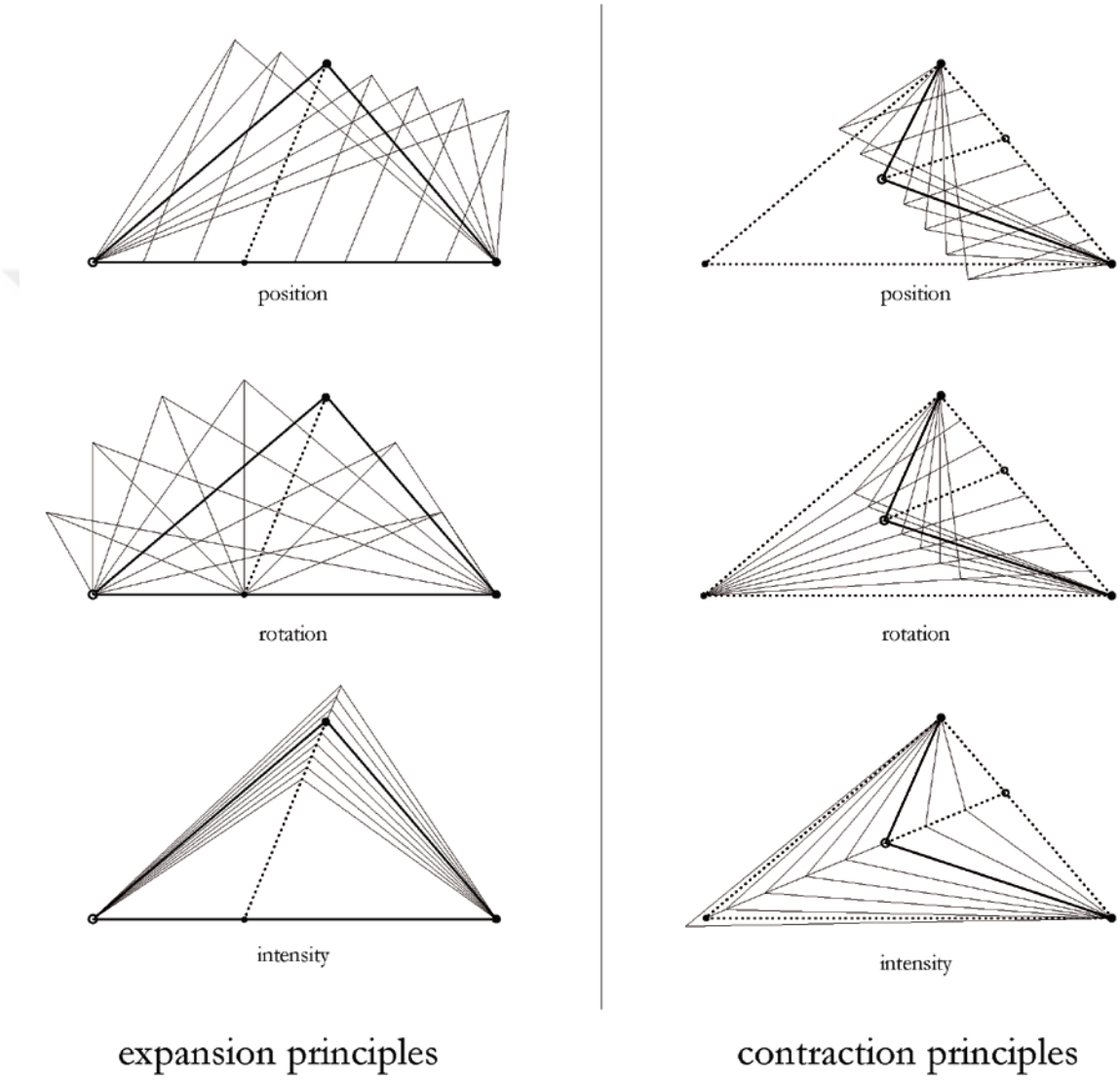

Figure 2.4.2.1 – Expansion and contraction principles showing development from a polarity axis. Position and interpolation parameters are influenced by polarity whereas intensity displaces new points away from the axis by either moving them outwards into space (expansion) or pulling them towards an anterior center of gravity (contraction).

An algorithmic aspect of the concept of polarity is its alternating function between expansion and contraction, similar to a breathing cycle for growth (Fig.2.4.2.1). This requires a bi-polar approach for formal development where the recursive functions alternatively trigger each other and operate through simple geometric principles that can expand and contract forms. This approach primarily divides the axis of growth by introducing new information in between opposite poles. Another algorithmic property of polarity is to rotate the axis for the placement of new points which either expands by moving away from the form outline or contracts by moving towards a center of gravity present along an axis. During these operations, intensity appears primarily responsible for the degree of the new points that characterize the outline of form. Thus, intensity as a formal principle relates more to the movement of information, while polarity is responsible for placement of information through the magnetic division of geometry anchored in between two poles.

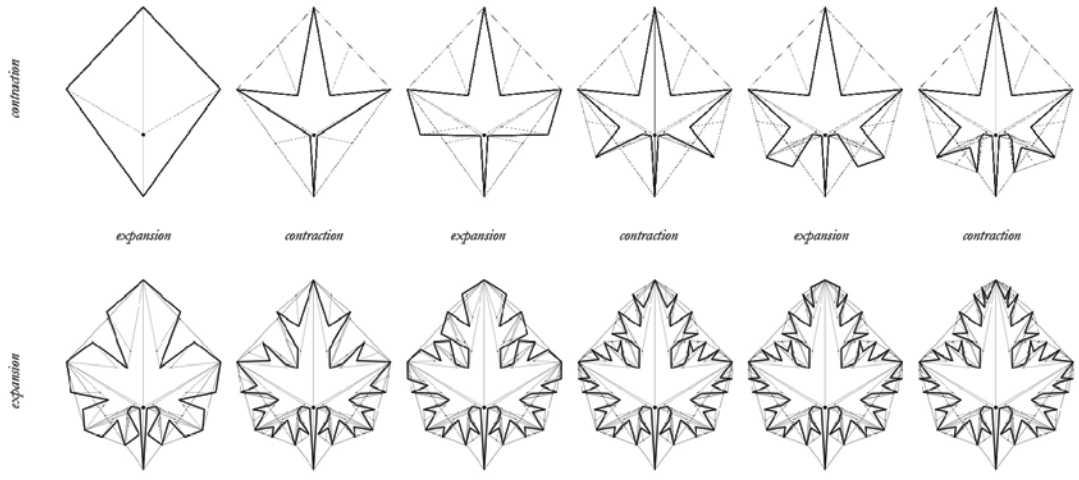

Figure 2.4.2.2 – Diagrams showing embrogenetic sequence of Common Buttercup. Contractive sequence is guided by shooting (CE) and segmenting (CC) that multiplies the main leaf axis into odd numbers (1-3-5-7). During expansion each axis grows separately using spreading (EE) and stemming (EC).

The algorithmic roles of expansion and contraction during growth can be better visualized through an example using the embrogenetic sequence of a single buttercup leaf (Fig.2.4.2.2).[598] This sequence shows that polarized growth mainly occurs as an alternation of forces that continually adds points to the growing blade using EC cycles. Furthermore the dual state of polarity also divides the overall sequence into two spatio-temporal stages. During contraction, the overall organization of the leaf blade is defined that can either establish a segmented, compound or single leaf. During expansion, each broken segment of the blade takes on further development separately by receiving expansive and contractive forces based on geometric thresholds between polarized points. The growth cycle begins primarily by expansion that breaks the initial polarity axis into four edge lines turning the axis of the leaf into a quad with different lengths of edges. In the next step contraction pulls each outline towards the geometric center of the expansive points as a way to return form towards an antedecent center of gravity. Thus, every expansion is complemented by a contraction where breathing and pulsating inner movements externalizes into a formal outcome.

Bockemühl's four morphogenetic principles of shooting, segmenting, spreading and stemming can be redefined through polarity. During the contractive cycle, shooting is responsible for expansion while segmenting operates through contraction. Depending on the amount of contraction and the direction of symmetry along the axis, the leaf can become lobed or compound distributing leaflets along the central axis. During the expansive cycle, spreading takes the role of topologically stretching the blade by increasing the size, adding more points to the blade, while stemming acts as a contractive force elongating the stem, producing indentations or stems of leaflets. When there is

[598] Pseudo code for this algorithm could be found in Appendix A.

excessive segmentation during contraction, the concave blade pulls towards the center of gravity until it meets the main axis of the leaf, producing a stem. Thus, the leaf can either produce an expansive planar surface or a contractive coiled stem since negative growth can not surpass the main axis of the leaf as it is countered by the opposite symmetry half. After the first EC cycle, each half of the leaf mainly produces four new edges that distribute expansive and contractive tendencies (Fig.2.4.2.3). When the growing edge is along the stem half then the leaf produces rotation during the contractive cycle. In the opposite case, the blade continually expands towards the tip producing more repetitive branches than are usually found in the recursive growth pattern of ferns. These two antagonistic rotational capacities define four types of polarity clocks for the leaves that mainly distribute radial symmetry along the blade (Fig.2.4.2.4).

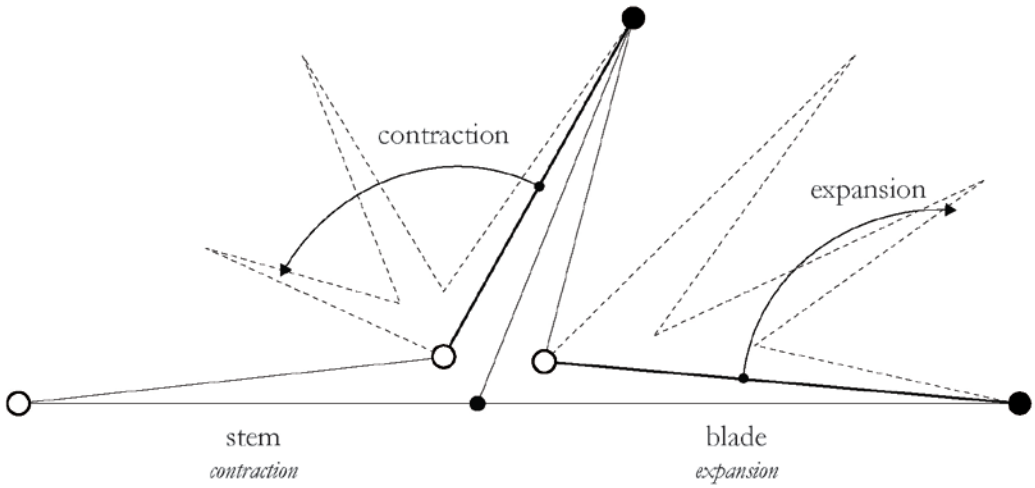

Figure 2.4.2.3 – A half leaf showing the polarity movement after first EC cycle. Contractive movement operates sinistral and rotational, while expansive movement is destral and linear.

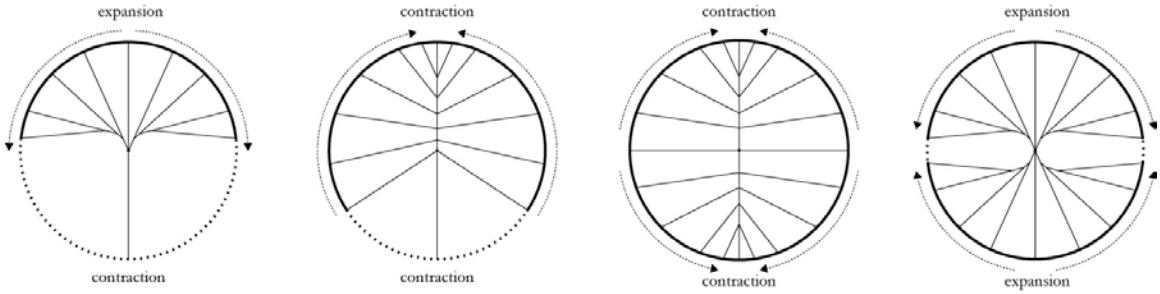

Figure 2.4.2.4 – Four types of polarity clocks based on the condition of poles that guide the development trajectory.

The leaf main axis is also responsible for establishing an overall symmetry between the left and right halves of the leaf.[599] Although all leaves start their growth three dimensionally due to the spiral tendency existing in the plant, this growth is often terminated when leaves are produced as planar surfaces during vegetation. Most evergreen trees, such as pine, follow phyllotactic formal development which can populate small leaflets in a spiralling fashion along a branch where reflective symmetry is not applicable.[600] Here, expansion and contraction offer a way of establishing a link between radial and bilateral symmetry; when the spiral that is primarily responsible for the expansion of plant is contracted, it becomes restricted to planar development producing a complementry half to itself which establishes a reflective symmetry axis for the leaf.[601] In other words, it is possible to consider the plant as primarily acting between two spiralling tendencies in opposite directions that appear compressed into a planar form to produce symmetrical leaves. Evidence of this tendency can be found in asymmetrical leaves such as american elm, that still express an imbalance between the opposite spiralling streams that produce unmatched radial symmetry between complementary halves. Thus,

[599] On the issue of mirror symmetry and enantiomorphism see Martin Gardner, *The New Ambidextrous Universe: Symmetry and Asymmetry from Mirror Reflections to Superstrings* (New York, NY : W.H. Freeman, 1990), 20. On its axial basis see Hermann Wely, *Symmetry* (Princeton: Princeton University Press, 2005), 4.
[600] Joe Rosen, *Symmetry Discovered: Concepts and Applications in Nature and Science* (Cambridge ; New York : Cambridge University Press, 1975), 90.
[601] On this speculative issue see *Martindale and Henry* "The Development of Radial and Biradial Symmetry."

expansion and contraction offer a dynamic transformation from three dimensional to two dimensional forms that produce both planar and spatial forms using phyllotactic distribution of lateral shoots (Fig.2.4.2.5-6).

Figure 2.4.2.5 – American Elm as an asymmetrical example of a contractive (planar) leaf showing radial asymmetry operating on both halves along the midrib.

Figure 2.4.2.6 – Cedar Cedrus as an asymmetrical example of an expansive (helical) leaf showing radial asymmetry distributed along a spiraling shoot.

2.4.3 Polarity and Generative Leaf Ontogenesis

The application of polarity towards an understanding of ontogenetic growth requires extension of polarity parameters over a sequence of leaves. To investigate how expansion and contraction are transformed during growth, Ronald Brady's Buttercup sequence will be used that displays adequate morphological complexity and variation among leaves (Fig.2.2.2.1). A linear arrangement of this sequence shows that radial symmetry predominates the embryogenetic cycle throughout the sequence (Fig.2.4.3.1). Among these, the middle forms display more complex development with increased overall size and balanced combination of parameters that articulate radially expanded leaflets with additional indentations. This further expansion decreases towards contraction while the radial arraying of leaflets also shows variation. The early leaves exhibit clear five-fold symmetry while towards contraction the fifth axis is compressed as it fully disappears before flowering. A similar variation occurs for expansion where early leaves show lack of contraction as the first leaf produces a larger unsegmented blade, while towards the end forms the blade becomes thinner showing the increased intensity of contraction during the first cycle of embryogenesis. Among these forms the last one appears the most contracted as it only displays three-fold radial symmetry for contractive cycle and no further articulation along partial shoots as expansion is highly reduced.

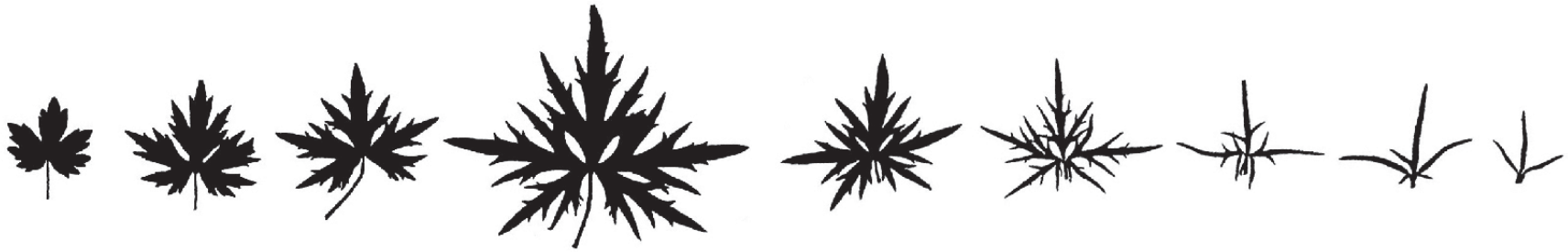

Figure 2.4.3.1 – Brady's Buttercup sequence presented in a linear order showing the waving outline of metamorphosis.

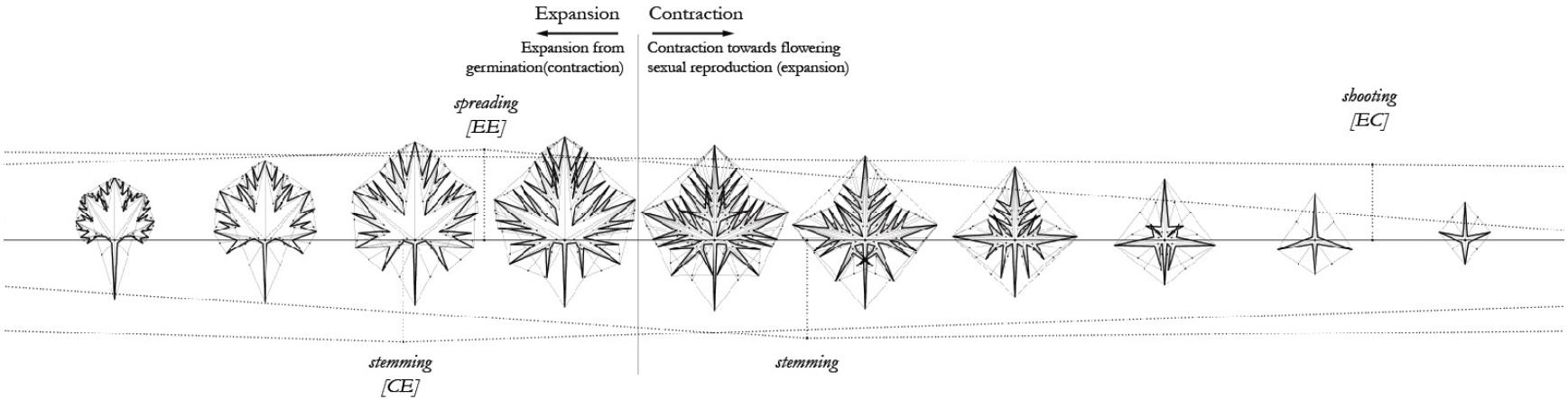

Figure 2.4.3.2 – Computer generated ontogenesis of Common Buttercup. Dashed lines show the intensity and interpolation of ontogenetic forces.

To compute the sequence, an embrogenesis algorithm is simultaneously applied towards the generation of a certain number of leaves that receive interpolated parameters of expansion and contraction.[602] This interface allows for the determination of high and low parameters for the quadruple inputs as well as their mean locations along the sequence (Fig.2.4.3.2). This way the parameters for each leaf in the sequence are found by determining three values: a starting, middle and ending value that first expands the parameters towards their mean, and then continually decreases, resembling a single wave function. The "wave" that is defined by Bockemühl can be understood as polarity manifesting itself in the transformation of the parameters responsible for the generation of each leaf, causing variation among the sequence.[603] It is necessary to note that the starting and ending values are never zero as the vegetative sequence is caught within the developmental stream of the plant that begins with its germination and continues until flowering. In this sense, the plant consistently grows and changes the quality of internal nourishment that effects the expression of expansion and contraction of each leaf. Bockemühl's later sequences that include flowering leaves, such as petals and sepals, also shows examples where the vegetative sequence is terminated with contraction which decreases the size of the leaf forms and their complexity before they are increased again during flowering and sexual organs.[604]

[602] Pseudo code for this algorithm could be found in Appendix B.
[603] Bockemühl, "Transformations in the Foliage Leaves of Higher Plants," 122-123.
[604] Examples of these sequences could be found in Jochen Bockemühl, *In Partnership With Nature* (Wyoming, R.I.: Bio-Dynamic Literature, 1981), 7.

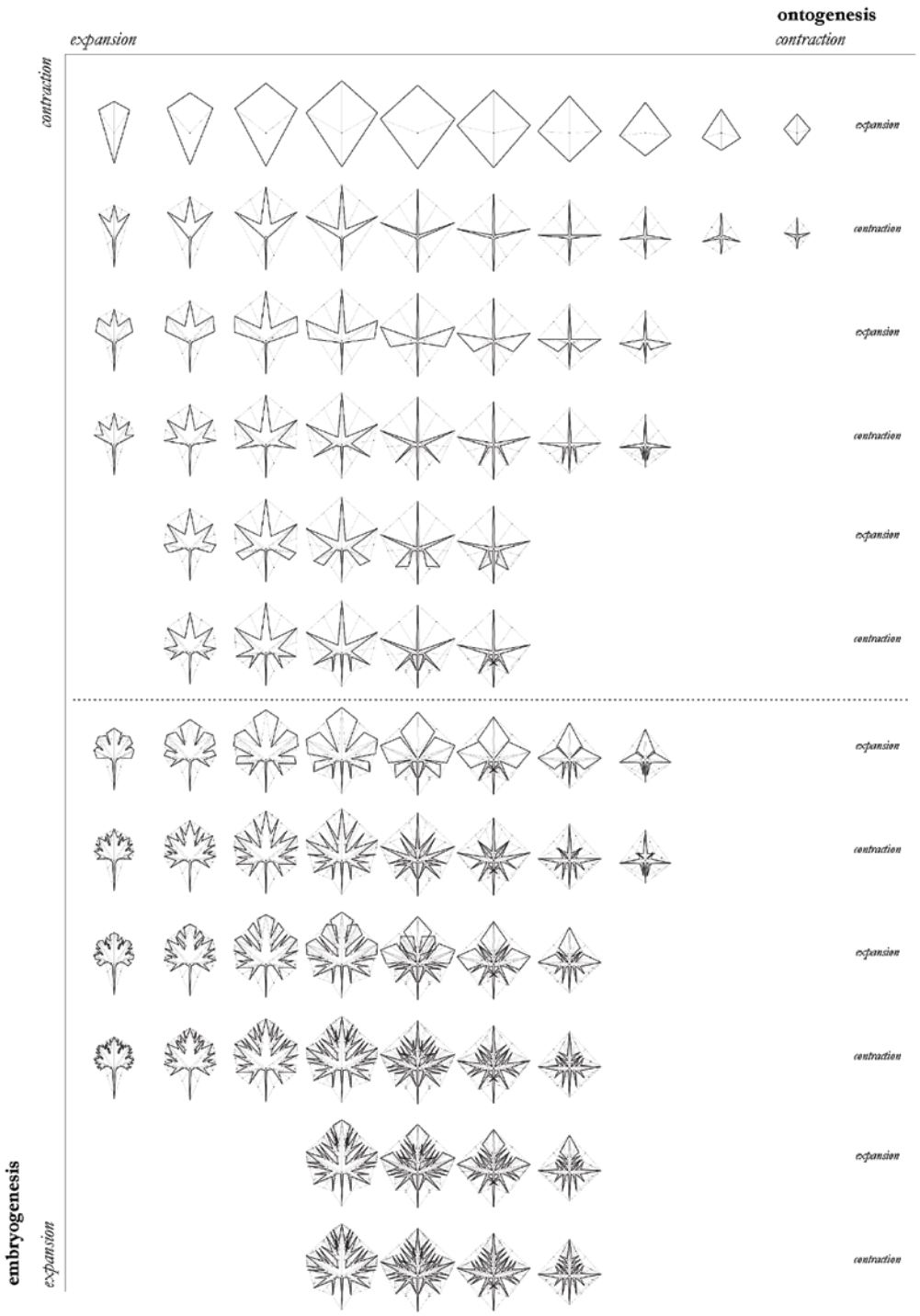

Figure 2.4.3.3 – Two dimensional leaf matrix showing computer generated Common Buttercup sequence. All leaves are normalized, topological changes are omitted to show organizational development. Ontogenetic development is horizontal, embryogenesis is vertical. Embroyogenetic sequence (Contraction [shooting (CE) + segmenting (CC)] and expansion [spreading (EE) + stemming (EC)]) is visually separated with a horizontal line.

When the ontogenetic sequence is combined with embryogenesis, the overall vegetative development of Buttercup leaves can be analyzed (Figure 2.4.3.3). This two dimensional chart shows contractive and expansive development of each leaf in the sequence with changing physiological properties. For instance, during contraction, the intensity of expansion that causes the radial multiplication of leaf axis is low in the early forms while it is maximum in the middle and then lowe again at the end. This shows that contraction both reduces the size of the leaflets, radial multiplication and rotation of the axis. For expansion the increase of size complements the amount of branching that continually breaks the topology of the blade. This linear repetition starts from the base of each leaflet and then decreases as the forms advance in the sequence. Toward the end, the amount of expansive branches produced along each leaflet is first reduced before they completely disappear prior to flowering.

Since polarity transcends all growth activities by guiding embryogenesis and ontogenesis and relating the two together in a polarized fashion, the motif of a particular species needs to be defined by the parameters of expansion and contraction as well as the type of symmetry expressed by the leaf. This raises questions of the nature of a common type for plant species which is often described from two contrasting positions. In taxonomy, type is often associated with the "prime" of the ontogenetic sequence that expresses the most expanded leaf and most commonly produced form by this species. However, another definition for type exists among Goethean scholars who attribute polarity not to individual forms but towards the undulating forces found among the ontogenetic sequences.[605] These two approaches conform to a disconnected

[605] Examples of these could be found in Rudolf Steiner, *Goethe the Scientist*, trans. Olin D. Wannamaker (New York: Antroposophic Press, 1950), 21. Brady, "Form and Cause in Goethe's Morphology," 275-6.

understanding of embryogenesis and ontogenesis that could be combined through polarity. In this sense, the computational investigations in this chapter aim to advance Bockemühl's leaf sequences while offering a digital understanding of the *UrBlatt* that is primarily considered an axial, geometric, polarized and morphogenetic template. In this way, the understanding of type in biology could be studied through parametric expressions of expansion and contraction as well as various symmetries expressed by certain leaf species. This means that Goethean morphology can never be understood by fixed types, but only through morphogenetic parameters that reveal formal tendencies and polarities during growth which can aid in a comparative study and a higher classification of leaf forms using algorithms.

2.4.4 Polar-Parametric Leaf Variations

The generative and diagrammatic notion of *UrBlatt* which combines embryogenesis and ontogenesis can be further extended as a polarity program to offer a parametric understanding of leaf morphology. This program primarily uses the embrogenesis algorithm to produce geometric leaf shapes which generates twenty chosen leaf samples (Fig.2.4.4.1). The selected array of forms shows expansive and contractive lobes as well as compound or conjoined formations that can be generated by using the parametric algorithm described above. Figure 2.4.4.2 shows the interface of this algoritm which offers manipulation for expansive and contractive cycles as well as switches that establish directions of growth in order to understand how metamorphosis occurs in a particular leaf species.

Figure 2.4.4.1 – Selected leaf samples for polarity study of *Urblatt*.

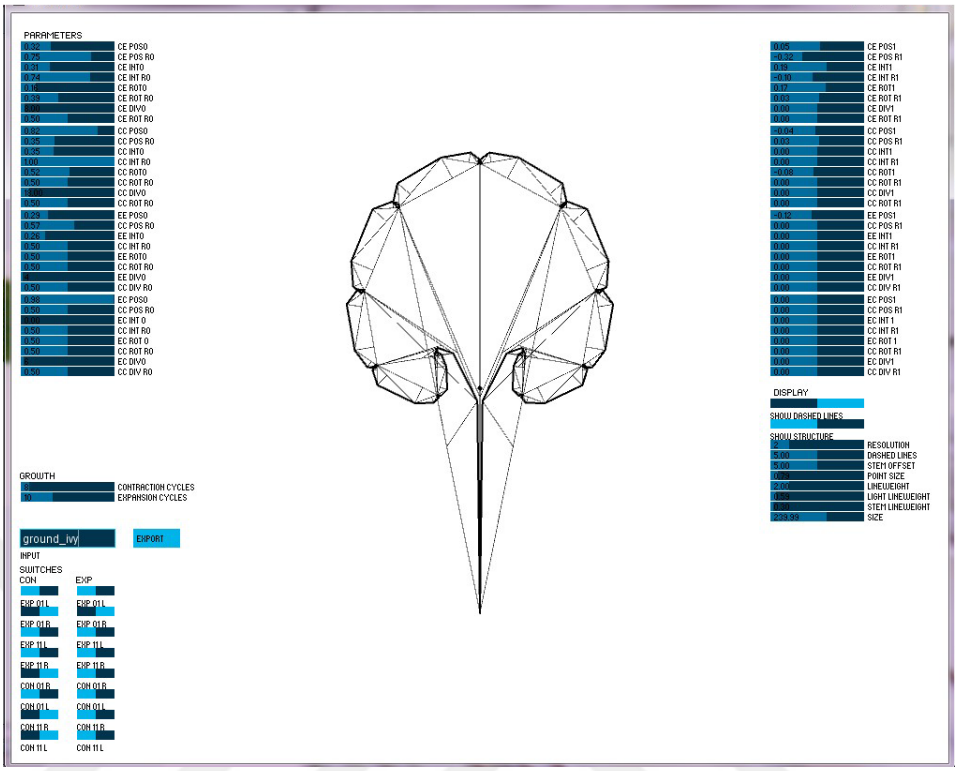

Figure 2.4.4.2 – The polarity program written in Processing (Java) for leaf embryogenesis studies showing EC parameters and switches that are used to control the development and to produce comparable results to chosen leaf samples.

Figures 2.4.4.3–23 show metamorphosis of selected leaf samples that allow various morphological comparisons to be made. Among these forms sycamore, ginkgo, bigleaf maple, buttercup, poplar, larkspur and cannabis show mainly contractive forms that produce a radial blade with anastomosed subsequent shoots. Linear-repetitive forms are exhibited by whiteoak, date palm, magnolia, white baneberry, and American ash. These show expansive tendencies producing either segmented or single elliptic forms that move towards the top of the leaf axis. Among the other forms grapefruit demonstrates an example of an expanded stalk with "an inclination to transform itself into leaf form" hinting at the existing duality along the main axis of the blade (Fig.2.4.4.3).[606] In this

[606] Goethe, *Goethe's Botanical Writings*, 38.

form, the main axis segments at a very early stage through contraction conjoining two leaves at a center from which each one expands and pushes against the other.

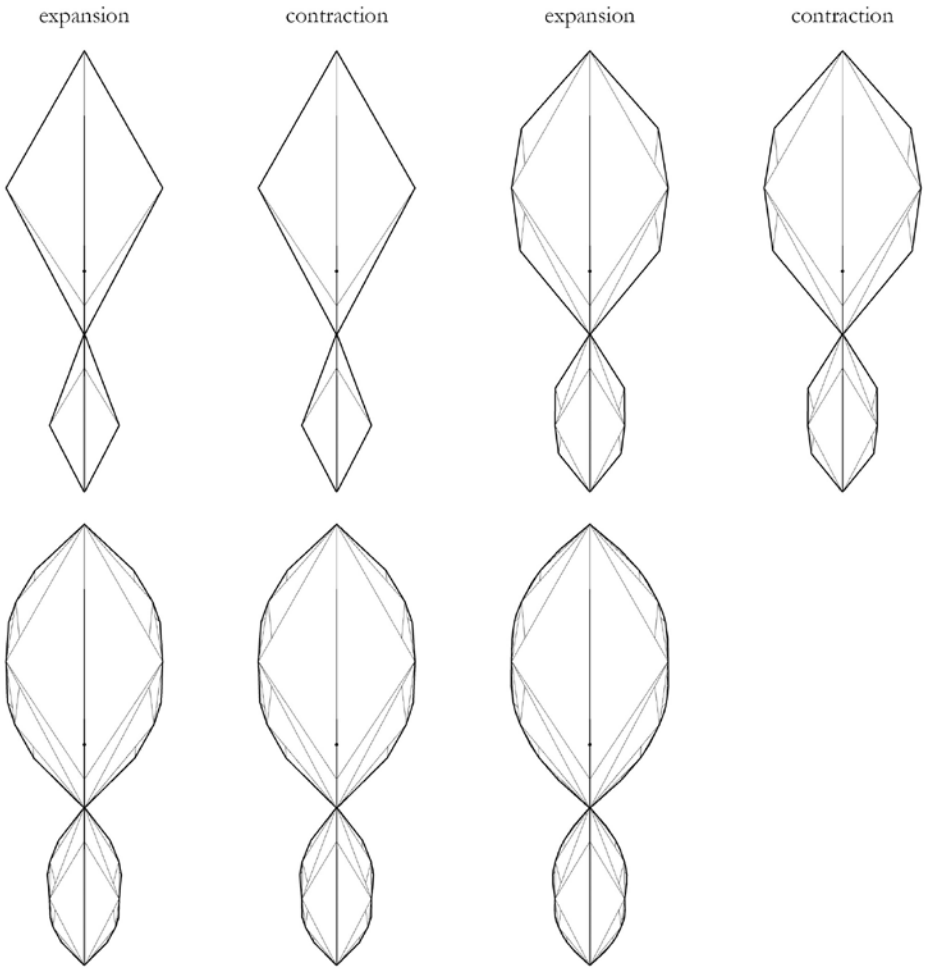

Figure 2.4.4.3 – Metamorphosis of grapefruit [*Citrus x paradisi*].

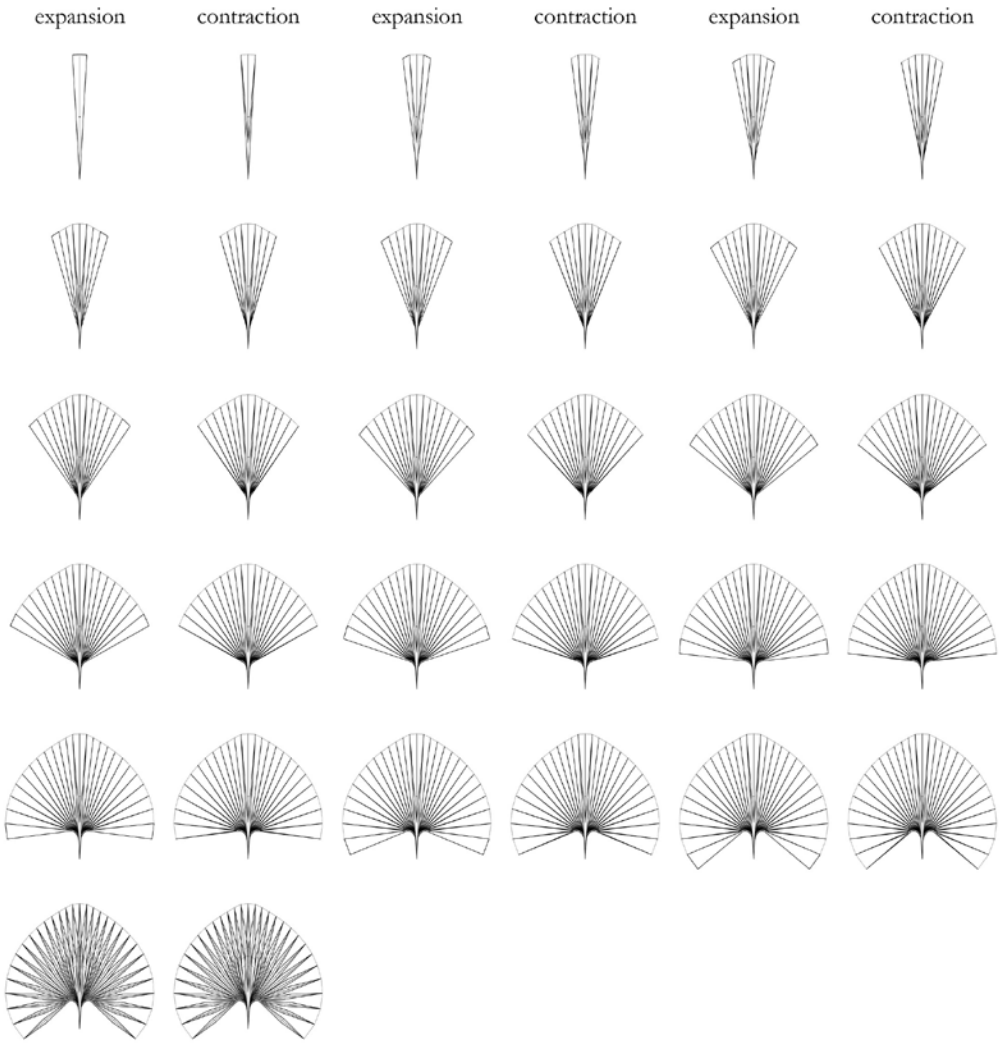

Figure 2.4.4.4 – Metamorphosis of sabal palm [*Sabal palmetto*].

A segmented version of a radial blade can be found in sabal palm (Fig.2.4.4.4) that contrasts with the miniature date palm (Fig.2.4.4.5) of the same species exhibiting expansive tendencies with lateral shoots moving toward the tip. Other examples of expansive development can be found in ginkgo and hop (Fig.2.4.4.6) which both lack segmentation in their development. In these leaves, contraction appears almost hidden and anchored to the blade outline, showing the predominate expansion of the blade radially in opposite directions. In this sense, ginkgo appears highly proliferative by not

producing excessive amount of radial shoots but by consolidating them into a highly articulated and expressive heart shaped blade (Fig.2.4.4.7).

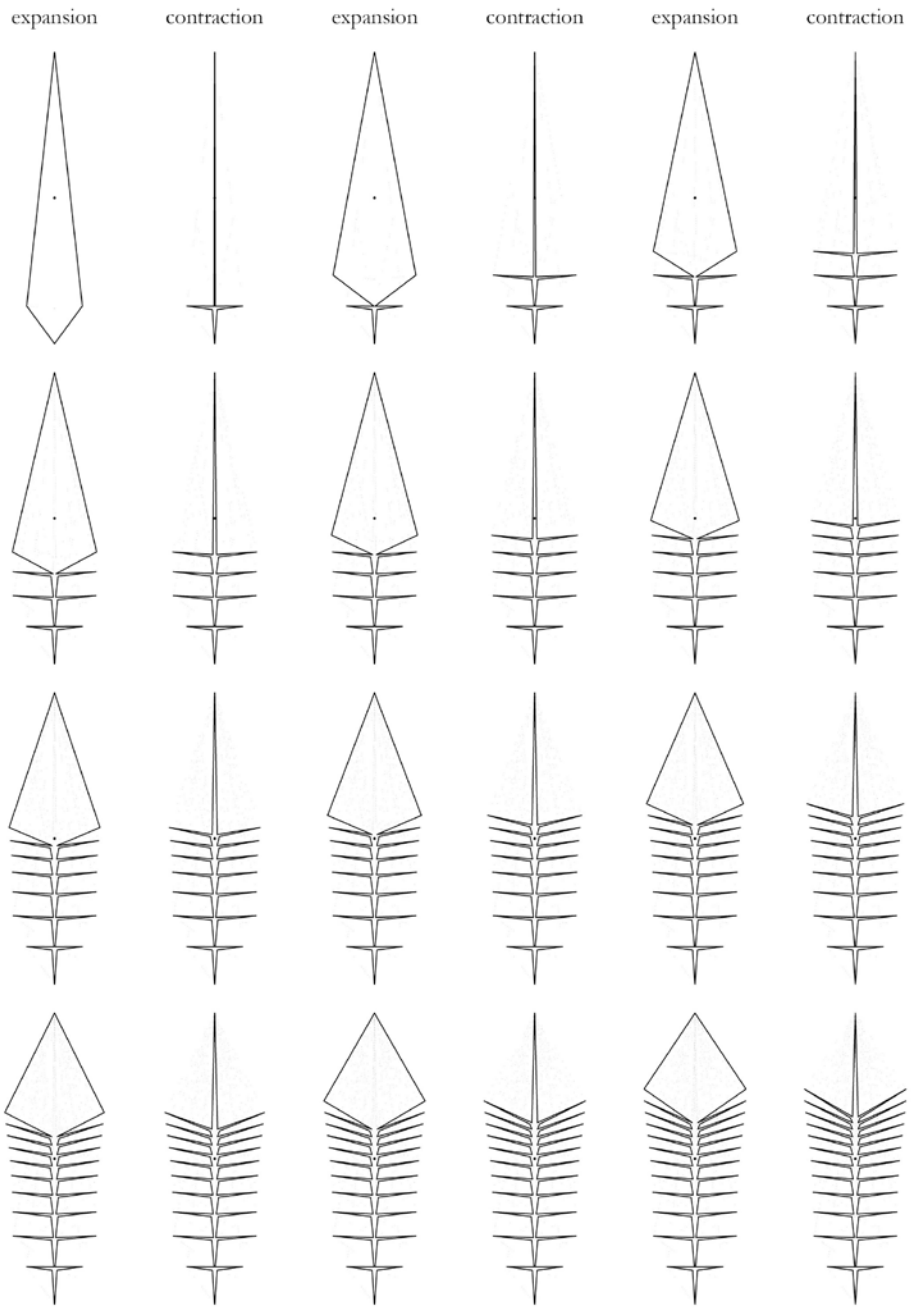

Figure 2.4.4.5 – Metamorphosis of miniature date palm [*Phoenix roebelenii*].

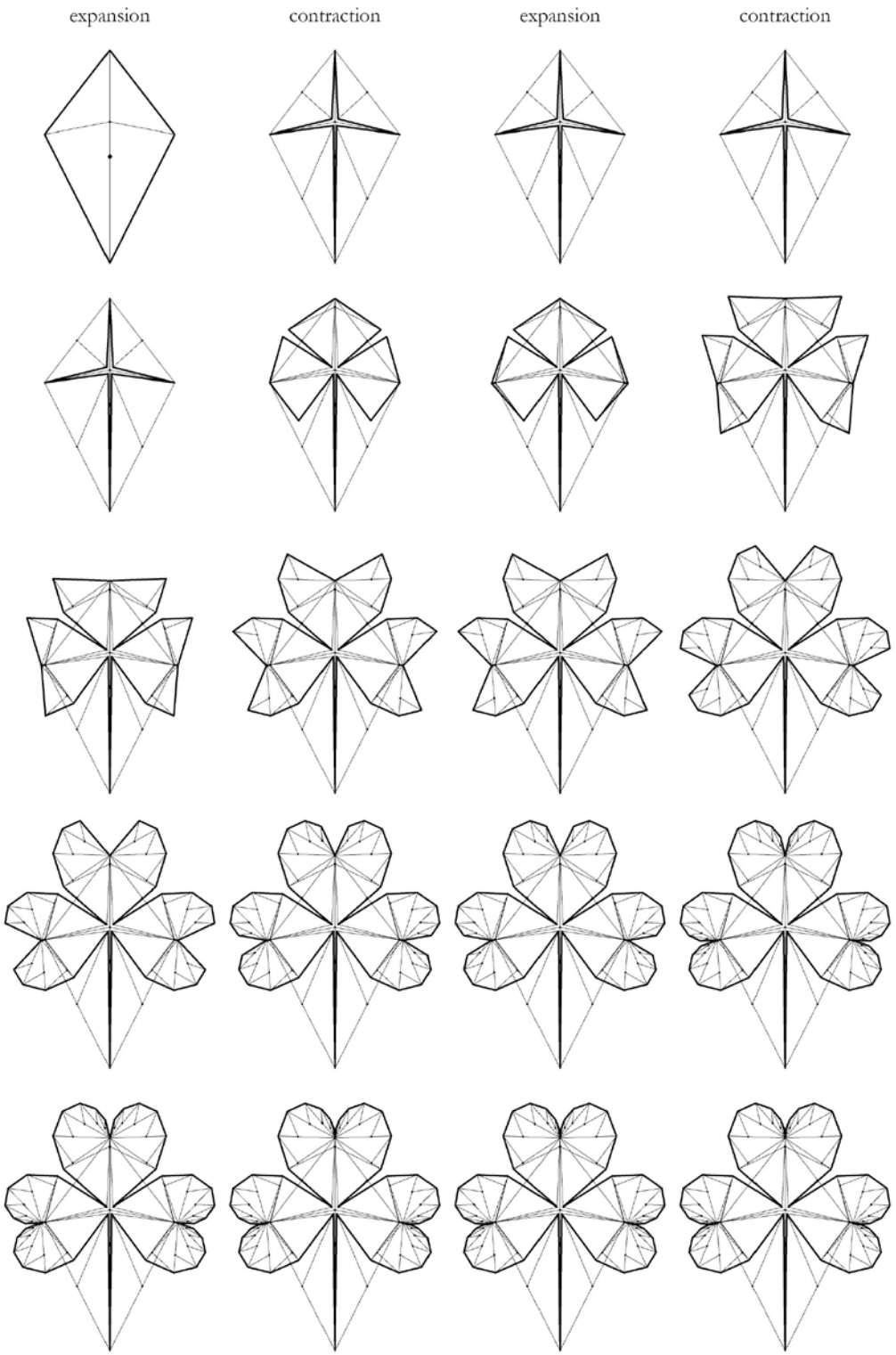

Figure 2.4.4.6 – Metamorphosis of little hop clover [*Trifolium dubium*].

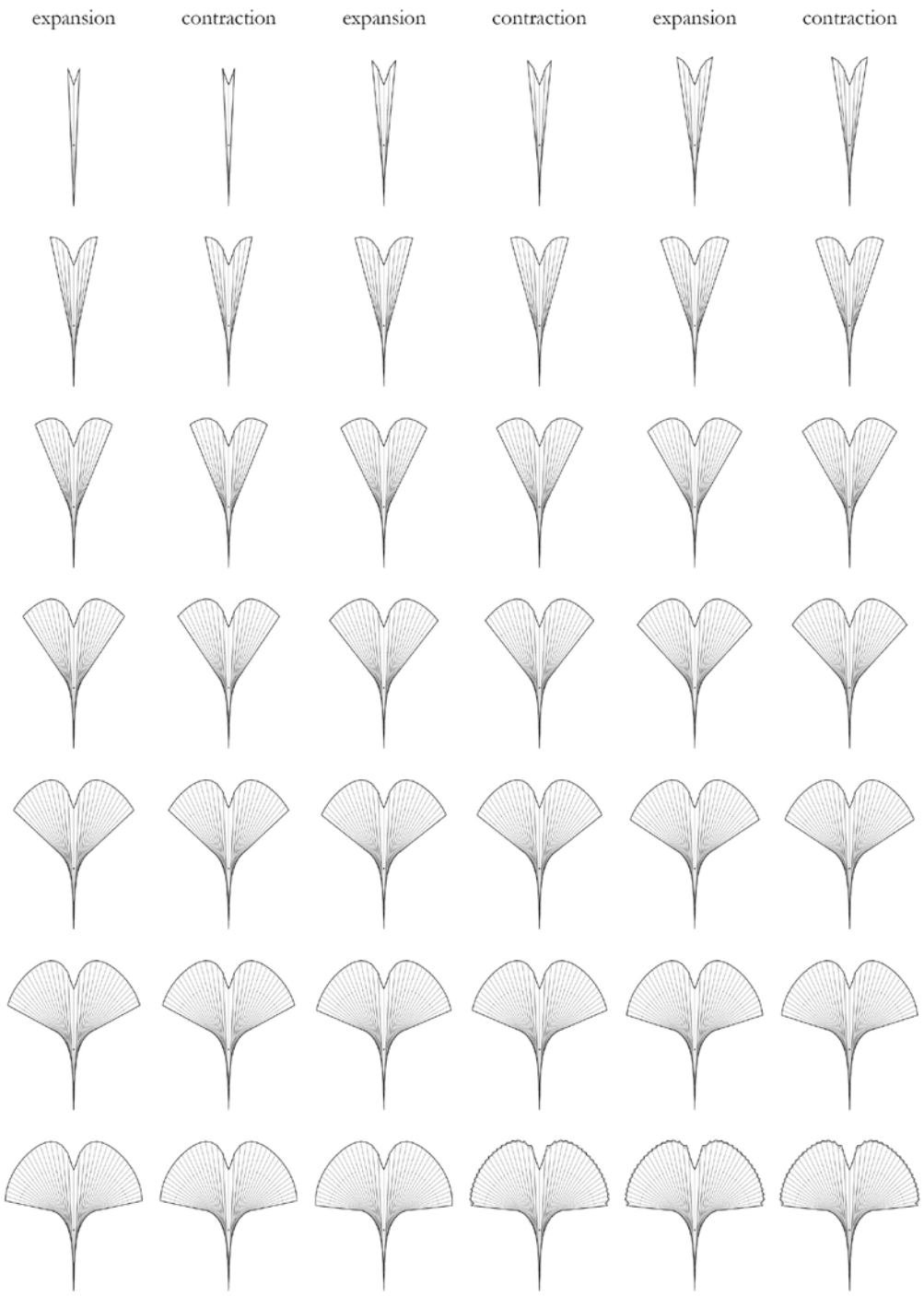

Figure 2.4.4.7 – Metamorphosis of ginkgo [*Ginkgo biloba*].

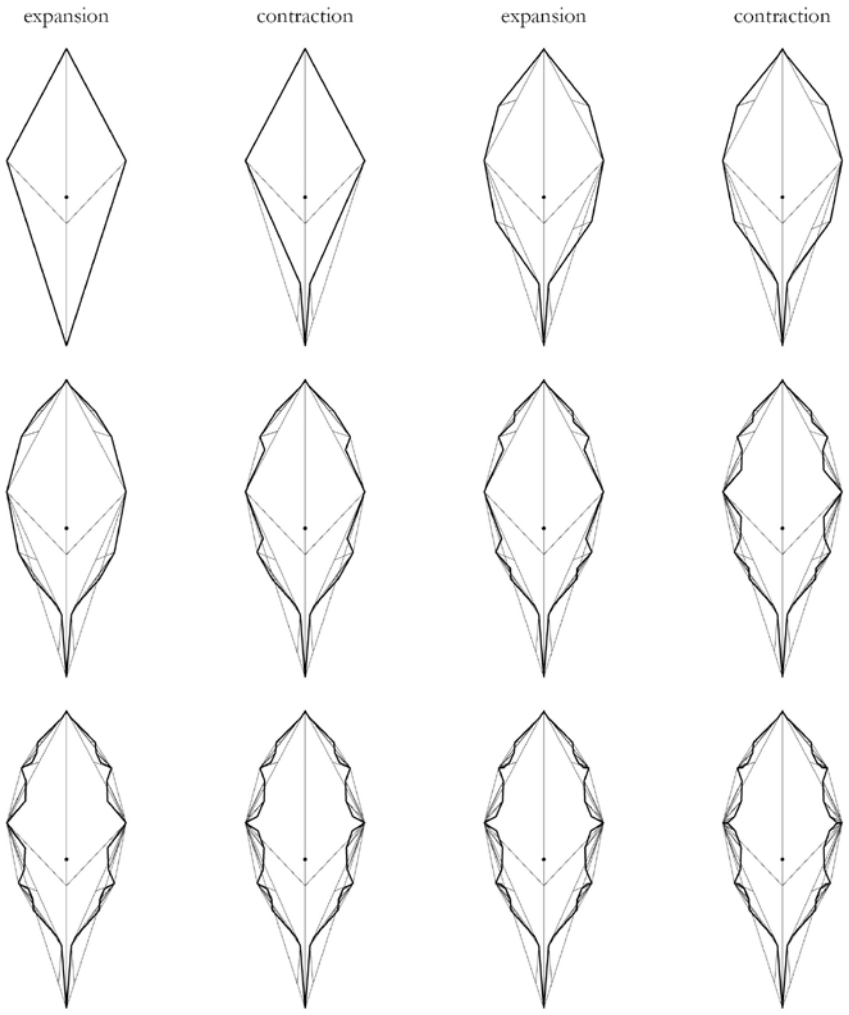

Figure 2.4.4.8 – Metamorphosis of holly [*Ilex aquifolium*].

Polarity in expansive growth can be discussed by comparing the contractive holly and expansive hop species. These two leaf forms show the same type of linear development during expansion which takes place in opposite directions. In holly, contraction turns initial shoots into spikes, while in hop each shoots becomed almost hidden with the expansive overflowing activity of the blade (Fig.2.4.4.8). This activity is also found in ground ivy where the initial segmented leaf is expanded transforming

expansive shoot points of each leaflet into contractive knots holding the outgrowing blade outline in place (Fig.2.4.4.9).[607]

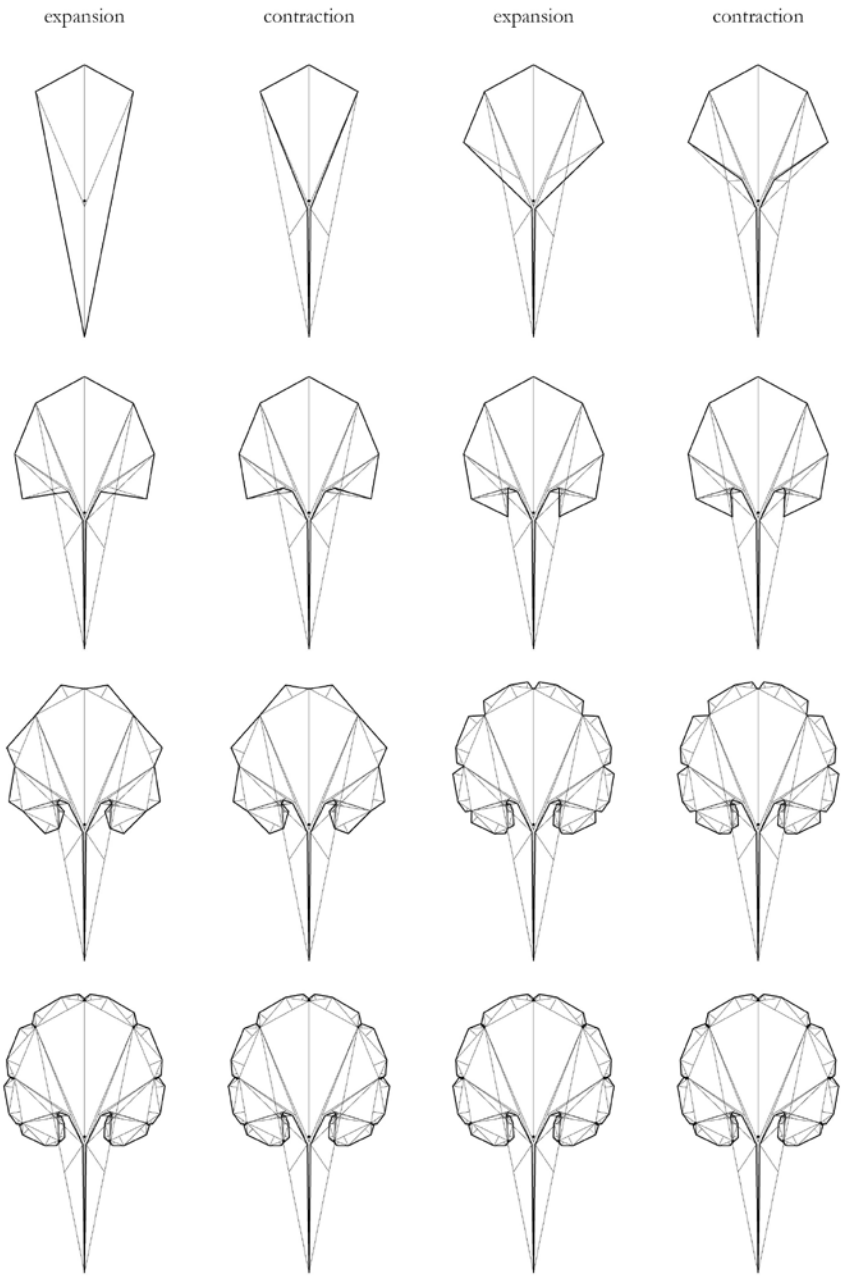

Figure 2.4.4.9 – Metamorphosis of ground ivy [*Glechoma hederacea*].

[607] Bockemühl, "The Formative Movements of Plants,"141. Bockemühl defines this expansive growth through the contractive poles "as though the apex and base of each lobe were held by a knot."

Sycamore and maple show close contractive morphologies as they display similar radial symmetry for contraction and contractive expansion for their concave lobes (Figs.2.4.4.10-11). Among the two, maple shows more contraction as the lobes that are formed earlier are closer to the center of the leaf.

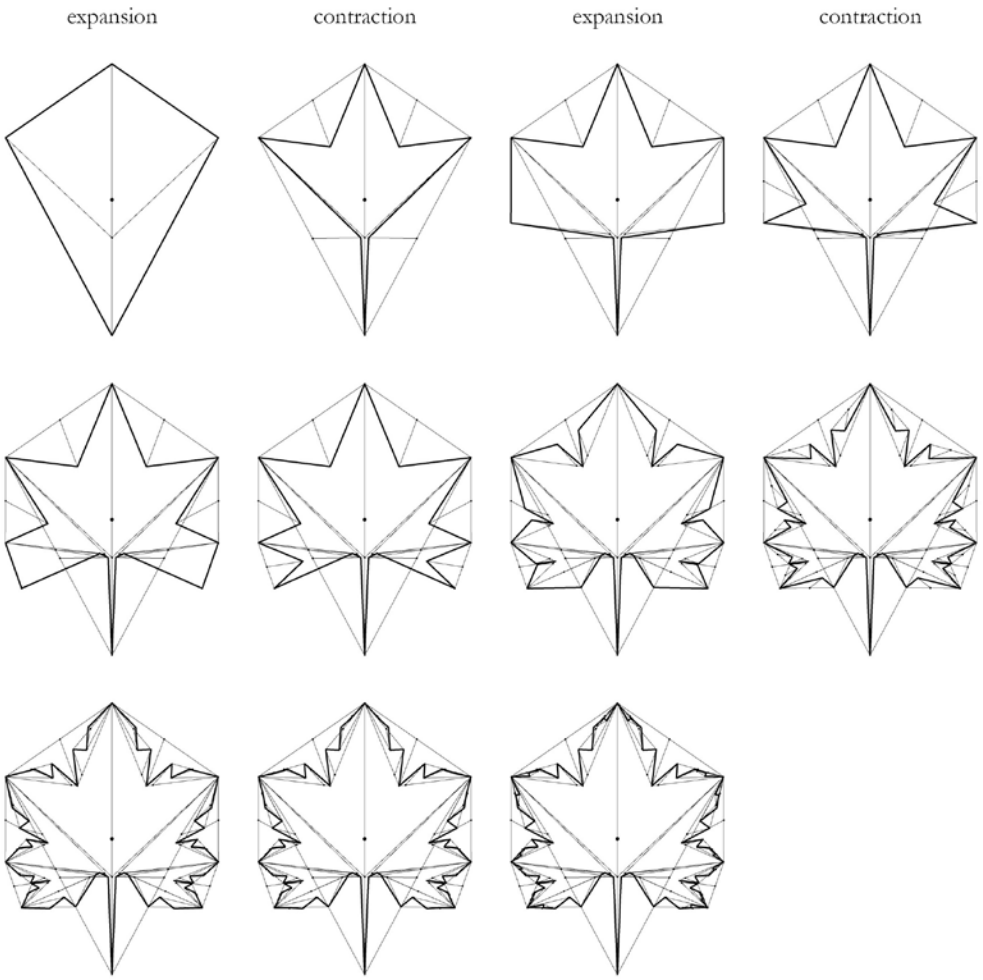

Figure 2.4.4.10 – Metamorphosis of sycamore [*Platanus occidentalis*].

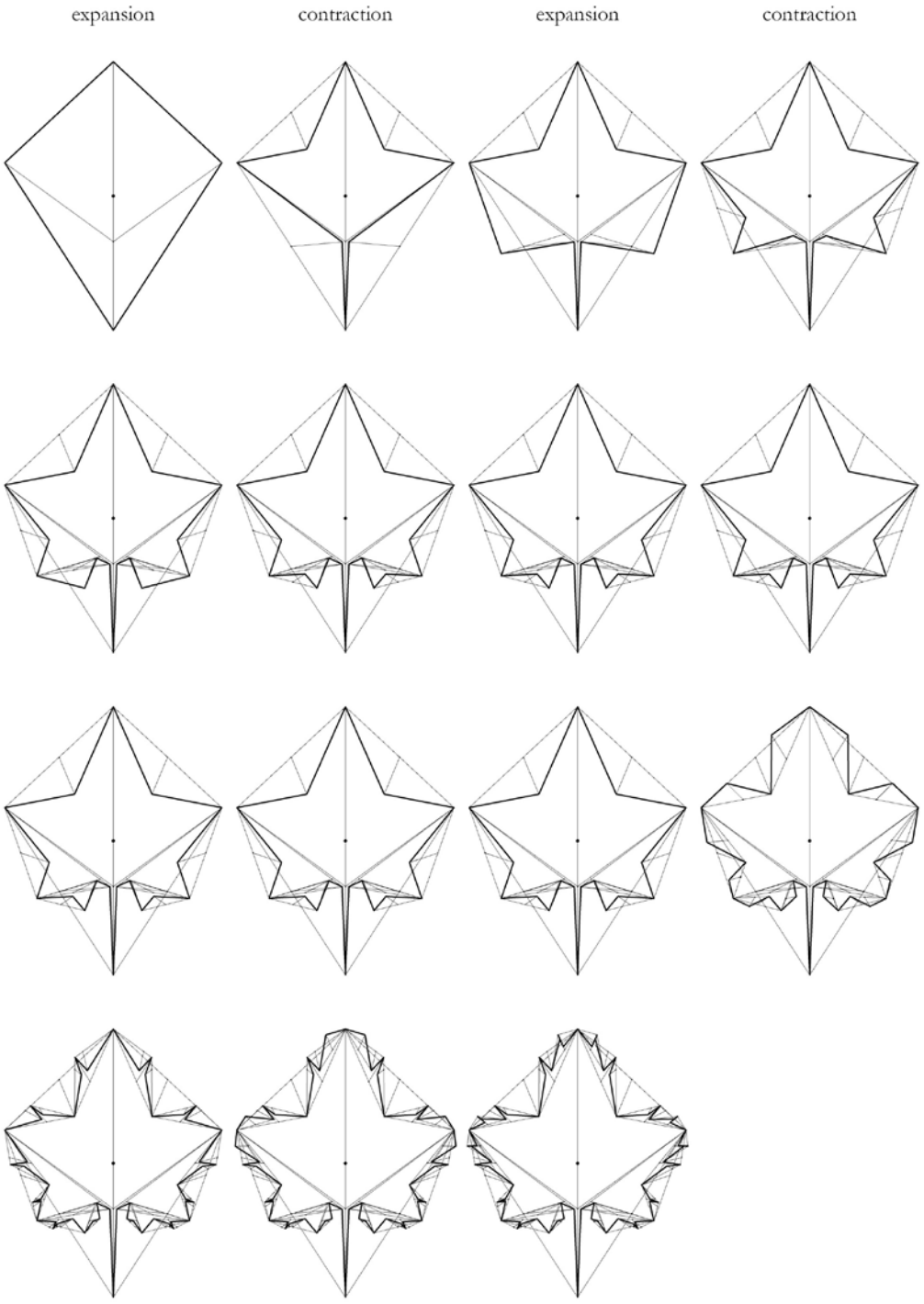

Figure 2.4.4.11 – Metamorphosis of bigleaf maple [*Acer macrophyllum*].

Buttercup and larkspur show similar contractive development producing radial leaflets that are highly proliferative (Figs.2.4.4.12-13). Among these, larkspur shows more expanded blade development with rounded symmetrical contours, while buttercup remains more contractive with a shortened stem and more asymmetrical distribution of branches during expansion.

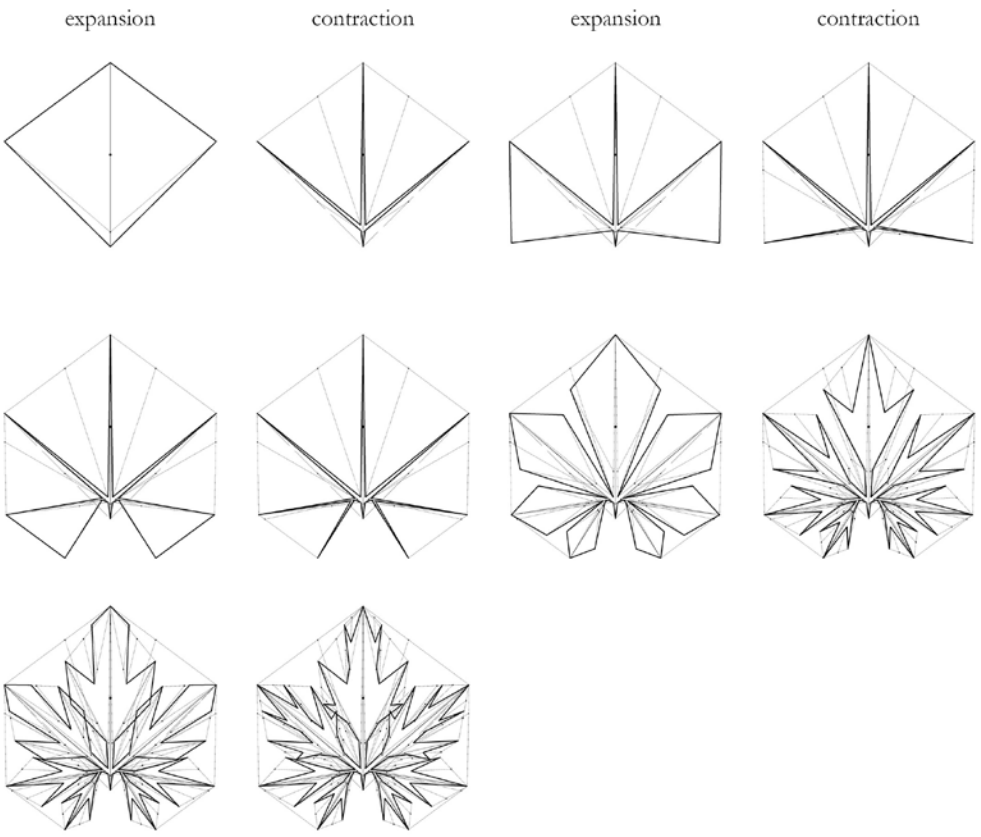

Figure 2.4.4.12 – Metamorphosis of meadow buttercup [*Ranunculus acris*].

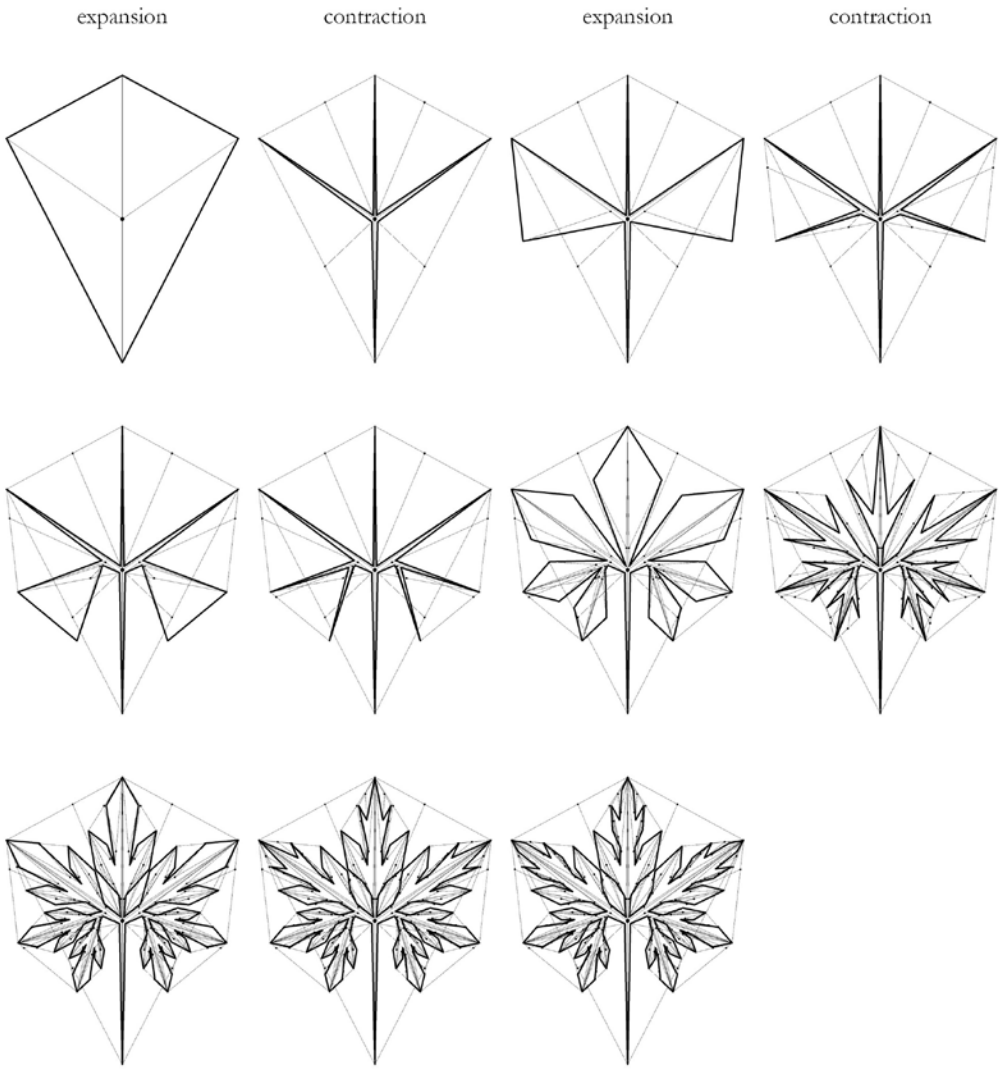

Figure 2.4.4.13 – Metamorphosis of lakspur [*Delphinium*].

Asymmetry appears as a common feature among all the discussed leaves. Among them, white baneberry expresses an expansive sinistral development complemented by a contractive destral half (Fig.2.4.4.1). If this leaf were to develop symmetrically then the left half would contract and right side would expand reducing the number of branches from the former and allowing the latter to grow more by producing more branches and serrations (Fig.2.4.4.14).

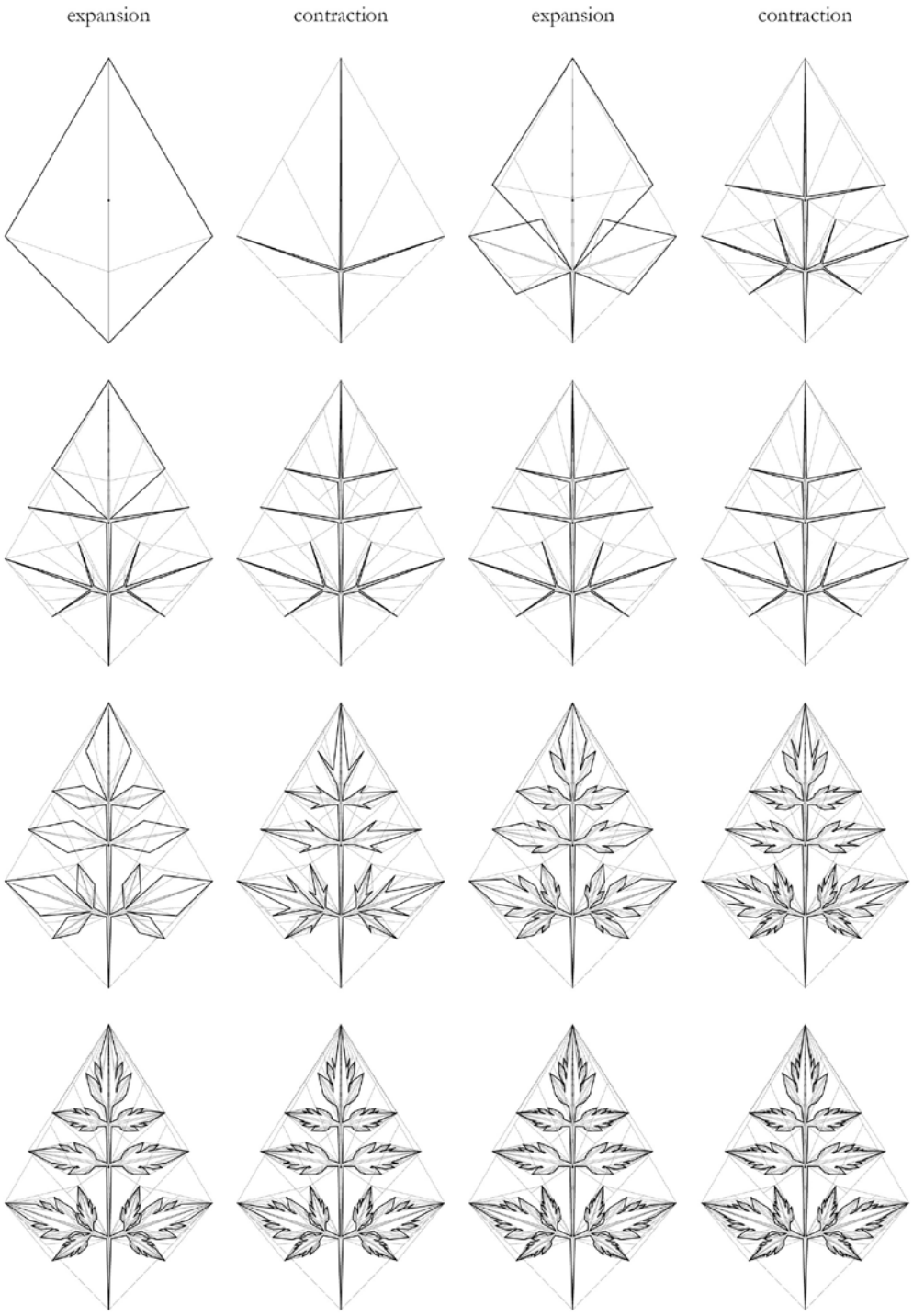

Figure 2.4.4.14 – Metamorphosis of white baneberry [*Actaea pachypoda*].

With their single forms, magnolia and balsam-popolar show similar morphological features that distribute polarity from a contractive tip toward an expansive blade (Figs.2.4.4.15-16). Similar morphological tendency exists in other species such as common walnut, white oak and tulip which presents a blade organized with rounded contours (Figs. 2.4.4.17-19). In this sense the two polar streams appear as the determining factor for the undulating outlines of the leaf in opposite directions.

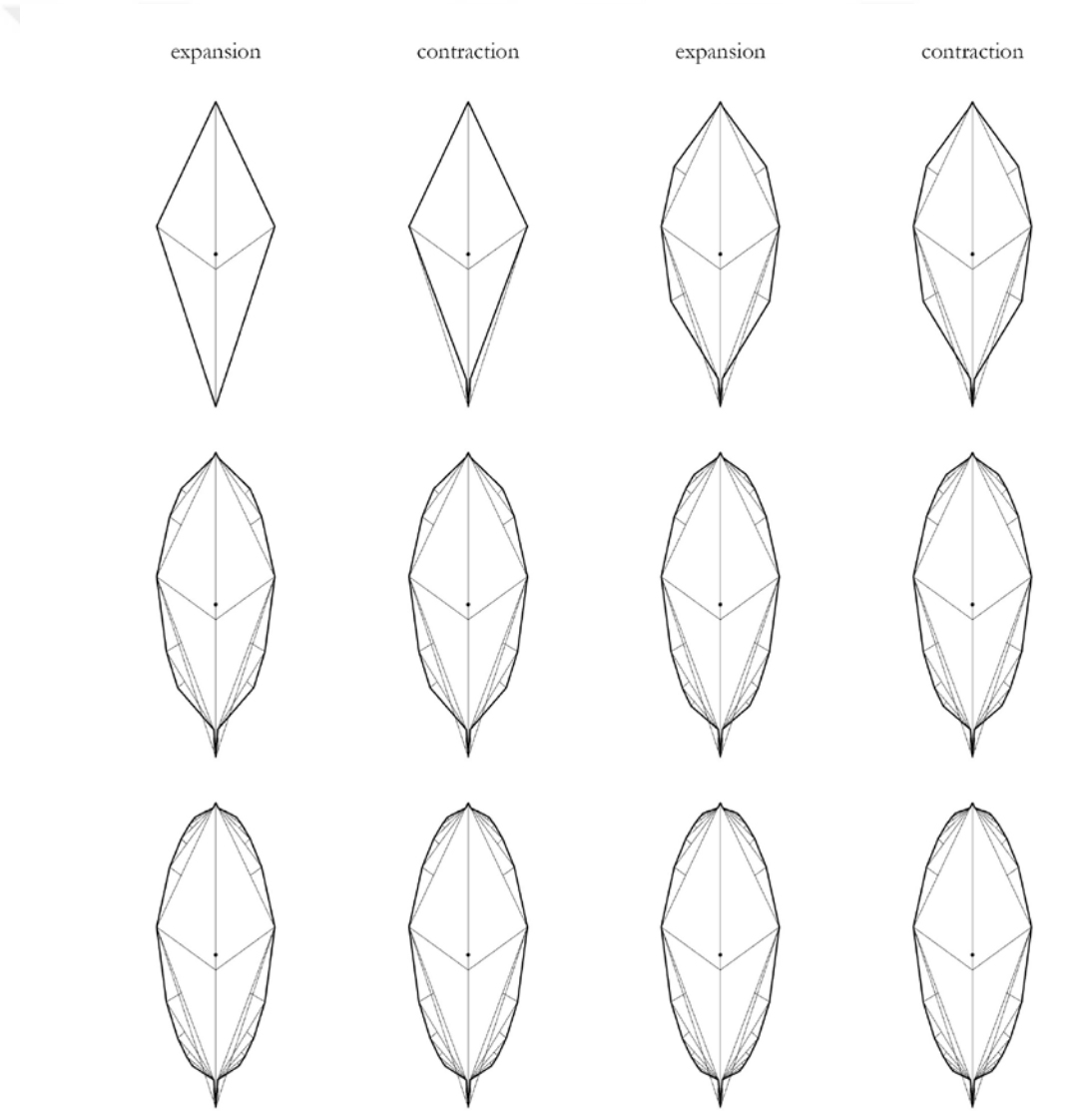

Figure 2.4.4.15 – Metamorphosis of magnolia [*Magnolia macrophylla*].

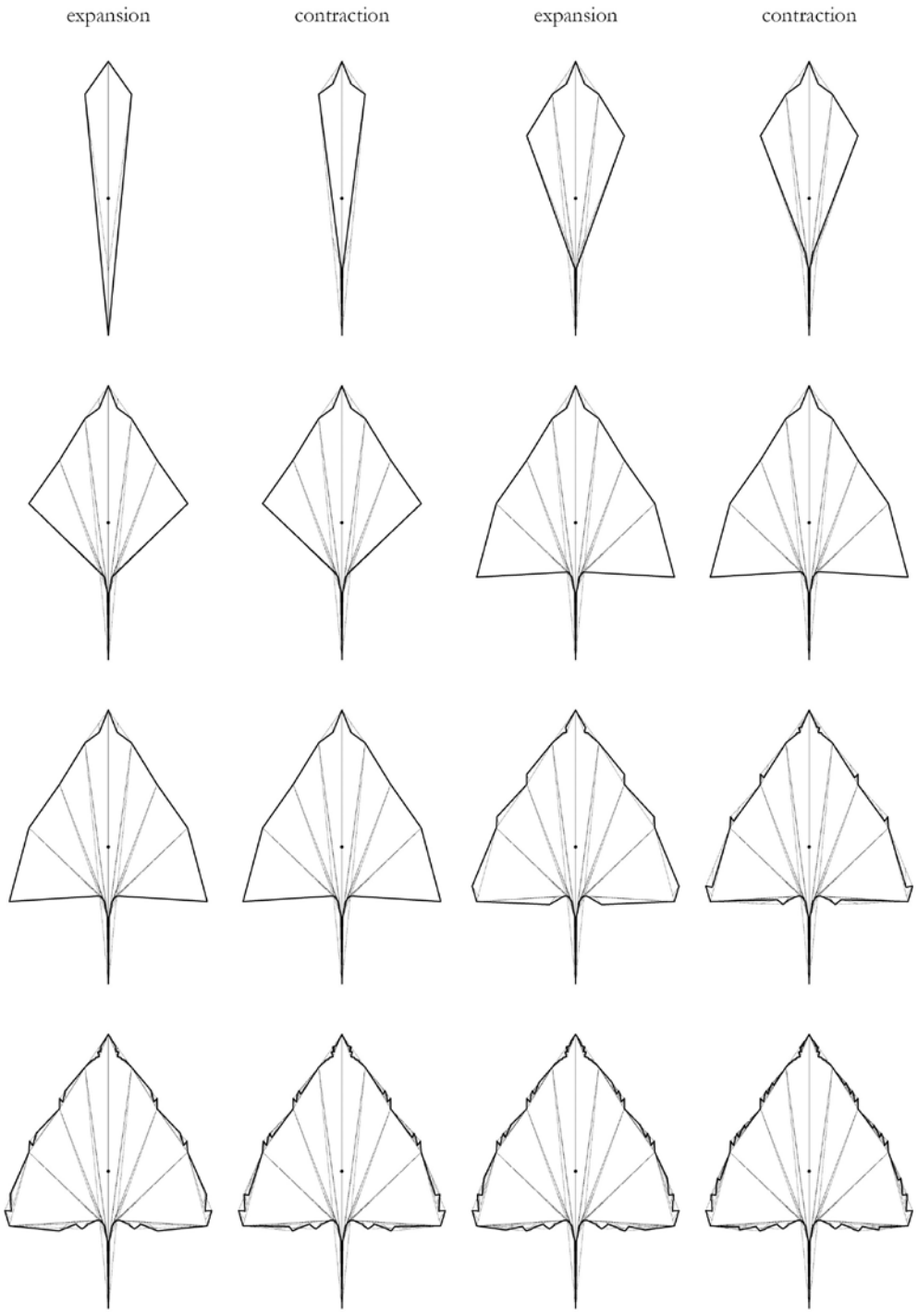

Figure 2.4.4.16 – Metamorphosis of balsam-poplar [*Populus balsamifera*].

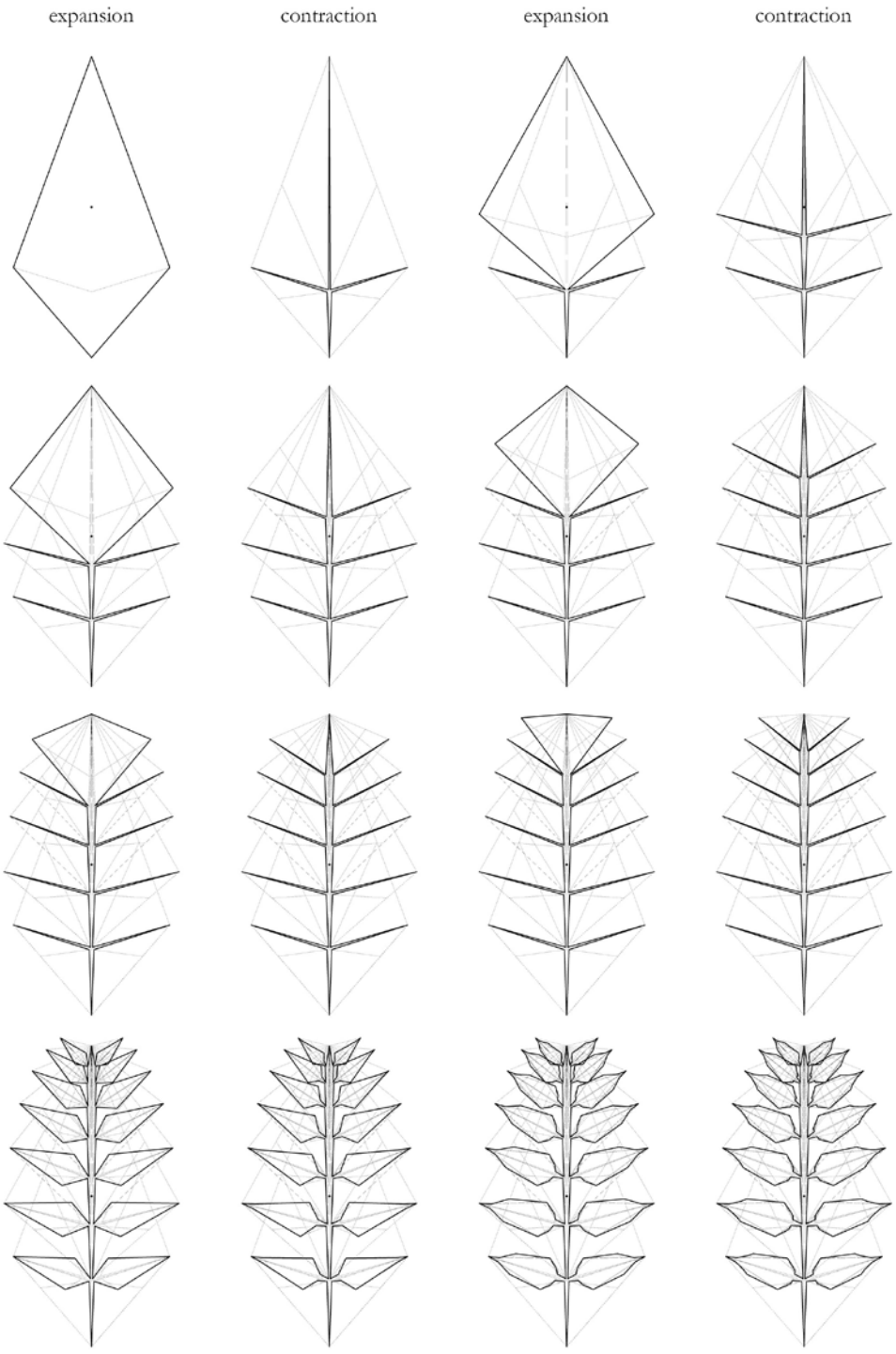

Figure 2.4.4.17 – Metamorphosis of common walnut [*Juglans Regia*].

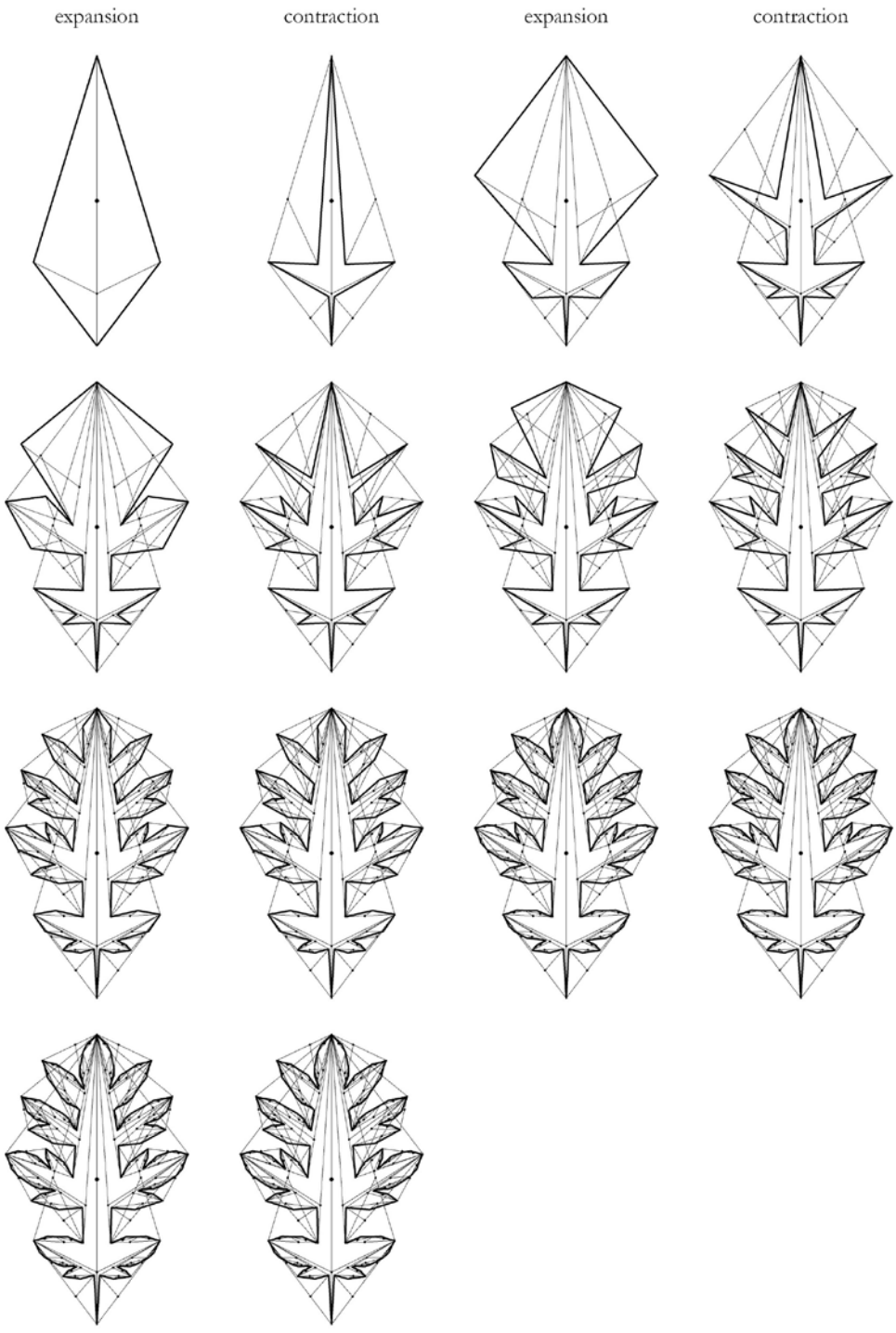

Figure 2.4.4.18 – Metamorphosis of white oak [*Quercus alba*].

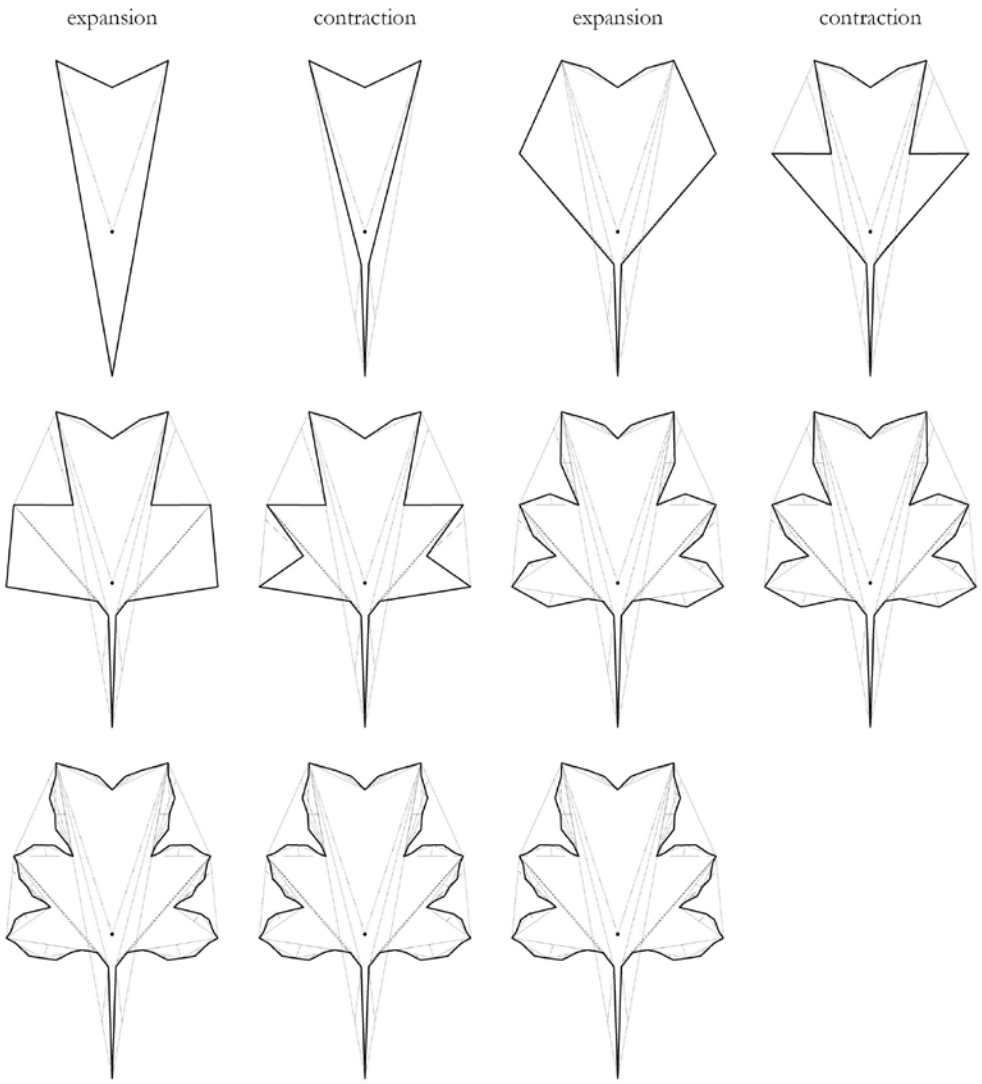

Figure 2.4.4.19 – Metamorphosis of tulip [*Liriodendron tulipifera*].

An example of opposite tendencies for the generation of leaf outlines during expansion can be found in maple and fig forms. In these species, maple mainly shows contractive lobes along its blade, while in figs the same forms appear expansive growing outward from the tips (Fig.2.4.4.20). White oak shows similar lobe development to maple, where contraction manifests itself as growth towards the center of the blade. If this development were to reach the midrib then it would reunite with the main leaf axis

forming a repetition of contractive stems since neither side of the blade can develop towards the opposite side.

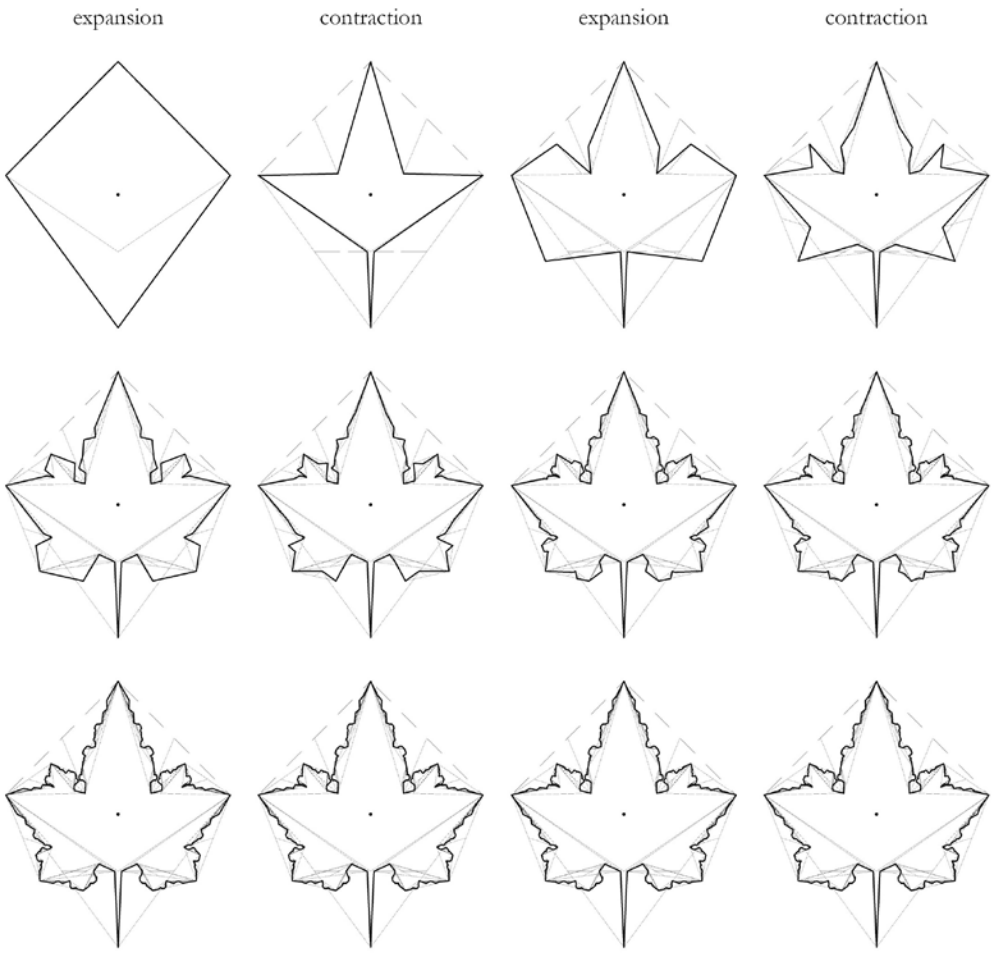

Figure 2.4.4.20 – Metamorphosis of common fig [*Ficus carica*].

Examples of this can be found most clearly in compound leaf forms such as the American ash and white baneberry where excessive contraction during embryogenesis leads to the repetition of stems for each leaflet (Fig.2.4.4.21). These two forms also appear polarized with the former lacking contractive movement during expansion while the latter shows more contractive activity towards its leaflets.

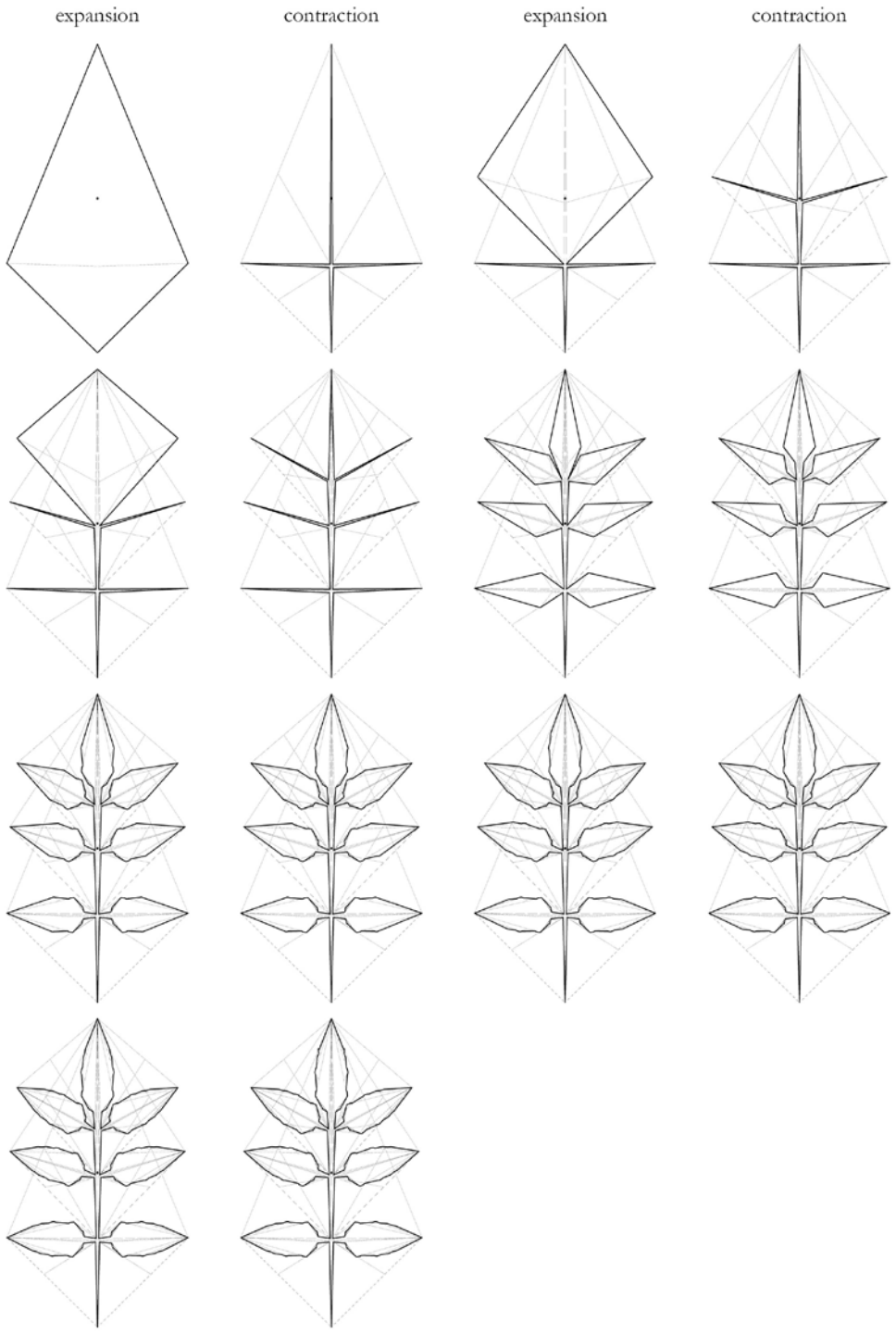

Figure 2.4.4.21 – Metamorphosis of American ash [*Fraxinus americana*].

An example of expansive growth can be found in Cannabis, where the initial radial symmetry is countered by linear proliferation which dominates during the

expansive cycle exhibited along leaflets (Fig.2.4.4.22). In miniature date palm, the same linear tendency occurs during contraction leading to the multiplication of leaflets which remain simpler in form (Fig.2.4.4.5).

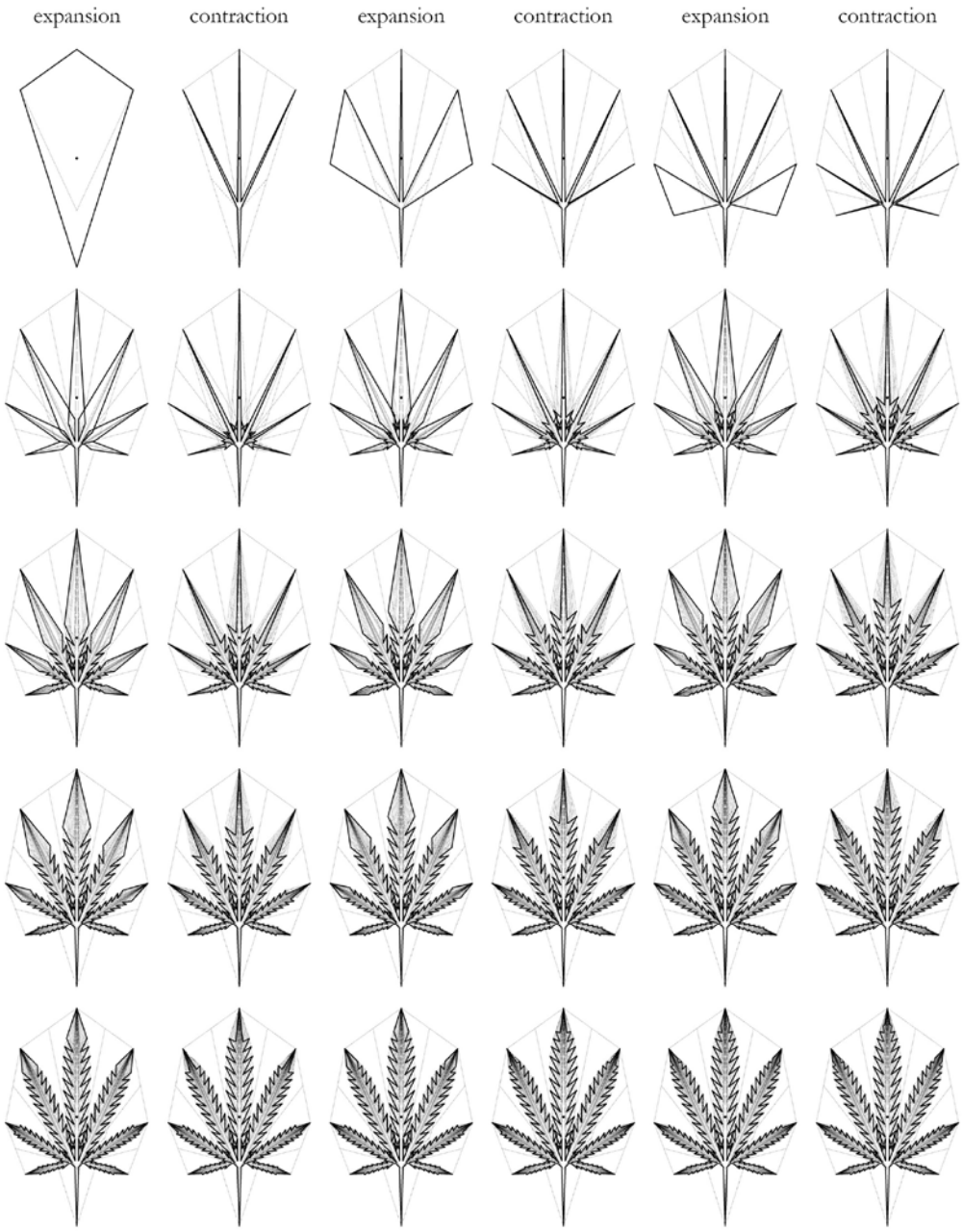

Figure 2.4.4.22 – Metamorphosis of *Cannabis sativa.*

The variations and comparative analysis presented in this chapter show convincing results that can redefine how leaf morphogenesis could be studied using polarity. Although the examples presented are entirely symmetrical, the algorithm could be further improved to accommodate asymmetry, developing a cumulative understanding of how both halves of the symmetry axis are related. To conclude, the generative studies mainly conforms to Bockemühl's hypothesis on axial and polarized development of leaves. In this sense polarity offers a way to reconsider internal rhythms as the driving factor of formal generation that could also be studied using algorithms and simple geometric and parameteric rules.

2.5 "*Alles ist Blatt*": Leaf-being as an Ontological Machine

In this speculative section, Goethe's understanding of polarity will be considered as an ontological system to offer reconciliation between the dichotomy in continental philosophy's predominant trends; being and becoming. While the former is usually related to ideas or archetypes that fail to explain growth and change in nature, the latter presents a realist view on processes, often relying on dynamic interactions among parts and unpredictable emergent wholes. This opposition is often used as a comparative method to discover the properties of an ontological system. These properties are often diverse and hint at understanding the relationship between parts and wholes by introducing polar terms such as exteriority and interiority, virtual and actual, intensive and extensive, transcendence and immanence.[608] Apart from the fact that dualities exist at the core of philosophical argumentation, an ontological discussion of Goethe's idea of

[608] A discussion of virtual and actual and how they relate to space and time can be found in DeLanda, *Intensive Science and Virtual Philosophy*. For a comparative view of mechanism and vitalism see Chapter 5 in Jane Bennett, *Vibrant Matter: A political ecology of things*, (Durham : Duke University Press, 2010), 62-81. Bennett revisits Bergson's *elan vital* and Driesch's *entelechy* to develop a non-deterministic formulation of vital materialism.

polarity offers a new philosophical perspective that structures its own discourse and system. In this view, Goethe's consideration of *Urtypus*, particularly his leaf [*Urpflanze*], presents a form of being comparable to other ontological entities such as Leibniz's sphere-monads, Sloterdijk's sphere, Lucretius's swerve, Democritus's atom, Schroedinger's wave/particle, Diderot's fiber, Deleuze's fold, DeLanda's assemblage, Spuybroek's gothic rib, Heidegger's thing and Harman's objects-oriented ontology.[609] To formulate its ontological position, this Leaf-being, as a metaphysical proposal based entirely on polarity concepts, will first be considered from two philosophical avenues of *being* and *becoming* and then expanded using an ontological diagram derived from Goethe's color wheel and Bockemühl's discussion of metamorphosis. This will extend Goethean morphology as a *technical philosophy of form* that can approach multiple sciences and scholarly fields in a cumulative framework while developing complementary philosophical, scientific and aesthetic arguments.[610]

2.5.1 Polarity and Being

Most of the contemporary scholarship on Goethe's works stems from a phenomenological point of view often attributed to Rudolf Steiner's contributions in the early twentieth century who considered Goethe's Leaf-being [*Urpflanze*] to combine a two-fold ontological dimension: "the immediate one of its apperance (phenomenal form),

[609] This unexhausted list shows that every ontological system requires a formal element to develop its metaphysical properties and operations. In this sense, Goethe's polarity aims to combine dynamic polar types (animals, plants, rocks, colors, characters…etc.) with polar forces under similar magnetic concepts.

[610] DeLanda also anticipates this contemporary development on form in his Manuel DeLanda, "Uniformity and Variability: An Essay in the Philosophy of Matter" presented at *Doors of Perception 3: On Matter Conference*, Netherlands Design Institute, Amsterdam, Holland, 07-11.11.95. He states that "We may now be in a position to think about the origin of form and structure, not as something imposed from the outsiede on an inert matter, not as a hierarchical command from above as in an assembly line, but as something may come from within the materials, a form that we tease out of those materails as we allowow them to have their say in the structures we create."

and the second containing its essence (being)."[611] By observing the myriad of forms that can be produced through its variability, the leaf is postulated as a general type that can be recognized during intermediate stages of growth, such as subsequent productions of leaf forms along the stem of an annual plant. When these transforming series of leaves are observed together they present an overall "movement" that "is neither an abstraction from the empirical process of plant development nor a hypothesis ventured prior to the actual observation of organic growth" but instead is caught within the "ontological belonging-together of the observer and the phenomenon" during the "event of seeing" that captures "the modern object as *phenomenon*, that is, as a manifestation of life."[612] In its phenomenological understanding, this archetype is often considered to be hiding behind or above physical formal manifestations like a form of vague essence, thus postulating the study of wavelike pattern in a series of forms as its expression, giving transformation an ontological primacy that requires the anthropocentric, thinking-perceiving engagement with living phenomena.[613] However due to its dynamic formulation by phenomenologists, the Type always points towards "potential rather than actual forms" and fails to establish any commonality for classification,- as Brady calls it "the nature of the constant remains obscure" and the only other option left to explore the phenomenon is "change."[614] While objects as phenomenon are cast under the shade of the type that is only visible within a series of changing forms, the lack of an ontic discussion of the archetype raises doubt as to whether the dynamism of becoming explains what is fixated

[611] Rudolf Steiner, *Nature's Open Secret: Introductions to Goethe's Scientific Writings* (Great Barrington: Anthroposophic Press, 2000), 68.
[612] Pfau, "All is Leaf," 30.
[613] A discussion of this anthropocentric approach using the analogy of a "hologram" could be found in Bortoft, *The Wholeness of Nature*, 86.
[614] Brady, "Form and Cause in Goethe's Morphology," 298.

in being–implying the potential existence of an invisible essence behind appearances. Thus, the archetype's peculiarity is achieved "*by having no form at all.*"[615]

From an ontological perspective, the discussion of formless archetypes favors considering inaccessible essences behind form. This dual formulation echoes how Heidegger saw the world of Dasein which is always caught in between two separate states of Being that we either "proximally encounter–readiness-to-hand [*Zuhandenheit*]" as in the case of turning a Thing into an equipment without recognizing it or "by going through the entities proximally encountered–presence-at-hand [*Vorhandenheit*]" that reveal their Being when they are broken or not functioning as equipment.[616] This polarity embedded in the ontology of being has been investigated in *Tool-being: Heidegger and the metaphysics of objects*, where Harman uses the tool analysis of Heidegger to construct an object-oriented ontology that is non-phenomenological and non-anthropocentric to advance towards what he calls as "guerilla metaphyiscs."[617] For Harman, the tool presents a duality in its essence. First, it shows an "irreducibly veiled activity" that defines it "ontologically"; second, the tool has a "sensible and explorable profile" that constitutes to the tool being viewed "ontically."[618] While the polarity of "present-at-hand and ready-to-hand cannot refer to two distinct kinds of objects, but mark the two irreducible aspects of *every* object", their relationship is explained by Heidegger "that being-in always belongs to Dasein, and spatial presence-at-hand always to non-Dasein."[619] This "dualism between presence-at-hand and the subterranean reality that lies

[615] Ibid., 272.
[616] Martin Heidegger, *Being and Time*, trans. John Macquarrie & Edward Robinson (London: SCM Press, 1962), 88.
[617] Graham Harman, *Tool-being: Heidegger and the Metaphysics of Objects* (New York: Open Court, 2011), 2.
[618] Ibid., 22.
[619] Ibid., 38.

concealed beneath it" is revealed by the tool / broken-tool distinction.[620] The functionality or appearance of a tool does not pose a limit or determine the possibilites or relations it can engage as–"the visible tool is simply *not* the tool in its being; in this way, insofar as they are ever encountered, *all* beings are broken equipment."[621] In his essay titled "The Thing" Heidegger extends his ontology of Being towards a "mirror-play of the simple one of earth and sky, divinities and mortals, we call the world" where a duality between concealed essences and physical manifestations is established.[622] This fourfold is united through a cycle where "the round dance does not encompass the four like a hoop" but rather is the "ring that joins while it plays as mirroring."[623] All four are present at all times and all of them define the ontological character of a thing while offering polarized relationships between hidden and visible aspects of objects (Fig.2.5.1.1).

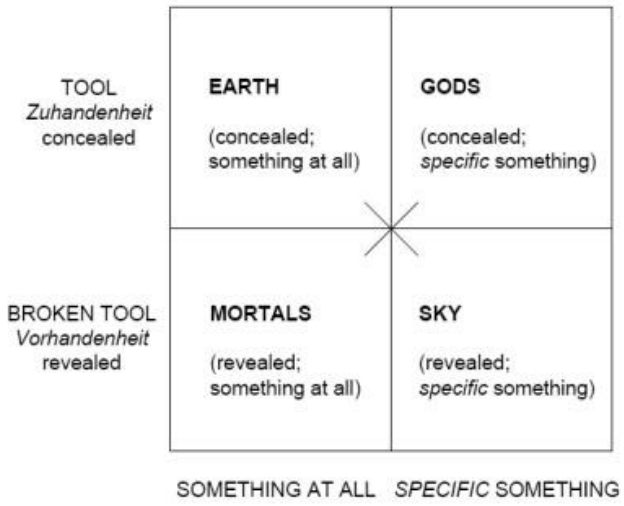

Figure 2.5.1.1 – Heidegger's fourfold [Das Geviert] according to Harman showing axial mirroring and diagonal relationships between essences and appearances (Reprinted from Harman, *Tool-being*, 203).

[620] Ibid., 39.
[621] Ibid., 46.
[622] Martin Heidegger, *Poetry, Language, Thought* (New York: Harper & Row, 1971), 177.
[623] Ibid., 178.

While Heidegger's fourfold presents an ontological system that relies heavily on the consistent identity of essences which shape the physiological properties of objects, the transformation of these objects appears problematic as the axial system does not allow any notion of growth. In his critique, Harman points out that the state of tool-being places "a doctrine so fixated on the duality of the absolute instant" that "*Heidegger has no theory of time."*[624] While *"a* genuine theory of time even becomes a *glaring need* in the wake of Heidegger's philosophy*"* Harman also finds similar remarks in the discussion of space. While the tool is discussed in spatial dimension of "both near and far" its spatial dimension as "a specific entity has already failed to stay afloat for Heidegger, since he is unable to distinguish it from any other instance of the reversal between tool and broken tool."[625] As a result, the tool-being as an essential construct doesn't give any consideration to time or space in the mirror-play of things. While Goethe considers archetypes to have a persistent "virtual inner identity" that are capable of reproducing their own kind, he does not attribute this identity simply to a phenomenal mirroring operation between forms and ideas, but as one of perfection and polarization.[626]

> Those bodies called organic have the characteristic of producing their like by themselves or from themselves. This is the part of the concept of an organic being and we can give no further account of it. The new and similar is at the beginning always a part of the same thing, and in this sense proceeds from it, thus supporting the idea of evolution. However, the new cannot develop from the old unless the old has reached perfection of a sort through a certain absorption of outer nourishment, thus supporting the idea of epigenesis. Both concepts are

[624] Harman, *Tool-being*, 65-66.
[625] Ibid., 54.
[626] Goethe, *Goethe's Botanical Writings*, 85.

crude and coarse compared to the delicacy of the unfathomable phenomenon itself.[627]

For Goethe, metamorphosis as a principle of reproductive growth extends polarity as an inner tension embedded into the essence of things. Thus, Leaf-Being doesn't present a mirroring dualism between two states of Being, but instead the mirror is placed between a form and its future. Archetypes "abstract the general picture in a genetic way" where the potential productivity of organisms is neither lost in formlessness nor is limited within any fixated leaf typology; yet, as a realist gesture, Goethe states that this "archetype must be established physiologically" as much as possible.[628] His leaf aims to reconnect two dimensions of existence as everything becomes super-actual in the universe–"let us not seek for something behind the phenomena- they themselves are the theory."[629] This is why Goethe carefully chooses the leaf as an ontological term to juxtapose ideal productivity of forces and forms as products of its ogive topology and virtual variability, anchored between its polar axis. For him, lack of polarization fails to permit neither appearances nor form in nature that yields to what Schelling calls *indifference* [*Indifferenz*]—a reversal to the state of equilibrium in the Absolute.[630] While polarity offers a bridge for the transition from the transcendental to the world of archetypes, a discussion of temporality and spatiality remains essential to speculate on the dynamics of its ontological system.

[627] Ibid., 86.
[628] Goethe, *Scientific studies*, 118.
[629] Ibid., 307.
[630] Schelling, *First Outline of a System of the Philosophy of Nature*, 185. For a discussion of Absolute indifference and how it relates to pure freedom see Žižek, *The Indivisible Remainder*, 14.

2.5.2 Polarity and Becoming

Apart from its archetypal construction that maintains a consistent essence, Goethe's dynamic understanding of Leaf-being as regulating developmental procedures can be found in his *Metamorphosis of Plants*, where he introduces the concept of polarity as a breathing, pulsating and sexual principle that drives transformation of subsequent organs formed along the axis of a plant.[631] This diametric opposition is also present among subsequent organs produced in an ascending order that have alternating relations to each other as these forms take on expansive or contractive expressions until their separation into sexual, reproductive organs of the flower. Furthermore, such a coupled relationship is also present within the nodal structure of plants, which either stack rolled up leaves on top of each other among the species of cereals, grasses and reeds; or couple stalks and leaf blades to produce all kinds of variable forms.

Böckemuhl's discovery of the dual formative movements in herbaceous plants shows that a circular arrangement of leaves, belonging to a plant's ontogenetic development, reveal the change in proportion and complexity in relation to an overall "*direction*" inherent in forms, where "the least expanded and the most contracted leaves both appear near the ideal zero-point" ending the cycle of vegetative growth of a plant (Fig.2.3.3.5).[632] Although rooted in phenomenology and the esoteric science of Steiner, Böckemuhl's research shows a pre-computational analysis of the leaf as a vehicle of inner movement, expressing its changing dynamism by shifting expansive and contractive forces–sprouting, segmenting, spreading and stemming–along its two poles

[631] Goethe, *Goethe's Botanical Writings*., 60.
[632] Bockemühl, "The Formative Movements of Plants," 133.

that considers each leaf as an organic magnet. While "the contour of any individual leaf can be seen as a function of the intensity, timing and duration" of generative activities, they also manifest themselves in reverse order to regulate the larger development of the plant –*ontogenesis*–as an impetus of metamorphosis.[633] As a result, all of the plant organs and external movements among leaf sequences present again and again the leaf contour as a wave function that is conditioned by two poles, expansion and contraction. This aspect not only relates parts to the whole in a dynamic and polar manner, but establishes polarity as a bridge between ideal-real constructions in nature. On one side, it reproduces new organs by modifying a common ideal form thereby maintaining a magnetic essence; on the other side, it structures how such modification occurs through metamorphosis, activating inner polar forces during morphogenesis. In the latter, polarity enters into the realm of becoming where its inherent duality transcends to the dimension of temporal development of form. This replaces the mirroring relationship of phenomenological Leaf-being with opposing polar forces that forms the backbone of its ontological change–metamorphosis.

A dynamic understanding of how duality structures an ontology of becoming can be found in Deleuze and Guattari's *A Thousand Plateaus* where form as an "abstract machine" does not evolve out "of a Platonic Idea, transcendent, universal, eternal" but instead "operate within concrete assemblages" through opposite processes of territorialization and deterritorialization.[634] In considering variation, Deleuze hints at the problematic paradox and relationship between one and many, where multiplicity has to offer "the principle of the simultaneous unity and variety of the stratum: isomorphism of

[633] Ibid.
[634] Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis : University of Minnesota Press, 1987), 510.

forms but no correspondence."[635] He finds this continuity in his discussion of the "unformed matter of the plane of consistency" that offers a way to reconcile dynamic processes of stratification which can either establish new concretized forms that maintain an identity, or dissolve into the absolute formlessness through their highly amorphous forms and viscous capacities.[636] Just like polarity, Deleuze defines two principles that drive such transformation, as in the case of territorialization and deterritorialization or the dual aspects of stratification that can be smooth-contractive or striated-expansive. He defines these as "two nonsymmetrical movements" which are "distinguished first of all by an inverse relation between the point and the line" where the smooth appears as a manifestation of the absolute and gravity; in contrast, the striated relates to how archetypes emerge out of the absolute by differentiating their identities through dynamic processes.[637] In his discussion of processes of becoming, Deleuze's volcanism aligns with Schelling's transcendentalism where "limited objects are exceeded on both sides by the forces and actions of matter and Idea."[638]

In his *A New Philosophy of Society*, Manuel DeLanda extends Deleuze's construction of assemblages into a realist ontology that can become a theoretical framework to model both social structures as well as biological entities.[639] The assemblage theory is presented in contrast to totalities and essences while producing emergent properties allowing analysis. Against totalities, assemblages "account for the

[635] Ibid., 46.
[636] Ibid.
[637] Ibid., *480*.
[638] Grant, *Philosophies of Nature after Schelling*, 191. Grant also emphasizes a crucial difference among the two. In Deleuze, he find "subterranean multiplicity of becoming" is directed towards the "vertical radiance of the solar One" whereas in Schelling's transcendental geology "the becoming of being consists in passages and transitions, while identity consists in potentiations and depotentiations."
[639] Manuel DeLanda, *A New Philosophy of Society: Assemblage Theory and Social Complexity*, (London & New York: Continuum, 2006).

synthesis of the properties of a whole not reducible to its parts."[640] Compared to organic wholes that lose their emergent properties when their "parts are fused together into a seamless web" the assemblages maintain such properties by facilitating dynamic interactions between their parts.[641] Challenging the "the very idea of relations of interiority" DeLanda describes assemblages as "wholes characterized by *relations of exteriority*" where parts "may be detached from it and plugged into a different assemblage in which its interactions are different."[642]

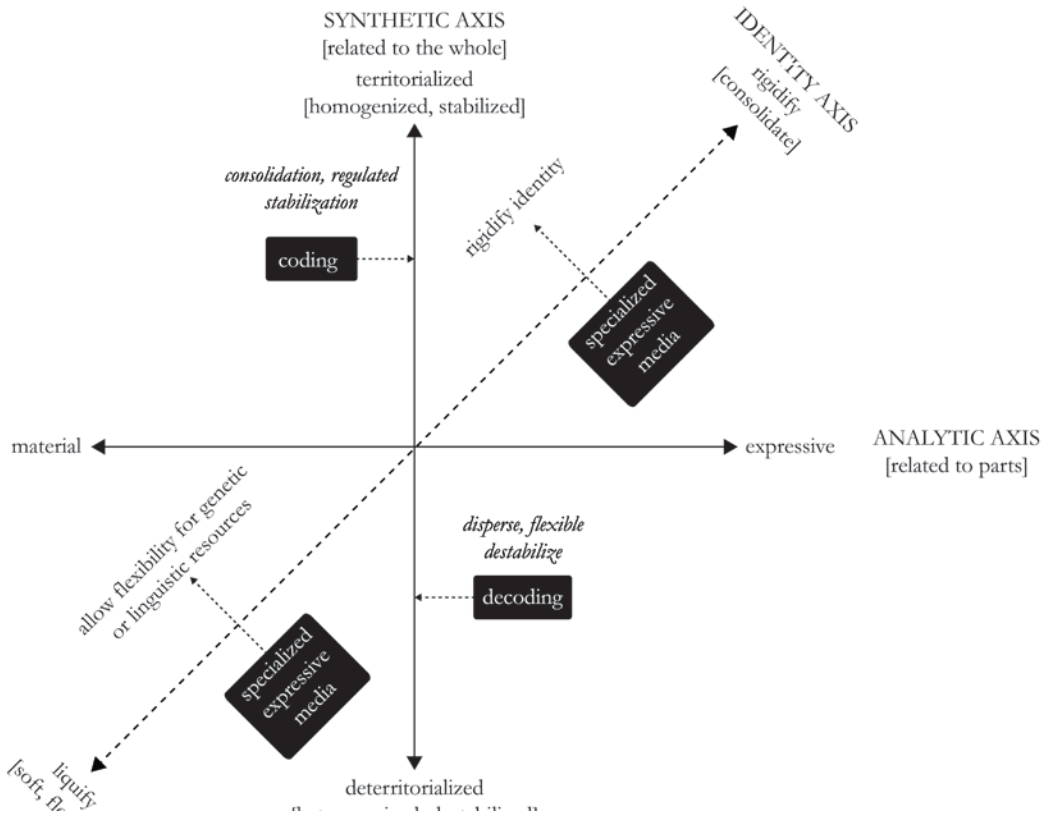

Figure 2.5.2.1 – The dual axes of assemblage ontology with a third identity axis. The processes polar processes of coding and decoding act as catalyzer to move entities along the axis.

[640] Ibid., 4.
[641] Ibid., 10.
[642] Ibid.

DeLanda's ontology is constructed along two main dimensions that explain both the properties of their constituent parts and the dynamic processes they produce. The first dimension constitutes to the analytic axis, defining "the variable roles which component parts may play, from a purely material role to a purely expressive one, as well as mixtures of the two."[643] The second dimension is the synthetic axis, that "characterizes processes in which these components are involved: processes which stabilized or destabilize the identity of the assemblage," the former happening through territorialization while the latter exerting de-territorialization (Fig.2.5.2.1).[644]

To solve their highly contingent devleopmental trajectories, assemblages present a historicity that at any level combines parts to produce an emergent whole. By avoiding any form of taxonomic classification and necessity for an essence to define the identity of produced individuals, DeLanda presents assemblage theory as a *flat ontology* where organic wholes emerge through the external affinity and capacity of their parts guided by attractors.[645] While assemblage theory allows plug-in play akin to botanical grafting of limbs, considering Leaf-being as an assemblage presents problems. Although the archetype requires a diagrammatic and generative body plan that establishes its organization, this singularity is not achieved through relations of exteriority but instead through *relations of interiority*–polarity of pulsing and alternating forces. While any leaf-like form could be detached and grafted on another mother plant, quasi behaving like an assemblage, the plant forms do not exist on an absolute flat ontology due to the progressive accumulation of complexity, recurring recapitulation and the polar influence

[643] Ibid., 18.
[644] Ibid., 19.
[645] Ibid. "the ontological status of assemblages, large or small, is always that of unique singular individuals ... unlike taxonomic essentialism in which genus, species and individual are separate ontological categories, the ontology of assemblage is flat since it contains nothing but differently scaled *individual singularities* (or *haecceities).*

of the environment. This is why, for Goethe, a malleable Platonic Type, in the form of a topological entity lacking internal bifurcation or an ever changing wave, can never truly explain how polarity works.

> These ideal archetypal bodies, even though we may picture them in our minds as simply as possible, we must nevertheless imagine as disunited in their interiors, for no third developing body can be imagined without previous division of the original body. These ideal archetypal bodies, which already have an inherent tendency towards duality, we shall allow to rest for the present in the womb of Nature. We shall only remark here that the atomistic and dynamic concepts are opposed at the very outset to developmental and formational procedures.[646]

From a philosophical perspective, polarity draws Goethe closer to his much younger protégé Schelling whose transition from Transcendental Idealism towards *Naturphilosophie* marks the development of an aesthetic-scientific systematization of nature based on a priori principles.[647] Goethe simply adds the notion of polarized archetypes to nature's becoming which provides ideation and a non-teleological view of for this framework.[648] Thus, the basis of this philosophy of nature is to constitute a reciprocal relationship between organic products (real) and productivity of nature (ideal) expressed through the dynamic activity of attraction and repulsion.[649] For Schelling, this universal conflict "is not something in matter, but is *matter* itself" where dynamic forces regulate continual production internally until they meet at an external equilibrium that

[646] Goethe, *Goethe's Botanical Writings*, 94.
[647] Richards, *The Romantic Conception of Life*, 128.
[648] For an evaluation of Goethe's view on teleology see: *Goethe's Botanical Writings*, 80. "I make bold to assert that it [final causes] does deter them [physiologists], therefore avoid it myself and consider it my duty to warn others against it." Goethe's non teleological view of nature can also be found in Tantillo, *The Will to Create,* 60. Richards considers Goethe to replace "divine teleology with natural causality, though a causality that retained a telic feature" in Richards, *The Romantic Conception of Life*, 445.
[649] Schelling, *First Outline of a System of the Philosophy of Nature.*

gives rise to organic forms.[650] Such dynamic organicism has Spinozian tones to it as well, as forms are produced out of productive polarity—*natura naturata*; later, these forms themselves become productive—*natura naturans*—where they never appear fixed and embrace their state of existence within "*infinite metamorphosis*."[651] However, such continual change cannot be conceived without foundational rules, requiring morphological templates to explain the internal relationship of forms as well as the coexistence of polar forces as the basis of nature. Yet, metamorphosis can not simply be explained by polarity alone and requires another principle to regulate its expansion and contraction, which Goethe defines as intensification. This forms the backbone of his work in physics particularly on color.

2.5.3 Polarity and Color

While Goethe's struggle to amalgamate being and becoming, one and many, ideas and processes can be traced through his botanical and morphological writings, perhaps a direct systematic approach towards his view of ontology could be found in his work on physics. Goethe's first interest in color dates back to 1790 when he tries to repeat Newton's highly complicated experiments in a white room following instruction in *Opticks*.[652] Among his numerous contributions to physics, Newton develops the "analysis of white light (sunlight) into lights of different colors, separated in the visible spectrum according to their different refrangibilities" where he "imagined that all colors can be produced by properly combining primary colors, of which he named seven."[653] In his *Theory of Colors*, Goethe describes how his engagement with Newton's experiments

[650] Ibid., 215.
[651] Ibid.
[652] Newton, *Opticks*.
[653] Bell, "Newton After Three Centuries,", 556.

using prisms yielded speculation to doubt that "Newtonian theory was erroneous."[654] He rejects the "explanation for the appearance of colors when white light is passed through a prism," considering Newton's colors to appear "from the point of view of the theory of refraction, which was not derived from nature herself, but from an artificial hypothesis."[655]

In his *Theory of Colors*, Goethe aimed to challenge Newton's approach based on light refraction with a theoretical and practical investigation of polarity as a way to study color appearances as well as their relationships. In his treatise he divides colors into three main classes; *physiological* colors that "belong to the eye itself, and to depend on an action and reaction of the organ"; *physical* colors that are "perceived in colorless mediums"; and *chemical* colors that belong "to particular substances."[656] The main difference in Goethe's work on color is not only his discoveries but also his method, particularly his experiments with physiological colors where he uses various monochromatic cards with white and black rectangular patches observed under a prism to determine the production of colors along contrasting borders. He conducts complementary experiments by looking at various black and white colored cards to experience changing color formations to outline their polar relationships (Fig.2.2.4.1). During these experiments, he often uses reciprocal patterns to observe how the same color sequences occur in a polarized fashion where warm colors—orange and yellow—appear on the black over white edge, and the cool colors—blue and violet—appear on the white over black edge. Goethe calls these two opposing order of color sequences "border

[654] Goethe, *Goethe's Color Theory*, 139.
[655] Jackson, "A Spectrum of Belief," 673-701. On the difficulty and complex nature of Newton's experiments see Magnus, *Goethe as a scientist*, 686. On the requirement of a polarized contrast to see color through the prism see James A. Marcum, "The Nature of Light and Color."
[656] Goethe, *Goethe's Color Theory*, 74.

spectra," and changing the color of the cards means changing their sequencing as well.[657] However, Goethe's real discovery is the ability of colors to mix their refrangibility by altering the distance of the prism from the cards which produced red through the mixture of orange and violet and green through yellow and blue (Fig.2.5.3.1). [658] This aspect also followed a quantifiable principle where "green emerges by subtraction of wavelengths as the light of the white strip gives way to darkness, while magenta emerges by addition of wavelengths as the darkness of the black strip gives way to light."[659]

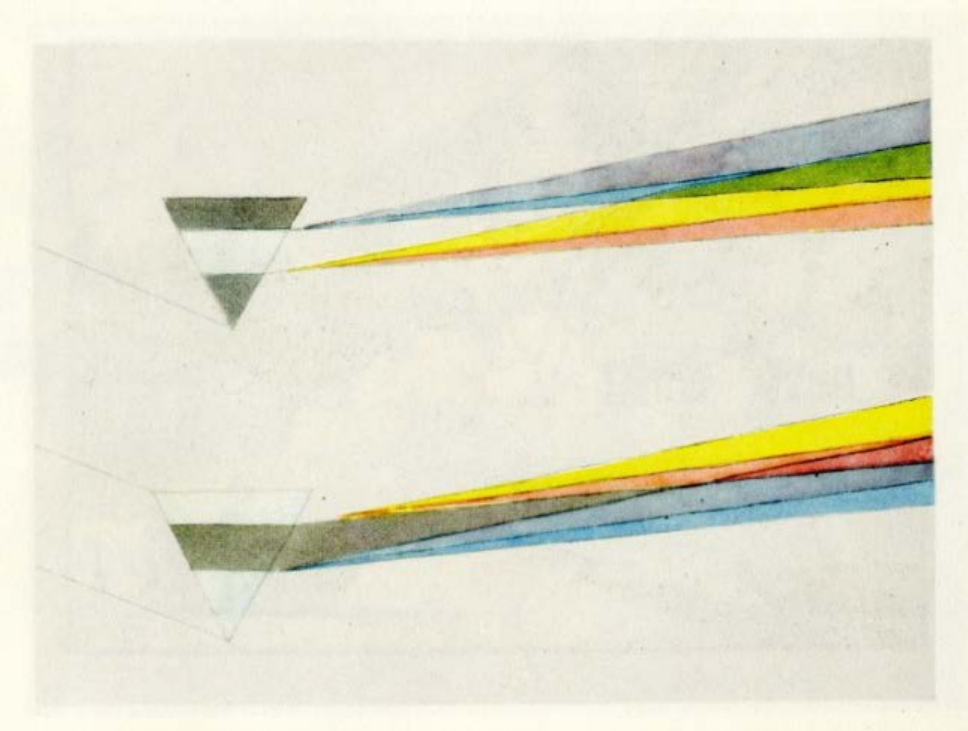

Figure 2.5.3.1 – Diagram of polarized color mixing. Alternating placement of black and white zones under the prism results in production of green through the mixture of blue and yellow, and red through orange and purple (Reprinted from Johann Wolfgang von Goethe, Gerhard Femmel, Rupprecht Matthaei, *Corpus der Goethezeichnungen. 5,a, Nr. 1-390, die Zeichnungen zur Farbenlehre* (Leipzig : Seemann, 1963 [erschienen] 1972), Plate 208)).

[657] Ibid., 42.
[658] Jackson, "Putting the Subject back into Color."
[659] Currie , "Goethe's Green," 270.

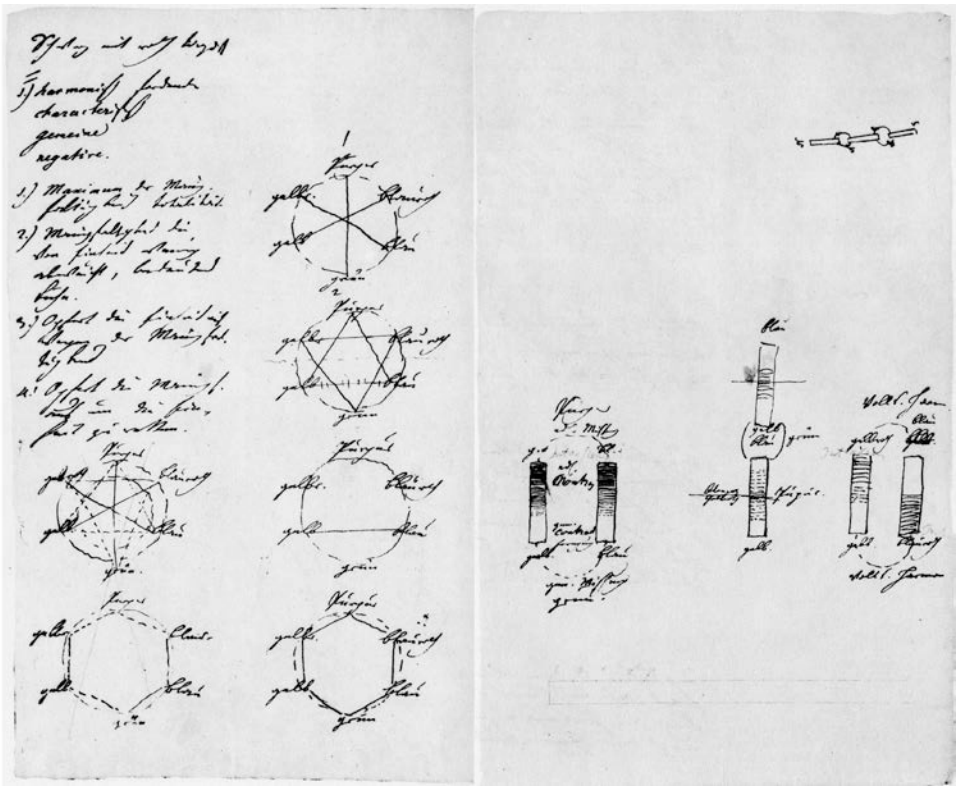

Figure 2.5.3.2 – The outline executed in Schiller's presence for the color wheel. Page left showing diagrams of how Goethe arrived at the symmetric construction of the color wheel. Page right shows initial polarized rods with primary color relationships that are magnetically brought together using arching lines marked with poles "S" and "N" (In Johann Wolfgang von Goethe, Gerhard Femmel, Rupprecht Matthaei, *Corpus der Goethezeichnungen. 5,a, Nr. 1-390, die Zeichnungen zur Farbenlehre* (Leipzig : Seemann, 1963 [erschienen] 1972), Plates 345-6).

Goethe called the colors observed over black background "the principal spectrum colors that Newton analyzed," contrasting the ones he identified over white background as "Goethe colors."[660] He gave equal rank to the reversed spectrum that produced harmony and contrast. When viewed at a greater distance, Newtonian colors converge to black while Goethean colors converge to white. Together, these six colors became the foundation for Goethe's symmetrical color wheel in contrast to Newton's asymmetrical

[660] Goethe, *Goethe's Color Theory*, 43.

construction with seven primary colors (Fig.2.2.4.2-3). The construction of the color wheel was accomplished together with Schiller on 1798, where Goethe first described polar color relationships using magnetic rods that are then combined where the word "intension is inserted three times" in between them to arrive at a cyclic, hexagonal diagram (Fig.2.5.3.2).[661] Rupprecht Matthaei states that the "brackets that connect the rods are reminiscent of force lines between magnetic poles" revealing how Goethe extended his ideas on polarity to produce a harmonic symmetrical system of color.[662]

In *Goethe Contra Newton,* Dennis Sepper revisits Goethe's formulation of *Theory of Colors* to offer a revaluation of its methodology and discoveries while reinstating its intellectual value in the historical development of physics.[663] On the difference of experiments with light and prisms, Sepper calls Newton's experiment an "anamoly" and instead considers Goethe's approach to color as "a function of a duality within a totality" where "the interrelation between the long-wave and short-wave components is more significant than the exact wavelengths reflected to the eye."[664] While Newton's experiments depended on a mathematical quantification of natural phenomenon due to wave-length, Goethe pursued a qualitative approach that tried to combine the organic behavior of color appearances with the organ of perception—the eye—that demanded a dynamic approach.[665] In constructing his symmetric color wheel, Goethe showed that "polarity does not imply a rigorous calculus" instead it "expresses a tendency or potential that may, under particular conditions, be actualized, modified, or suppressed."[666] In *Theory of Colors*, Goethe hints at how he used polarity as the main principle for the

[661] Ibid., 50.
[662] Ibid., 52.
[663] Dennis L. Sepper, *Goethe Contra Newton* (Cambridge, GBR : Cambridge University Press, 2011).
[664] Ibid., 14.
[665] On the significance of visual perception in color see Platt, "Newton, Goethe and the process of perception."
[666] Sepper, *Goethe Contra Newton*, 90.

construction of his color wheel that not only brings two primary oppositions together, but also their intensified halves to produce higher and lower mixtures.

> The color wheel has been gradually presented to us; the various relations of its progression are apparent to us. Two pure original principles in contrast, are the foundation of the whole; an augmentation manifests itself by means of which both approach a third state; hence there exists on both sides a lowest and highest, a simplest and most qualified state. Again, two combinations present themselves; first that of the simple primitive contrasts, then that of the deepened contrasts.[667]

Goethe's symmetric color wheel presents a harmonical system of polarity that both establishes relationships among color through oppositions, adjacency and mixing, as well as extends these towards understanding their sensual and aesthetic effects on the mind. Although his color hexagram did not find much recognition among physicists during his time, his system later became influential to the work of many philosophers such as Schopenhauer, Steiner and Wittgenstein and to painters such as Philipp Otto Runge and J.M.W. Turner who embraced his color theory in their work. In *Remarks on Color*, Wittgenstein considered "Goethe's theory of the origin of the spectrum" to be "not a theory at all" since "there is no *experimentum crucis*" for it.[668] However, he praised the logical construction of polarity as a basis for communicating visual phenomena by means of six primary colors. He compared Goethe's experience based approach with Newton's physical experiments to confirm the difference of their methods. For Wittgenstein, colors are differentiated from white and black since neither one can be expressed by the

[667] Goethe, *Goethe's Color Theory*, 159.
[668] Ludwig Wittgenstein, *Remarks on Colour*, ed. G E M Anscombe, trans. Linda L McAlister, Margarete Schättle, (Berkeley : University of California Press, 2007), 32e.

summation of other, nor described by means of its opposite. “This is why colours were shadows for Goethe”, since comparing brightness of different colors yields to identifying them.[669]

In his *On Vision and Colors*, Schopenhauer considers the “*qualitatively divided activity of the retina*” to define a polar relationship between external stimulus and the simultaneous impulse in the eye that produces a continuous and common experience of colors that “must be known to some extent *a priori*.”[670] Schopenhauer states that the visual perception of color has spatio-temporal aspects; “it is characteristic of the polarity of the retina that its occurrence is in time, and therefore successive, whereas the other polarity phenomena occur in space, and are therefore simultaneous.”[671] He considers Goethe’s color wheel to produce a coherent system where “the basic idea of *all polarity*, under which magnetism, electricity, and galvanism might be brought.”[672] Thus, Goethe’s color wheel aligns with his views on morphology where polarity, as a system of natural productivity, transcends all products in nature, turning the wheel into an ontological machine.

2.5.4 Polarity Machine

As an ontological diagram, Goethe’s color wheel shows similar properties to Böckemuhl leaf diagrams where both of them expresses cyclic transformations as well polar oppositions among forms. In Böckemuhl’s leaf sequences “form and pattern transformations [*Bildebewegungen*]” place *embryogenesis*–development of individual

[669] Ibid., 24e.
[670] Arthur Schopenhauer, Georg Stahl, Philipp Otto Runge, *On Vision and Colors* (New York : Princeton Architectural Press, 2010), 68.
[671] Ibid., 71.
[672] Ibid.

leaves, and *ontogenesis*–the overall development of the plant– in a radially polarized fashion that corresponds with how Goethe envisons a color wheel capable of color mixture and transformations.[673] This dual radial tendency is also present in the Nipplewort diagram which shows how the two genetic functions of Leaf-being are overlapped, relating contractive ontogenesis with expansive embryogenesis by continually bending the trajectory of development back towards younger forms (Fig.2.3.4.3). While the embryonic sequence marked by continuous production of forms constitutes to the *spatial* domain of Leaf-being that is topologically driven, it is then counter balanced by discontinuous forms produced along the stem as the *temporal* domain that still presents a continuous wave or "formative movement" expressing the consistency of underlying polarities.[674] For Bockemühl, the undulating sequences show that the expression of an underlying archetype can not be directly observed, but manifested as an esoteric body of time and space. However, the sequencing demonstrated by the plant reveals how Leaf-being produces a harmonic and cyclic system of metamorphosis, turning forms as indeces of underlying forces into the complementary polar forces and regulating activity of intensification. This is why for Goethe "All" beings display leaf-like properties that combine polar axis, forces and developmental trajectories whether they are color, leaves, plants, animals or architecture. Thus, when the prefix Ur- is added to types, it opens up a comparative model for polarity, turning archetypes into dynamic polar entities that are subjected to metamorphosis while Un- becomes the superlative form that represents the formless and apolarized Absolute.[675] In

[673] Jochen Bockemühl, "Transformations in the Foliage Leaves of Higher Plants," 115.
[674] Jochen Bockemühl et al., *The Metamorphosis of plants*, 35.
[675] Schelling also uses this principle in his conception of the *Ungrund* as the Absolute productivity of nature which represents a symmetrical balance of polar forces lacking any notion of space and time. The transformation to *Urgrund* simply signals a polarization

his most idiosyncratic way, Goethe extends polarity as an all inclusive system of form that is non-holistic or monistic, but in its construction is entirely generative, diagrammatic and dualist.

> All is leaf, and through this simplicity the greatest multiplicity is possible. The leaf has vessels, in its convolution produces another leaf, where you can form a crude image by entanglement of two lines. The point, where the vessels meet, and it begins to form a leaf, is the node. The node not only produces the following leaf, but several. A leaf that sucks moisture under earth, we call root. A leaf that extends out from moisture we call a bulb, an onion, for instance. A leaf that expands the same is a stalk. Stem. The main reason for this hypothesis is the observation that the seed or the evolution consists of more parts, which are related to each other, but in the development cancel each other…[676]

Goethe's construction of the color wheel marks a crucial achievement in his morphological investigations because it extends polarity as a generative diagram of metamorphosis, offering a cyclic understanding of how *Urphänomene* come into being and dynamically transforms. Furthermore, his wheel combines two main principles of morphology together, polarity and intensification, where the former is associated with the first primary colors of yellow and blue as deviations of white and black, and the latter is represented by red and green as simple and complex mixtures of color oppositions. In this

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act that occurs through asymmetry among forces. The *Urtypus* borrows the viscous productivity of Nature while anchoring space and time along their forms. Schelling, *Philosophical Investigations into the Essence of Human Freedom*,68.

[676] Johann Wolfgang von Goethe, *Goethe's Werke*, Berliner Ausgabe (Berlin: Aufbau-Verlag, 1972-73). S. GA17:189u (Kap.Nr.:1956). "Alles ist Blatt, und durch diese Einfachheit wird die größte Mannigfaltigkeit möglich. Das Blatt hat Gefäße, die in sich verschlungen wieder ein Blatt hervorbringen, wo man ein krudes Bild durch Verschlingung zweier Linien sich formieren kann. Der Punkt, wo die Gefäße sich treffen und dies eine Blatt zu bilden anfangen, ist der Knoten. Dieser Knoten bringt nicht bloß das folgende Blatt hervor, sondern mehrere.Ein Blatt, das nur Feuchtigkeit unter der Erde einsaugt, nennen wir Wurzel. Ein Blatt, das von der Feuchtigkeit ausgedehnt wird pp., Zwiebeln. Bulbus. Ein Blatt, das sich gleich ausdehnt, einen Stiel. Stengel. Der Hauptgrund dieser Hypothese ist die Betrachtung, daß der Keim oder das zu Entwickelnde aus mehr Teilen besteht, die miteinander verwandt sind, sich aber in der Entwicklung einander aufheben zum Exempel."

sense, Goethe describes a relationship between polarity and intensification, matter and spirit, which together aims to construct a fourfold understanding of life.[677] Yet it is valid to speculate whether polarity and intensification constitute a coherent systematic ontology.[678] To visualize this system, form and pattern transformations [*Bildebewegungen*] can be aligned with the color wheel to constitute into two orthogonal axes, a lateral one relating to the polarity among analytical parts and forces, and a vertical one relating to synthetic wholes that are placed along an intensity axis which produces simple or complex forms (Fig.2.5.4.1).

The Leaf-being ontology presents a different model than Heidegger's four-fold [*das Geviert*] where the overlapping of the two genetic streams and cyclic motion of metamorphosis constitutes a dynamic model of growth. As metamorphosis becomes a metaphysical term that anchors two main principles—intensification and polarity—its dynamism becomes an expression of both time, not space alone, pulling ontogenesis—as the temporal expressive domain of the archetype—even closer to the ontology of the leaf. While the diagram of metamorphosis shows similarity to the dualist construction of assemblages, in its generative expressions it is mainly *intrinsic*, where the radial wheel acts like an ontological clock placing the spiraling tendency at the heart of nature as radial movement occurs due to the axial splitting of primordial forces of nature.[679] This

[677] Goethe, *Scientific Studies*, 6. Goethe associates matter and spirit to polarity and intensification in his essay titled "A Commentary on the Aphoristic Essay 'Nature'" where he denies a monistic view of nature found in Spinoza and instead he considers a dualist approach based on polarization.

[678] For an overall discussion of a fourfold in ontology see Graham Harman, "DeLanda's ontology: assemblage and realism," in *Continental Philosophy Review*, Volume 41, Issue 3 (September 2008): 367-383. Harman states the basic requirements of a fourfold ontology as it "must do two things. First, it must ensure that its two basic dualisms are sufficiently deep to warrant inclusion in the backbone of the universe...A second thing four fold models must do is explain the interrelation of the four poles and their possible transformation into one another."

[679] Goethe mentions his intrinsic view of nature in his second essay *Metamorphosis of Plants* in *Goethe's Botanical Writings*, 80. "…a creature is self-sufficient, that its parts are inevitably interrelated, and that nothing mechanical, as it were, is built up or produced from without, although it is true that the parts affect their environment and are in turn affected by it." A return to intrinsic view of ontology is developed in Lars Spuybroek, *The Sympathy of Things: Ruskin and the Ecology of Design* (Rotterdam: V2, 2011). In the third chapter Spuybroek examines at the development of Sympathy first in the work of James and Bergson, then relates these to the German

motion guides the development and activity of forces that will produce form and links time with space. Thus, Leaf-being, as a rule based, polarized, generative template becomes a prototype for Goethe, within its shape-shifting character, its variability and consistency is somehow guided by its axiality and polarity of parts that presents an ideal-real product, form is placed in a primordial tension between polar forces that anchor space with time.

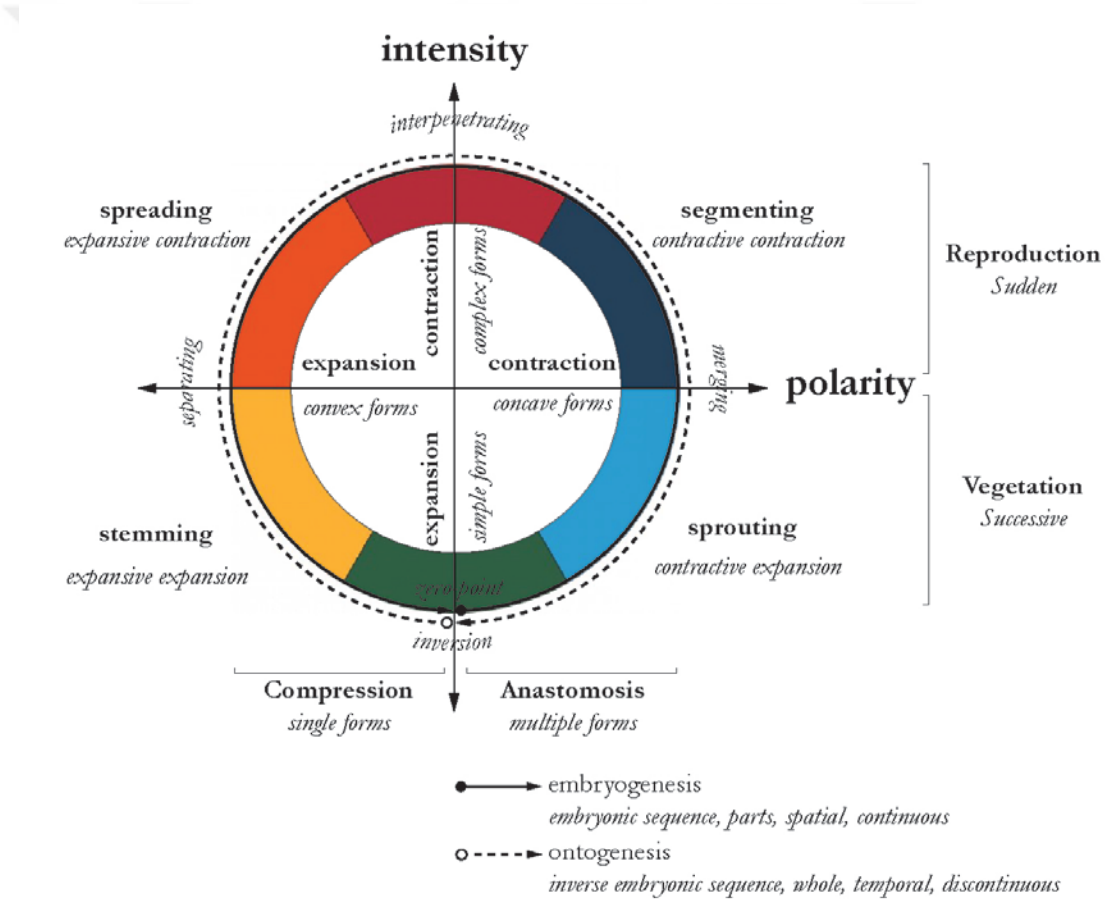

Figure 2.5.4.1 – Polarity Machine: ontology of the leaf-being combining two polar axes by juxtaposing intensification and polarity.

aesthetic theory of *Einfühlung*, developed by Lipps and Worringer. Sympathy originates from the last quarter of nineteenth century in German Romanticism and Philosophy which focused on understanding the relationship between men and things. This relationship is defined as an aesthetical form of thinking and feeling for things rather than a psychological or sensual connection.

As an ontological system metamorphosis can also change the misconception regarding the biogenetic law relating ontogeny to phylogeny. Current research in evolutionary developmental mechanics reconsiders form as a result of dynamic interactions between parts driven by internal unchanging laws -morphogenetic fields- that replaces "empirical forms as transformations to a consideration of generative structures".[680] Although there is a repetitive relation between ontogenegy and phylogeny, recapitulation is not linear due to the involvement of time, but it's cyclic in behavior, where "the phylogenetic development of the leaf runs counter to metamorphosis", as forms evolve, they tend to express younger traits in their ontogenesis as if evolution is working backwords on forms that are rapidly produced.[681] As Suchantke mentions "the process of juvenilization is a prelude to a genuine leap in evolution, i.e. the emergence of something new and completely unprecedented."[682] Thus, the intensification in the form of striving does not present a vertical ascension in the form of great chain. Instead, Goethe's ontological landscape as the *Urgrund* appears as a manifold trajectory for forms, turning the chain of creation into a loop that is capable of both ascending towards the summer house and descending toward the dark waters of the lake as the *Ungrund*. While variation in ontogeny is expressed through growth and aging, phylogeny shows morphological tendencies expressed among species under changing spatial conditions, such as climate and geography, that are still effected under the dynamic rubric of the ideal productivity of nature. Such a proposition states that evolution is not guided by external factors alone, but mainly drives on the morphological tendency of polarized

[680] Webster and Goodwin, *Form and Transformation,* 116.
[681] Bockemühl et al., *The Metamorphosis of plants*, 54.
[682] Ibid., 63.

forces that try to revert their activity back to an equilibrium, albeit failing at it but still yielding to forms that populate the world.

CHAPTER 3 POLARITY AND ARCHITECTURE

3.1 Polarity and Symmetry: Animals and Architecture

Among many historical theories that aim to justify the field of architecture and its operations, the organic analogy that relates it to the animal body, proportion and symmetry has been the most pervasive. When considered as a form of art, architecture displays methods akin to living nature that exploits mainly two tendencies. Firstly, architecture could either imitate natural forms for the production of beauty as an act to give the illusion of life to inanimate matter, or secondly, the process of design could imitate the methods of nature to both invent new styles as well as develop a strategy to understand the works of the past. This dichotomy has been elaborately discussed in Caroline van Eck's *Organicism in Nineteenth-century Architecture* in which she gives an extensive "reconstruction of the philosophical and theoretical origins of nineteenth-century organicism, and the analysis and clarification of its role as a strategy of invention and interpretation in the context of the search for style."[683] Although organicism is often considered as a reaction towards the mechanical understanding of architecture that is more rational and functional, Van Eck opposes this trend and considers organicism as part of a historical continuum starting with Vitruvius where the main tenet was that "architecture should imitate the purposive unity of living organisms."[684] This aspect of organicism not only relates animal body to architectural body, but also poses some challenges to contemporary architectural discourse such as finding architectural

[683] Eck, Caroline van, *Organicism in Nineteenth-century Architecture: An Inquiry into Its Theoretical and Philosophical Background* (Amsterdam: Architectura & Natura Press, 1994), 28.
[684] Ibid., 21.

archetypes for historical analysis and developing a strategy for the study of symmetry in architecture. These aspects will be investigated in three parts focusing on the polarity in animal bodies through body-limb dualities, historical development of symmetry and the primitive hut [*Urhütte*] as a model of an architectural archetype.

3.1.1 Polarity and Organicism: Animal Body and Architecture

As an application of natural principles and forms towards architecture, organicism poses paradoxically ahistorical and more technical-philosophical methods. Among these, the theories that relate architecture to nature were firstly developed with the use of rhetoric that established and transformed its flexible principles, an approach also encountered in the historical development of sciences such as biology.[685] For architecture, this rhetorical development originates from the first treatise written on architecture by Marcus Vitruvius Pollio [c.80-70 BC–c.15 BC] titled *De Architectura* [On Architecture, published as The Ten Books on Architecture] that describes the main principles of architecture to establish it as an artistic and technical practice for the reconstruction of the Roman Empire.[686] Although Vitruvius's treatise included information about construction and types of buildings, in its theoretical discussion on architecture it remained mainly rhetorical. This was evident in one of Vitruvius's most famous claims about architecture that developed an analogy between the architectural body and the human body opening up the possibility of treating buildings like organisms. This enabled architecture to establish rules about

[685] An example of rhetoric in the development of biology could be found in Donna Jeanne Haraway, *Crystals, Fabrics, and Fields: Metaphors that Shape Embryos* (Berkeley, Calif. : North Atlantic Books, 2004). Haraway looks at three important figures in 20th century that changed the course of organic research after the mechanism-vitalism debate in the late 19th century. These scientists were: American Ross G. Harrison, English Joseph Needham and Austrian Paul Weiss. The goal of the book is to elaborate extensively on the works of these three scientists to reveal if a new paradigm was developed for embryology during 1920s-30s.
[686] Vitruvius Pollio, *The Ten Books on Architecture*, trans. Morris Hicky Morgan with illustrations and original designs prepared under the direction of Herbert Langford Warren (New York: Dover Publications, 1960).

proportions and symmetry among its parts and the whole to investigate beauty in its formal development. In *De Architectura*, Vitruvius applies this analogy to describe how the Greek antiquity borrowed the proportions for their temples from the measurements of the human body. In Chapter I of Book III titled "On Symmetry: In Temples and in the Human Body" he defines two principles, symmetry and proportion, the former relating to a relationship among parts and a whole, and the latter determining the ratio between them for the design of a temple.[687]

> The design of a temple depends on symmetry, the principles of which must be most carefully observed by the architect. They are due to proportion, in Greek *αναλογία*. Proportion is a correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard. From this result the principles of symmetry. Without symmetry and proportion there can be no principles in the design of any temple; that is, if there is no precise relation between its members, as in the case of those of a well shaped man.[688]

This analogy not only allows Vitruvius to discuss topological and proportional relations among the anatomical parts of a body but also establishes a comparative method that is applicable towards architecture. But for him the dualism does not exist between two related parts; instead, a single part acts as a module of measurement for the whole to define consistent ratios that might give an aesthetic recipe for the design of buildings. For Vitruvius, these fractions describe "the relationship between the modular unit and the

[687] Ibid., 72.
[688] Ibid.

figure by which it is multiplied or divided to arrive at the dimensions of the whole."[689] This correspondence between the module and the whole defines *symmetria* [Symmetry] as a parts to whole strategy where parts that are "mechanistic, reductionist, or atomistic" are contrasted with wholes that are "holistic, organismic, or ecological."[690] Vitruvius considers symmetry through the depiction of an ideal male body that is geometrically justified by taking the navel as the center of a circle circumscribing the rotational movement of the arms and legs and defining an orthogonal correspondence between the overall height and the width of outstretched arms that fits into a square. During the Renaissance, this topological description and correspondence among parts was reconstructed by many artists and architectural theorist including Leonardo da Vinci and Cesare Cesarino (Fig.3.1.1.1–2).[691] Leonardo imagined the *Vitruvian Man* "as all those things and more: as a study of human proportions; as an overview of the human anatomy; as an exploration of an architectural idea; as an illustration of an ancient text, updated for modern times; as a vision of empire; as cosmography of the lesser world; as a celebration of the power of art; as a metaphysical proposition."[692] Cesarino chose to emphasize the juxtaposition of the body with ideal geometrical figures of a circle and square. Among the two, Leonardo's depiction showed asymmetry between upper and lower halves of the body due to the transposed center of the square that was positioned lower than the navel

[689] Thomas Gordon Smith, *Vitruvius on Architecture* (New York, NY: The Monacelli Press, 2003), 18. Also quoted in Vitruvius, *The Ten Books on Architecture*, 73-74. Vitruvius gives various examples on the mathematical relationship of the parts within a body. Between the face and the overall body the ratio is 1/10, for the length of the foot it becomes 1/6, and for forearm and breadth of breast its 1/4. He also describes proportional relationships among parts of a face, looking at the overall tripartite organization formed by the mouth, nostrils and forehead that all show 1/3 ratio to the face.
[690] Fritjof Capra, *The Web of Life: A New Synthesis of Mind and Matter*, (London: Flamingo, 1997), 17.
[691] Rudolf Wittkower, *Architectural Principles in the Age of Humanism* (New York, Random House, 1965), 14. Wittkower writes on the cosmic importance and influence of this drawing on architects and artists during Renaissance as "the image haunted their imagination." A lot of artists of the era depicted the Vitruvian figure including Francesco Giorgi (1525), Francesco di Giorgio, Fra Giocondo (1511), Leonardo da Vinci (c. 1490) and Cesare de Lorenzo Cesarino (1668). Marcus Vitruvius Pollio, *De architectura*, translated into Italian, with commentary and illustrations by Cesare de Lorenzo Cesariano, 1668.
[692] Toby Lester, *Da Vinci's Ghost: The Untold Story Of Vitruvian Man* (London : Profile Books, 2011), 216-7.

to conform to the proportions of the body.[693] In contrast, Cesarino's figure aimed at capturing absolute symmetry among parts by over stretching the arms to fit the corners of the square and radius that deviated from a realistic human figure.

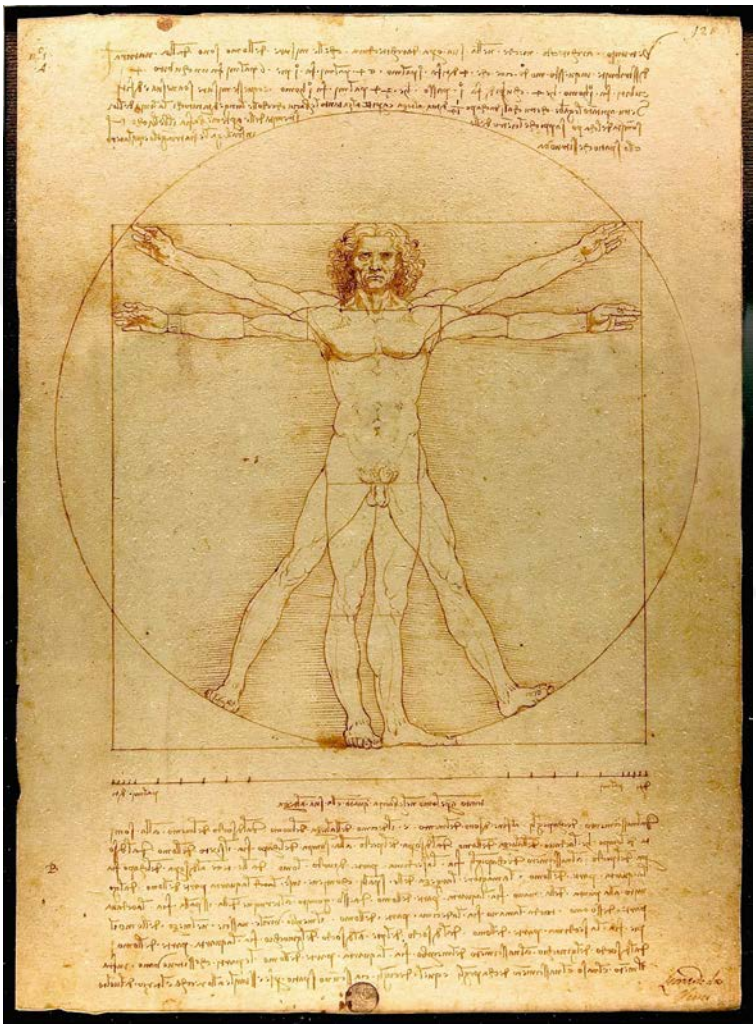

Figure 3.1.1.1 – The *Vitruvian Man* [*L'Uomo Vitruviano*] drawn by Leonardo da Vinci around 1490. Leonardo shows the proportional lines at the bottom of the drawing along a line. There are also vertical and horizontal segmentations along arms and legs that show proportional divisions.

[693] Ibid., 209-210. Lester emphasizes a similar artistic intervention by Leonardo comparing the drawing to Francesco di Giorgio Martini's depiction: "Instead of drawing a circle and a square that shared a center with the human navel, as Francesco had done, Leonardo shifted his square downward…this allowed him to draw a single fifure whose navel occupied the center of the circle and whose genitals occupied the center of the square: a figure, in other words, that corresponded to both the Vitruvian ideal *and* anatomical reality." Another review of di Giorgio's depiction of the male body as a determinant for the city geometry could be found in Diana I. Agrest, "Architecture from without: Body, Logic, and Sex," *Assemblage*, No. 7 (Oct., 1988): 28-41.

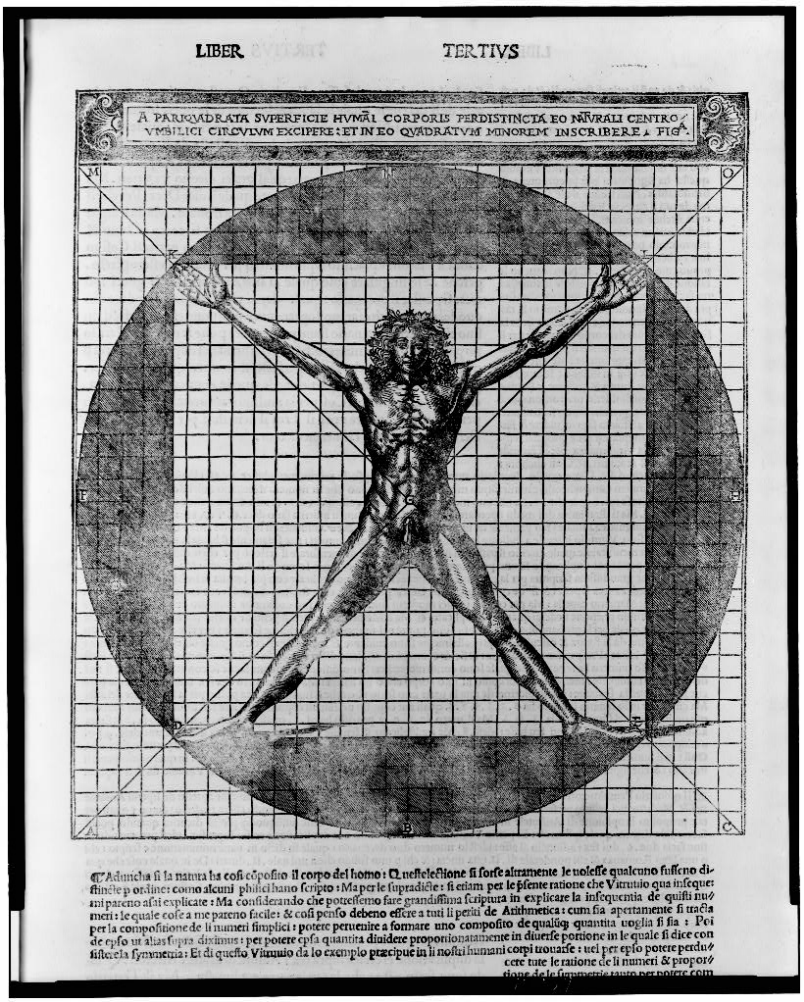

Figure 3.1.1.2 – Engraving from Cesarino's 1521 edition of Vitruvius' *De architectura*. Cesarino's depiction stretches the arms of the *Vitruvian Man* to fit into the square diagonally to enforce the absolute proportional match between the two ideal geometries.

Although the Renaissance description, construction and depiction of the *Vitruvian Man* presents a whole to part duality, the symmetry is not considered among parts themselves, but among parts and the whole that is often considered fixed, pointing towards an idealistic balanced aesthetic. Similarly, Vitruvius extends this approach towards architecture, where the overall parts of a building could also be derived from the measurement of the whole–architectural body.

> Therefore, since nature has designed the human body so that its members are duly proportioned to the frame as a whole, it appears that the ancients had good reason for their rule, that in perfect buildings the different members must be in exact symmetrical relations to the whole general scheme. Hence, while transmitting to us the proper arrangements for buildings of all kinds, they were particularly careful to do so in the case of temples of the gods, buildings in which merits and faults usually last forever.[694]

Vitruvius even considers how this harmony of parts are brought to the structure through a "perfect number" that "the ancients fixed upon ten" by borrowing the total amount of digits on hands and feet as a representation of symmetry and offering a numerical basis of fraction for the body.[695] Thus, architecture became highly anthropocentric, developing a proportional understanding of spaces with respect to human body proportions only. Under the influence of Da Vinci's depiction for the *Vitruvian Man*, many Renaissance architects and artists tried to extend such geometric juxtaposition towards architecture seeking a correlation between the human body and the architectural body through proportional relationships.[696] Among these the analysis of cruciform ground plan of churches became a direct symbol of Christ as early as the fourth century that resembled the arms-wide depiction of the *Vitruvian Man*.[697] Many Renaissance artists and architects such as Pietro di Giacomo Cataneo, Francesco di

[694] Ibid., 73.
[695] Ibid.
[696] Agrest, "Architecture from without," 30. Agrest lists several Renaissance texts as an example of this tenet such as Alberti's *De re aedificatoria*, Filarete's *Trattato d'architettura*, Di Giorgio Martini's *Trattato di architettura civile e militare* and his *Trattati di architettura, ingegneria e arte militare.* Lawrence Lowic, "The Meaning and Significance of the Human Analogy in Francesco di Giorgio's Trattato," in *Journal of the Society of Architectural Historians*, Vol. 42, No. 4 (Dec., 1983): 360-370. Lowic focuses on the influence of Vitruvian thought on di Giorgio's development of architectural treatise, where the analogy between man and temple is extended towards the city, forts and the castle.
[697] Peter Fingensten, "Topographical and Anatomical Aspects of the Gothic Cathedral," in *The Journal of Aesthetics and Art Criticism*, Vol. 20, No. 1 (Autumn, 1961): 8. Fingensten writes on the analogy used in religious texts where Christ compared his body to a temple. The first cross ground plan for churches was realized in Old St. Peter's built in 326 A.D.

Giorgio, and Cesare Cesarino tried to extend the Vitruvian proportions towards architecture. Among these, Pietro di Giacomo Cataneo in his *I Quattro Primi Libri Di Architectura* "even drew a nude male body within the confines of a basilica based upon a Tau cross plan" extending the Vitruvian idea of proportions to the overall organizational scheme of church plans (Fig.3.1.1.3).[698]

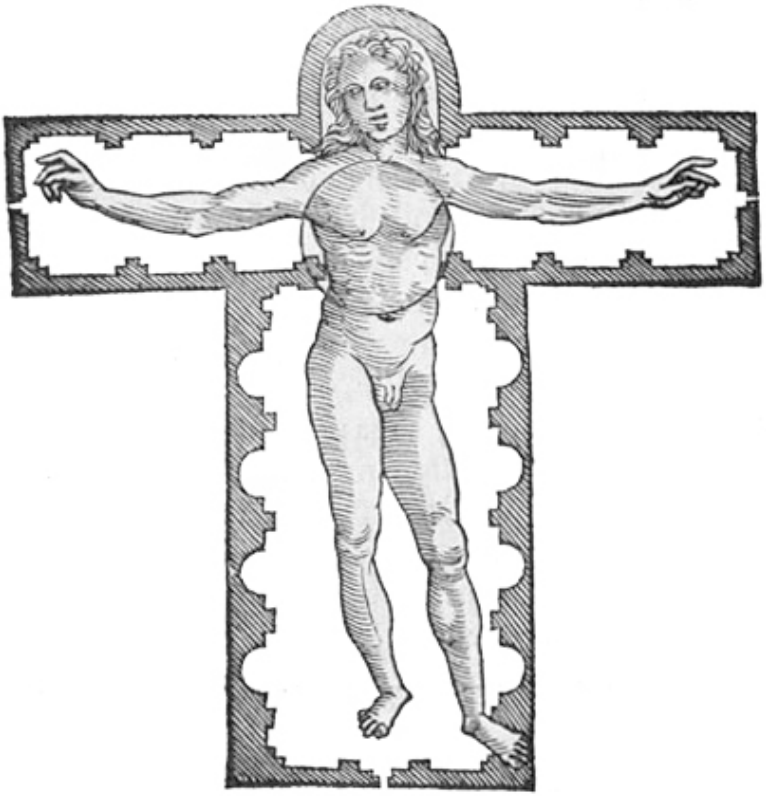

Figure 3.1.1.3 – Vitruvian Figure juxtaposed on a basilica plan (Reprinted from Pietro Cataneo, *I Quattro Primi Libri Di Architectura* (Venegia, 1554)).

Although Vitruvius's discussion of symmetry and proportion of the human body as a guide for architecture was highly influential during the Renaissance, the classical

[698] Ibid., 13. Fingensten draws emphasis on the masculine depiction of the body over the church plan and proposes a sexual unison for the design of Gothic cathedrals where the feminine body is mostly employed in the interior. He makes formal comparisons between the anatomical body and architectural elements such as "the pointed ribbed vault system suggests the rib-cage of a gigantic mother bending over her son" as well as "the doors, now symbols of her virginal organ."

juxtaposition of the animal body with architecture that particularly occurs on the plan of structures presented various morphological problems. Firstly, the Vitruvian body appears highly patriarchal by being restricted to the male gender only and lacking any sexual understanding of form for the design and construction of architecture.[699] Secondly, the classical notion of the architecture–body juxtaposition is highly schematic in character due to its limitation to proportional relationships among parts and the whole that are typological and multipliable.[700] Thirdly, anthropocentric architecture poses a strict limitation on the formulation of an archetype for the architectural body that can produce multiple limbs as well as use different topological ratios for its parts.[701] This is why the classical body is restricted to topological expansion only, and fails to understand contraction that effects the organization of the body in a way that is more diagrammatic and dynamic. Morphologically, the *Vitruvian Man* presents a notion of symmetry from the whole only, and not as a dynamic polar principle among all parts of the body. In his morphological writings on the animal archetype, Goethe offers a different view of the animal body that rests on a symmetry axis presenting three distinct parts: the sensuous head, the locomotive torso, and the reproductive organs.

> The head is always the forward part; there the individual senses meet, and there the governing organs of sense are bound together in one or more ganglia, which we usually call the brain. The midsection contains the organs for inward

[699] Agrest, "Architecture from without," 34. Directly quoting Filarete, Agrest criticizes the exclusion of woman from the body analogy. She uses the term "architectural transsexuality" where the architect as male figure, "possesses the female attributes necessary for conception and reproduction."
[700] Greg Lynn, "Probable Geometries: The Architecture of Writing in bodies," in *Any* (New York: Anyone Co., 1993): 43. Lynn describes the static and proportional forms as "eidetic" that are "(1) exact in measure and contour, (2) visually fixed, and (3) identically repeatable."
[701] Brian C. Goodwin, *How the Leopard Changed its Spots: The Evolution of Complexity* (New York : C. Scribner's Sons, 1994), 142-147. Goodwin describes Goethe's archetypal form for all animals as being able to produce different limb morphologies with changing proportions. In this sense, the animal body-architecture body juxtaposition needs to be seen more variable and dynamic offering proliferation and transformation of limbs that can bifurcate and topologically stretch.

> maintenance of life and constant movement outwards; the organs of the inner life impulse are less important in the insect, since each part of this creature seems to be endowed with its own life. The rear section contains the organs of nourishment and reproduction, as well as those of grosser elimination.[702]

By establishing the animal body through a polar axis, Goethe offers a dual understanding of the animal body that relates various segmentations of the torso with their complementary appendages or auxiliary organs. This not only brings a polarized proportional relationship between various parts of an organism, but also puts an antagonistic expression between members of the animal kingdom, the contractive invertebrates and the expansive vertebrates. Goethe considers the former to express clear separation of three domains; while in "fully developed animals, the head is separated rather decisively from the second section" and the locomotive and reproductive parts are merged "by a lengthened backbone and a common covering."[703] In insects, exoskeletons support inner soft tissue and muscles that aid their movement. In animals, the bone-muscle relationship is reversed, where the spinal column and bones act as the main structural support of the body that is covered with skin and muscle.[704] This also produces effects on the overall size of the animals with insects remaining relatively smaller and contractive (Fig.3.1.1.4).

[702] Goethe, *Scientific studies*, 119.
[703] Ibid., 120.
[704] Sean B. Carroll, *Endless Forms Most Beautiful: The New Science of Evo Devo and the Making of the Animal Kingdom* (New York : Norton, 2005), 142-143. Animals and insects share bilateral symmetry in the evolutionary tree, differentiating them from the radially symmetric Cnidaria and Porifera. Carroll writes "one feature we can assert is that the last common ancestor of protostomes and deuterostomes was bilaterally symmetric." Although animals and insects share less common genes (app. %36), with their rapid rate and mutability Drosophila (fruit fly) has become a model animal for genetic experimentation for the study of morphological mutations that can produce multiple wings, legs instead of antennae and different morphological expressions of eye formation.

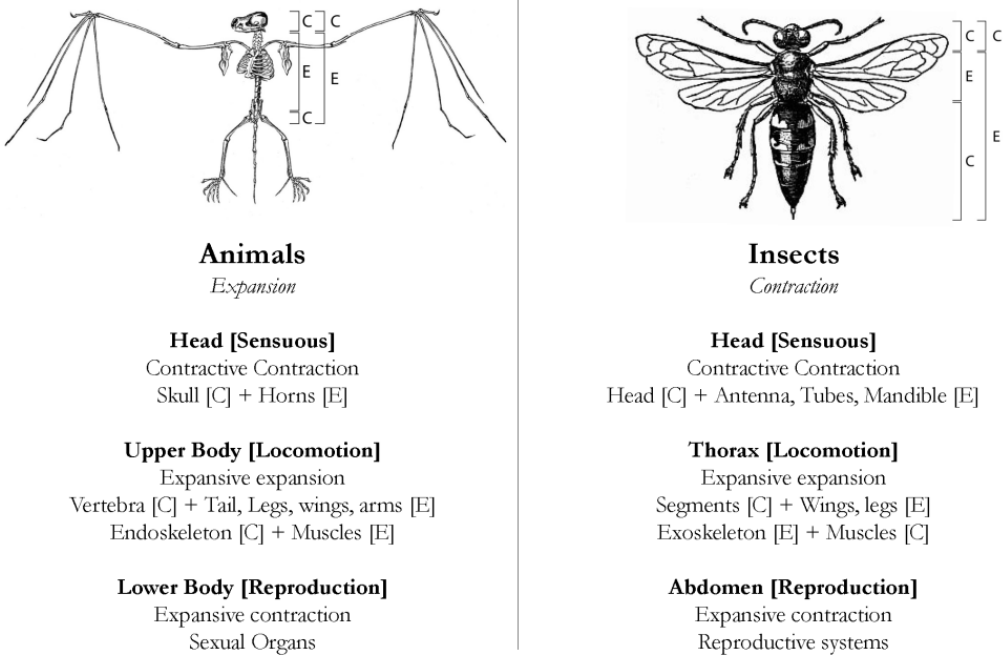

Figure 3.1.1.4 – Polarity between animals and insects showing the segmentation of the main bodies into expansive and contractive organs.

While Goethe's axial animal body proposes a symmetrical understanding of the archetype organized in three main sections, his main extension of the classical body is how he defines a polarity between the body and its appendages. He describes each auxiliary organ attached to the body as not deriving their proportion from the whole body but from their corresponding part of the torso where they appear as an extension towards the outer space acquiring specialized functions.

> Auxiliary organs are present in the head insofar as they are needed to ingest food; sometimes they appear as pincers, and sometimes as mandibles which may be connected to some degree.

> In the less developed animals the midsection has a large variety of auxiliary organs: feet, wings, and wing covers. In the more developed animals the midsection is where the middle auxiliary organs are found: arms and forefeet. In developed insects the rear section is without auxiliary organs, but in developed animals (where the two systems life compressed together) the final auxiliary organs (called feet) are at the end of the third system. Thus we find the structure of mammals to be consistent. Their last or hindmost part may have a further extension (the tail), but this can be considered simply an indication of the infinite variety of organic life forms.[705]

Goethe gives various examples from the animal kingdom to explicate on the body-limb polarity and how the animal archetype produces variations among auxiliary organs and body proportions. For instance, in snakes the head is merged with the torso where the "body is practically endless, and this is possible because neither material nor energy are required for auxiliary organs."[706] The lack of appendages for external movement is compensated with the flexibility of the extensive torso.[707] When this torso contracts, the expansion of limbs is curtailed as in the case of lizards. In frogs the extensive hind limbs are complemented by the shortening of the torso and forelimbs. Goethe also compares the morphological effects of the various anatomical systems for the production of bones where "the organs of nourishment and reproduction seem to

[705] Goethe, *Scientific studies*, 120.
[706] Ibid., 122.
[707] On the aspect of polarized compensation in morphology see: Tantillo, *The will to create*, 115. In the idea of compensation, Goethe states that animals need to balance an internal economy of structure and traits of their form. For instance, the animals with long tusks do not have enough material left to develop horns. This economical metaphor could be seen as a way "to allocate the resources within the limitations of the budget."[707] Thus, Goethe aims to replace the type with the "notion of a balance sheet or budget, where every feature has a price." Studying of forms also requires a clear understanding of how this budget is utilized and expressed for various traits.

consume far more energy than the organs of movement and circulation."[708] Due to their placement on the axial body, the circulation systems are housed with chest bones whereas the reproduction and digestion systems are contained in softer tissue lacking further structural development.

Goethe also draws similar remarks on the polarity of limb bones. In an essay titled "Tibia and Fibula" he describes how each bone in the body could be reconsidered through duality that is encountered in the sphenoid bone in the skull that has anterior and posterior parts. Identifying these bones poses a real challenge for comparative anatomy as the quantity and position of bones show great versatility among animals. However, rather than resorting to a quantitative picture for the animal archetype he seeks a "constructive interrelationship" where the comparison is made "serially" to approach the ulna-radius and tibia-fibula as polarized couples.[709] In *Metamorphosis: Evolution in Action* Suchantke applies such polarity towards the bones of the spinal axis to compare thoracic, lumbar and cervical vertebrae that show polarity between spinal and bone tissue.[710] In the upper region of the spinal column, the vertebral body contracts while the spinal column expands giving rise to the expanded brain tissue. Whereas towards the lower body, "the vertebral bodies become ever more massive, achieving their largest size in the lumbar region."[711] He attributes bone formations to two polar tendencies: "the *axial tendency*, which is evident most clearly in the limbs, but also in the ribs, and especially in the

[708] Ibid., 123. The chest bone also shows a polarity among the coronal plane of the body where the vertebrae display a housing function for the internal organs. "The vertebrae of the breastbone are longish and narrow or broad in shape; where the backbone adjoins full or partial ribs, the breastbone has only cartilage. Thus the breastbone appears to sacrifice part of its potential for the upper organs, and the whole of its existence for the lower ones. The backbone itself likewise sacrifices the potential rib structure at the lumbar vertebrae to a complete development of the important adjoining soft parts." A discussion of the threefolded organization of Mammals could be found in Schad, *Man and mammals,* 30-37. Schad associates the three main segments of the body to three kinds of mammals. Rodents are nerve-sense oriented, carnivores have rhythmic functions, ungulates favor more metabolic-limb orientation. He also draws similar comparisons based on the diet, teeth structure and activities.
[709] Ibid., 127.
[710] Andreas Suchantke, *Metamorphosis Evolution in Action* (Hillsdale, NY: Adonis Press, 2010), 23.
[711] Ibid., 22.

columnar form of the spine itself" and its polar opposite–"the *spherical tendency*" that has both its center and its culmination in the form of the cranium" that becomes an "intensification of the formative tendency expressed in the neural arch!"[712] Suchantke also discusses the homologous limb structures found in animals that have discontinuous bone development that are retraceable to "one ancestral form–the *pentadactylic* (five-fingered) limb."[713] Thus the spine that organizes the torso and the limbs that aid movement appear polarized in the body, the former achieving contractive tendencies that lack movement but have continuous variation, the latter showcasing expansive tendencies that are highly expressive in their structural organization and mobility (Fig.3.1.1.5).

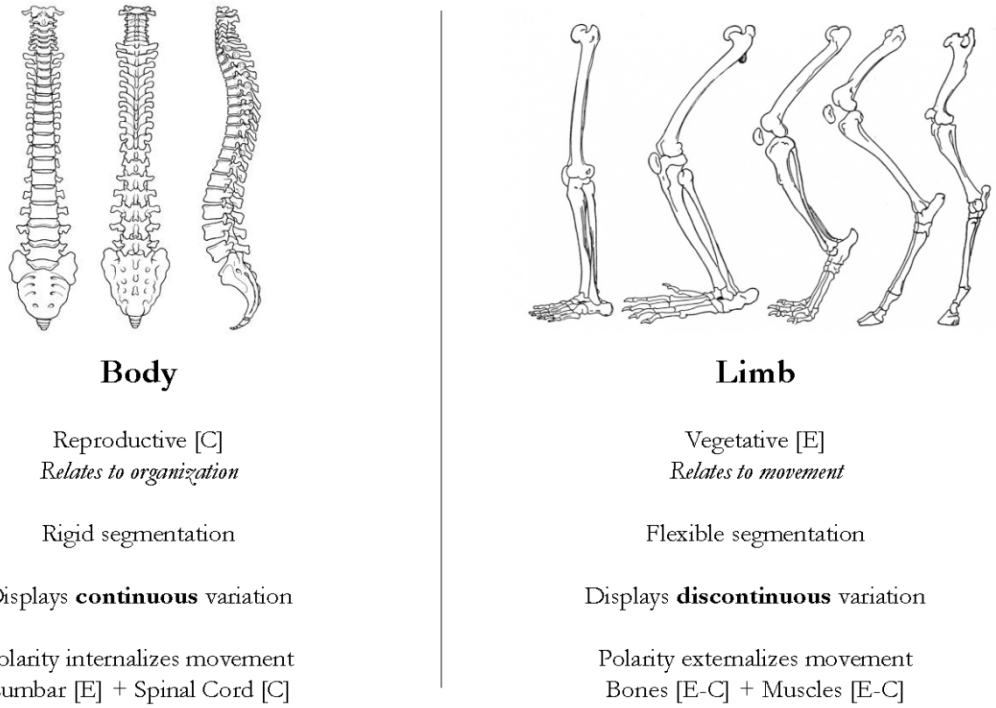

Figure 3.1.1.5 – Polarity between body (torso) and limbs showing expansive and contractive relationships of muscles, bones and sensory tissue.

[712] Ibid., 23.
[713] Ibid., 20. Another review of axial limb morphogenesis could be found in Webster and Goodwin, *Form and Transformation*, 146. Goodwin describes three main processes for the formation of the limb "initial or focal condensation, branching bifurcation and segmentation" that appear on the axial morphogenetic limb space. The temporal activity of genes during development produce effects on the production of digits, their motility and topological proportions.

While the classical notion of the architecture–animal body relationship is restricted to humans, Goethe's polarized body extends it to the highly variable animal realm, where there could be different proportions among limbs and torso, as well as different amounts of bifurcation for auxiliary organs as observed among invertebrates. Current genetic research in evolutionary development biology shows that it is possible to produce legs instead of antenna on the head of a fruit fly through homeobox gene expression, as both antenna and legs appear as modifications of auxiliary organs.[714] In this spectrum, Vitruvius' proportional comparisons among parts of the body appear more idealistic because they treat the human body as a template of measurement deriving the length of parts from the whole, instead of considering dynamic proportions for the polarity among parts that are simultaneously growing within the body. Morphologically, the overall proportions of the body are ill-fated, because the full height of the body includes both the head and the legs as a measurement failing to capture the hinging relationship of the legs to the torso, and the segmentation of the head. This is why Goethe does not consider the animal body as a variation of the human skeleton as "the human being cannot serve as the archetype for the animal, nor the animal for the human being," as the archetype needs to be more diagrammatic and variable offering transformations of parts as well as dynamic polar relationships between the body and its appendages.[715]

3.1.2 Symmetry and Architecture: Vitruvius and Alberti

Among the essays that have touched upon the term symmetry in architecture, Kipnis' "Fearless Symmetry" captures the dilemma of its contemporary status: symmetry has

[714] Carroll, *Endless Forms Most Beautiful*, 50-51. This type of mutation is called "antennapedia," where the fruit fly produces a leg instead of an antenna attached to its head. This might occur due to the expression of certain genes that regulate the morphology of appendages that can create antennas, legs and wings.
[715] Goethe, *Scientific Studies*, 124.

become treated by architects as a "cliché" or "passé" that failed to offer any type of reconciliation between its classical or modern formulation.[716] Historically the term has been one of the fundamental principles of architecture and an essential aspect of aesthetics. Many famous Renaissance architects, including Palladio and Alberti, utilized symmetry in their designs through bi-lateral architectural bodies by reviving some of the ideas of antiquity, but also by introducing new ways of dealing with problems of proportion and beauty in their pursuit of novelty in design.[717] Apart from its classical description that is related to beauty in its modern scientific formulation as presented by Hermann Weyl, symmetry is often described as "well-proportioned, well-balanced" parts within a whole where parts seek states of equilibrium through their dynamic opposition.[718] Apart from its various definitions, symmetry appears closely related to polarity that could offer a revitalization of the term as a universal principle of architecture.

The classical definition of symmetry also derives from Vitruvius's *De Architectura* who defined it among the six fundamental principles of architecture among "Order, Arrangement, Eurythmy, Symmetry, Propriety and Economy."[719] While the first three are directly related to symmetry as intrinsic principles of architecture, the last two are defined as external components that resonate with utility, construction and management. Among the six principles, Vitruvius gives a special role for symmetry as a proportional relationship between parts and the whole.

[716] Kipnis, J., "Fearless Symmetry," in *PIDGIN 7* (Princeton, NJ, 2009): 20. In this short essay Kipnis gives an anecdote from a conversation with Greg Lynn on how symmetry became cliché among architects as it is no longer seen as an effective tool of design.
[717] Wittkower, *Architectural Principles in the Age of Humanism*, 56. Wittkower considers both Alberti and Palladio to tackle the issue of church designs by going beyond archaeological readings of antiquity and offering new ways to develop wall architectures.
[718] Weyl, *Symmetry*, 3.
[719] Vitruvius, *The Ten books on Architecture*, 13.

> Symmetry is a proper arrangement between the members of the work itself, and relation between the different parts selected as standard. Thus in the human body there is a kind of symmetrical harmony between forearm, foot, palm, finger, and other small parts; and so it is with perfect buildings. In the case of temples, symmetry may be calculated from the thickness of a column, from a triglyph, or even from a module…[720]

From this description symmetry appears as a property of beauty that somehow harmonizes the "relationship of a part to the whole, not of similar parts to each other with respect to some fixed reference point."[721] Secondly, symmetry is considered as a shared property between the whole and parts that could be extracted from a building block in contrast to its modern notion of ambidexterity, where "there is no inner difference, no polarity between left and right, as there is for instance in the contrast of male and female, or of the anterior and posterior ends of an animal."[722] Finally, the classical definition of symmetry appears atemporal, considering the relationship of parts to the whole as fixed to only allow scalar changes for appendages, such as the head, arms, or hands to maintain a balance of beauty. This is why Vitruvius considers the column or the triglyph to have a similar modular role, as their size is dictated by the overall size of the building or vice versa. Since there is no dynamism between parts, there is no notion of temporal growth as the whole is only allowed to topologically scale up or down, and the whole does not produce parts through reproduction but through addition.[723] In contrast to its modern

[720] Ibid., 14.
[721] Giora Hon and Bernard R. Goldstein, "From proportion to balance: the background to symmetry in science," in *Studies in History and Philosophy of Science***,** Vol. 36, Issue 1, (March 2005): 6.
[722] Wely, *Symmetry*, 17.
[723] Gottfried Semper, *The Four Elements Of Architecture And Other Writings*, trans. Harry Francis Mallgrave and Wolfgang Herrmann (Cambridge: Cambridge University Press, 1989, orig. 1851), 177. Semper defines such dichotomy as tectonic and

reading, Vitruvius offers limited variability of symmetry as it is locked to certain pleasing proportions and topological scaling of bodies.

In his Renaissance reading of Vitruvius, Alberti considers a similar relationship between architecture and nature that occurs in book IX of his *De re aedificatoria* [Ten Books on Architecture].[724] While this book has a lot of similarities to Vitruvius' *De architectura*, Van Eck considers it as "not a collection of instructions for the builder, but an inquiry into the principles of architecture considered as an essential contribution to civilized society."[725] In order to achieve this goal, Alberti's *Ten Books on Architecture* presents a hierarchical understanding of building typologies that separates not only sacred and secular structures according to their functions, but also structure and ornament according to their aesthetic roles in a building. However, the main contribution of Alberti's work is the definition of architectural beauty as *concinnitas* that draws a relationship between nature and architecture.

> Beauty is a form of sympathy and consonance of the parts within a body, according to definite number, outline, and position, as dictated by *concinnitas*, the absolute and fundamental rule in Nature. This is the main object of the art of building, and the source of her dignity, charm, authority and worth.[726]

Alberti's definition of *concinnitas* is often understood through the shared proportionality of human body and architecture that reflects the mathematical principles of the harmonic order thought to be found in nature. This concept was analyzed by

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stereotomic, the former "*mobile*" presents a multiplication of parts as an additive technique, whereas the latter "monumental" is more about the whole that develops through subtraction.

[724] Leon Battista Alberti, *De re aedificatoria* [On the art of building in ten books], trans. Joseph Rykwert, Robert Tavernor and Neil Leach (Cambridge, Mass.: MIT Press, 1988).

[725] Caroline van Eck, "The Structure of 'De re aedificatoria' Reconsidered," in *Journal of the Society of Architectural Historians*, Vol. 57, No. 3 (Sep., 1998): 280-297.

[726] Alberti, *De re aedificatori*a, 303.

Rudolf Wittkower in his *Architectural Principles* where he described Alberti's notion of beauty as "a rational integration of the proportions of all the parts of a building in such a way that every part has its absolutely fixed size and shape and nothing could be added or taken away without destroying the harmony of the whole."[727] While *concinnitas* aimed at formulating a higher order of design, building systems had to mirror the proportions of the human body through established mathematical principles taken from nature. This approach is applied by using two perfect figures, sphere and circle, that are considered as symbols of the Deity from which all other polygonal shapes could be directly extracted. However, the mathematical principles derived from these perfect shapes aimed at fixing equilibrium among the organic geometrical relationships among parts and the whole where "harmonic perfection of the geometrical scheme represents an absolute value, independent of our subjective and transitory perception."[728] Yet, as Van Eck states "Alberti's view of nature, by contrast, is not exclusively mathematical."[729] There are qualitative aspects, such as fitness and adaptation that are required for buildings. And such variants are regulated by unity that is "based on a plan or concept of the whole that determines the structure of the parts."[730] While the parts are regulated with three concepts: number (*numerous*), outline (*finitio*) and position (*collocatio*) that effect mathematical proportioning of elements, *concinnitas* as the regulating factor of the whole brings forth beauty in forms. Van Eck relates this principle to an inherent duality that is often described as sexual opposition in forms that seeks equilibrium where Alberti's concept of beauty as a "qualitative unity" considers symmetry "in terms of the union between male and female–which is related to the purpose of a living being or a

[727] Wittkower, *Architectural Principles in the Age of Humanism*, 7.
[728] Ibid., 8.
[729] Eck, *Organicism*, 47.
[730] Ibid., 48.

building."[731] Thus, *concinnitas* presents both qualitative and quantitative oppositions that have more than mathematical aspects or use of modular proportion that aims to "concentrate on imitating the methods rather than the appearance of nature."[732] For Alberti this principle is executed in the establishment of various orders for the decoration of buildings through Doric, Ionic and Corinthian that all relate to the purpose of the building developed by the ancients who studied nature. Alberti often uses the analogy of relating columns or walls to bones through his anatomical vision for structure that appears more crystalline, where the ornament is treated as appendage to the body.[733]

> Beauty is that reasoned harmony of all parts within a body, so that nothing may be added, taken away, or altered, but for the worse. It is a great and holy matter; all our resources of skill and ingenuity will be taxed in achieving it; and rarely is it granted, even to Nature herself, to produce anything that is entirely complete and perfect in every respect. .... In this case, unless I am mistaken, had ornament been applied by painting and masking anything ugly, or by grooming and polishing the attractive, it would have had the effect of making the displeasing less offensive and the pleasing more delightful. If this is conceded, ornament may be defined as a form of auxiliary light and complement to beauty. From this it follows, I believe, that beauty is some inherent property, to be found suffused all through

[731] Ibid., 50. Eck relates this definition to the pseudo-Aristotlian *On the Cosmos* that shows similarities through the unification or conflict of opposites. A discussion of the patriarchal view of marriage and sexual relations in family structure during in Alberti's *I libri della famiglia*, see Amyrose, J. and Gill, McCue, "Rereading *I libri della famiglia*: Leon Battista Alberti on Marriage, *Amicizia* and Conjugal Friendship," California Italian Studies, 2(2).
[732] Ibid., 51.
[733] Alberti, *De re aedificatoria*, 71. Alberti describes the columns as a part of the wall system for architecture where they could be exposed to open the form of the structure for light and movement.

> the body of that which may be called beautiful; whereas ornament, rather than being inherent, has the character of something attached or additional.[734]

Alberti pays equal interest to the role of the perception of the mathematical structure of the universe which would not be possible if *concinnitas* were a Platonic concept inaccessible to our senses. Van Eck considers *concinnitas* as being part of the Aristotelian teleology where "the unity of opposing and varying qualities referred to as *concinnitas* is made possible because the maker acts according to a logically prior plan or concept of the whole, by which all the parts and the relations between these and the whole are regulated and determined."[735] Furthermore this teleology gives *concinnitas* a way to reach a definitive goal through its regulative structuring of the whole and the parts without destroying unity. Therefore the modularity or use of proportion becomes an expression of such purposive unity and not the scientific basis of architecture. This is in a way confirmed by Alberti by considering *concinnitas* as an expression to reach the balancing of opposition as a form of absolute symmetry for the whole where the duality of the body is taken as an exact copy of the two halves mirrored along an axis that considers polarity among parts as balanced.

> We must therefore take great care to ensure that even the minutest elements are so arranged in their level, alignment, number, shape and appearance, that right matches left, top matches bottom, adjacent matches adjacent, and equal matches equal, and that they are an ornament to that body of which they are to be part. Even reliefs and panels, and any other decoration, must be so arranged that they

[734] Ibid., 156.
[735] Ibid., 54.

> appear to be in their natural and fitting place, as though twinned. The ancients attached such value to this balancing of the parts one against another, that they even tried to match their marble panels exactly in quantity, quality, shape, position, and color.[736]

The classical notion of symmetry that is developed by Alberti based on the aesthetic foundation of Vitruvianism considers symmetry as not a dynamic principle of Nature but as a fixed regulating aspect for the whole. In this sense, classical symmetry resonates more with preformation on its treatment of the whole through proportions and axiality, but fails to explore the dualist structure of bodies that are dynamic and variable. In a fragment "Philosophie" Goethe describes symmetry not as a mirroring function of the whole but as a dynamic interaction of parts through successive steps.

> In the case of the word symmetry in the German plane, one conceives of a relation of external parts which are congenial to one another. In most cases, the word is used of parts which are regularly opposed to one another and are related to a center. We have referred to the word, because the parts do not follow one another, but in succession, one after the other, but they do not always stay on the same level, instead present an intensified from the lower, a strong from the weak and a beautiful from the invisible.[737]

[736] Ibid., 310.

[737] Goethe, *Werke*, S. BA20:174. "Bei dem Worte *Symmetrie* im Deutschen *Ebenmaß*, denkt man sich ein Verhältnis äußerer, sich aufeinander wohlgefällig beziehender Teile; meistens wird das Wort von regelmäßig einander gegenüberstehenden, auf eine Mitte sich beziehenden Teilen gebraucht. Wir haben das Wort *Bezug* genommen, weil die Teile nicht, insofern sie neben- und gegeneinander, sondern nacheinander beobachtet und gedacht werden, hierbei aber nicht allein nacheinander identisch sich folgend, nicht Gleiches aus Gleichem immer auf derselben Stufe bleibend, sondern ein Erhöhtes aus dem Niedern, ein Starkes aus dem Schwachen, ein Schönes aus dem Unscheinbaren."

While Goethe's description of symmetry is similar to Alberti's *concinnitas*, compared to the classical agenda of balance among parts, it appears to be more modern and related to polarity. Due to the internal tension among parts, symmetry does not occur simultaneously along the whole, but through successive morphological steps that present differentiation of parts that may then end up in balance.[738] Morphologically, symmetry does not relate to static properties or proportions of a whole, but to temporal balances during growth that occur during the successive development of parts within a whole.

Alberti's classical system for symmetry with its "Platonizing aesthetics of proportions" and stylistic monopoly received criticism in the eighteenth-century.[739] During the development of the picturesque movement Hogarth criticized the fixed proportions of Renaissance aesthetics that are based on human body—*homo quadratus*. For him the body never appeared fixed in posture and was always in motion, therefore "the criterion or justification for a doctrine of beauty is thus located no longer in the supposedly constant and measurable properties of the object, but in our changing and variable perceptions of it."[740] Similar critiques were made towards the harmonic order or musical properties of architecture that were considered to be fixed. Related concepts of regularity and symmetry were considered as tiring and dull and instead they were only

[738] Ian Stewart and Martin Golubitsky, *Fearful symmetry: is God a geometer?* (Mineola, N.Y. : Dover Publications Inc., 1992), 156 - 188. Early morphogenetic development of organisms shows that spherical symmetries are broken by axial symmetries. For instance, in snails early development shows polarized cells and rotational symmetry compared to a spherical blastula. Similar symmetry breaking could also be found during the invagination of the blastula that expresses an axis of contraction after spherical cell equilibrium is established.

[739] Eck, *Organicism*, 66. First one was directed towards its rhetorical view of the Early Renaissance, mainly criticizing its aesthetic development and use of proportions. This was developed by Hogarth and Burke under the Picturesque Movement in England. Second opposition looked at the philosophical view of architecture characteristic of the High Renaissance that regarded architecture more related to science and considered meaning as connected to construction rather than emotion. This criticism was developed by Perrault in seventeenth and Laugier in eighteenth-century France. While the Picturesque tried to remedy the fixed nature of proportions and symmetry with the dynamic concept of movement, the High Renaissance tried to restrict architecture to structural concerns avoiding Humanist principles such as the perception of imitation of Nature that either copied its forms or methods.

[740] Ibid., 70. On this issues see Daniel L. Purdy, *On the Ruins of Babel: Architectural Metaphor in German Thought* (Ithaca : Cornell University Press, 2016), 181. Purdy also considers Goethe's engagement with architecture to be highly picturesque developing a phenomenological engagement with space where his "encounters with ancient architecture follow a pattern that starts with the anticipation of seeing the building, the surprise of engagement, and then a dialogue between himself and others (often the ghost of the architect) that attempts to resolve the strong emotions engendered by the sight of the building."

satisfactory when they led to an idea of fitness. This made Hogarth reject the objective notion of beauty and instead focus on the sensuous principles of it. In his famous "serpentine line" he developed an idea of beauty that is based on variety, movement and the importance of captivating the onlooker that later formulated the Picturesque Movement.[741] In a similar vein, Goethe sought a dynamic alternative to symmetry by not considering the body as a direct juxtaposition for architecture but as a tool to discover its proportions moving through space to reveal the morphological proportions of structure. In his essay "Architecture" in 1795 he describes buildings as a form of art seeking the harmonic proportions that are akin to music.

> But if architecture deserves the name of an art, it must also produce sensuous and harmonious objects in addition to the necessary and useful. This sensual harmony is found in every art of its own kind and condition; it can only be judged within its own condition. These conditions arise from the material, from the purpose, and from the nature of the sense for which the whole is to be harmonious.
>
> One should think that architecture works as a fine art alone for the eye; but it is said to work excellently, and what is least of all, for the purpose of the mechanical movement of the human body. We feel a pleasant sensation when we move during dance according to certain laws. We should be able to arouse a similar feeling with someone as we pass through a well-built house with blindfolded eyes. Here we

[741] William Hogarth, *The Analysis of Beauty* (Pittsfield, Mass. : Silver Lotus Shop, 1909, orig. 1753), 50.

enter into the difficult and complicated doctrine of the proportions, which determine the character of the building and its various parts.[742]

For Goethe symmetry is only applicable through dynamic proportions that can never be found in the classical fixed notion of symmetry. Von Mücke states that Goethe considers architecture as an "embodied sense of motor control" where "dance provides pleasure equivalent to that of a well-proportioned building allows him to redirect the discourse on proportions and harmony."[743] In this sense he is closer to the picturesque notion of movement that generates the architectural body through inner rhythms akin to dancing. On the other hand, Goethe's view of symmetry and movement presents humanist aspects of experiencing architecture where there is an organic sensuous harmony that bridges between the forms and the onlooker that we find in the concept of *concinnitas*.[744] Thus, the concept of polarity aims at bridging between classical and modern views on symmetry, where the former is concerned about developing universal principles of beauty and the latter extending the dynamic proportions through duality. As a result, architecture is capable of generating its own body that moves internally and does not require an external principle to derive its proportions that could be fixed; however,

[742] Goethe, J.W.von, *Werke* , Berliner Ausgabe (Berlin: Aufbau-Verlag, 2005) S. BA19:108. Bis: S. BA 19: 109. "Soll aber das Baugeschäft den Namen einer Kunst verdienen, so muß es neben dem Notwendigen und Nützlichen auch sinnlich-harmonische Gegenstände hervorbringen. Dieses Sinnlich-Harmonische ist in jeder Kunst von eigner Art und bedingt; es kann nur innerhalb seiner Bedingung beurteilt werden. Diese Bedingungen entspringen aus dem Material, aus dem Zweck und aus der Natur des Sinns, für welchen das Ganze harmonisch sein soll.
Man sollte denken, die Baukunst als schöne Kunst arbeite allein fürs Auge; allein sie soll vorzüglich, und worauf man am wenigsten achthat, für den Sinn der mechanischen Bewegung des menschlichen Körpers arbeiten; wir fühlen eine angenehme Empfindung, wenn wir uns im Tanze nach gewissen Gesetzen bewegen; eine ähnliche Empfindung sollten wir bei jemand erregen können, den wir mit verbundenen Augen durch ein wohlgebautes Haus hindurchführen. Hier tritt die schwere und komplizierte Lehre von den Proportionen ein, wodurch der Charakter des Gebäudes und seiner verschiedenen Teile möglich wird."

[743] Dorothea Von Mücke, "Beyond the Paradigm of Representation: Goethe on Architecture," in *Grey Room*, No. 35 (Spring 2009): 19.

[744] Susanne K. Langer, *Feeling And Form: A Theory Of Art* (New York: Charles Scribner's Sons, 1953), 82. Langer also describes this vitalist notion for architecture: "Living form' is the most indubitable product of all good art, be it painting, architecture or pottery, Such form is 'living' in same way that a border or a spiral is intrinsically 'growing': that is, it expresses life-feeling, growth, movement, emotion, and everything that characterizes vital existence."

because symmetry is still shared between buildings and animals, the aesthetic proportions of form could be revealed when the building is exhibited.

3.1.3 Polarity and Symmetry: Urhütte

Throughout the development of architecture, architects have often revisited historical writings that provided rhetoric on the origins of architecture. A common thread among historians has been to reconsider primitive huts as prototypical structures where "the perception of architecture as a bridge between the mutable world and the deeper order of the cosmos underpinned the dedication of immense intellectual and material resources to the arts of building."[745] Drawing on the analogy with biological types, the first structures erected by making were often seen as ideal models of architecture providing shelter for human accommodation and congregation as well as developing a mimetic relationship with nature. Many theoretical works that were written on the primitive huts in the history of architecture always refer to Vitrivius's *De Architectura* as the first treatise that offered theories on the origins of architecture.[746] In Chapter I of Book II, Vitruvius gives a description of how architecture was born as a result of social congregation and communication of people around fire that lead to the construction of structures to house their community.

> And since they were of an imitative and teachable nature, they would daily point out to each other the results of their building, boasting of the novelties in it; and thus, with their natural gifts sharpened by emulation, their standards improved daily. At first they set up forked stakes connected by twigs and covered these

[745] Richard Wittman, "The Hut and the Altar: Architectural Origins and the Public Sphere in Eighteenth-Century France," in *Studies in Eighteenth-Century Culture*, Vol. 36 (2007): 236.
[746] Vitruvius, *The Ten Books on Architecture*, 39.

> walls with mud. Others made walls of lumps of dried mud, covering them with reeds and leaves to keep out the rain and the heat. Finding that such roofs could not stand the rain during the storms of the winter, they built them with peaks daubed with mud, the roofs sloping and projecting so as to carry off the rain water.[747]

Rather than describing an ideal form for these first structures, Vitruvius describes two versions built by Colchians in Pontus and Phrygians located in Anatolia. These two early civilizations occupy different climates and use different materials for the construction of their primitive huts. The Colchians are located in a humid climate and are surrounded by forests. Using the trees they gather from the forest, they first lay down an orthogonal outline formed by trunks on both sides of their huts "then place above these another pair of trees, resting on the ends of the former and at right angles with them."[748] Due to their bilateral symmetry and tetrapodal structure Vitruvius calls these huts the "tortoise" model because of the elevated character of the roof that is constructed out of crossbeams "from the four sides in the shape of a pyramid."[749] In contrast, the Phrygians are bounded by their dry climate where the trees are scarce, but naturally occurring small mounds or hills offer them a way to produce spaces by digging the ground. These raised or buried huts made of earth are topped with "a pyramidal roof of logs fastened together" that are covered with various plants to keep their "winters very warm and their summers very cool."[750] While Vitruvius draws a similarity to early structures of antiquity that followed similar principles of construction, the much later Greek forms were enhanced

[747] Ibid.
[748] Ibid.
[749] Ibid.
[750] Ibid., 40.

with large foundations and walls built out of brick or stone and roofs covered with timber and tiles enabling further articulation of symmetry for their design.

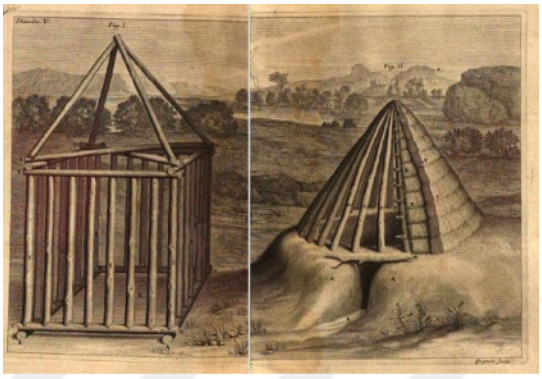

Figure 3.1.3.1 – The two models for the primitive huts (Reprinted from Claude Perrault, *Dix Livres de Vitruve*, 1684).

During Renaissance, architects who translated Vitruvius's text also attempted to develop formal representations for primitive huts, an approach similar to Leonardo's attempt with *homo quadratus*. The huts of Colchians and Phrygians were first brought into the architectural discourse in Claude Perrault's *Dix livres de Vitruve* [The ten books of architecture of Vitruvius] (1684) and Giovanni Poleni's *Exercitationes Vitruvianae Primae* (1739).[751] These translations often transformed the initial ideas of the primitive hut by providing new rhetoric on the origins of architecture. Among these, Perrault's depictions were similar to Vitruvius's original ecological description of the huts, however he considered a conic roof instead of a pyramid one above the raised earth mounds for Phrygian huts (Figure 3.1.3.1). In his much later treatise, Poleni extended on the original

[751] Vitruvius Pollio, *Les dix livres d'architecture de Vitruve* [The ten books of architecture of Vitruvius] corrected and translated newly into French by Claude Perrault with notes and figures (Paris: J.B. Coignard, 1684). Poleni, G., Morgagni G., Baldo, B., *Exercitationes vitruvianae primae*, hoc est: Ioannis Poleni Commentarius criticus de M. Vitruvii Pollionis architecti X. Librorum (Patavii : Apud Ioannem Manfré, 1739). The interest of eighteenth century French scholar on Vitruvian huts could be found in Maarten Delbeke and Linda Bleijenberg, "Reconfigurations of Vitruvius' Origin Myths in the Eighteenth Century," in *Von Ursachen Sprechen : Eine Aitiologische Spurensuche* [Telling Origins: on the Lookout for Aetiology], in *Spudasmata* 162, eds. Christiane Reitz and Anke Walter (New York: Georg Olms Verlag, 2014), 162: 491–517.

models by showcasing six huts that included cubic, pyramidal, cylindrical, and gabled or tented roof versions (Fig.3.1.3.2). Rather than seeing the two models as the only possibility for the hut designs, Poleni offered a new way of interpreting ancient texts as a way to speculate on the origins and develop new theories on the variability of the primitive hut. However, this was not the common trend among architectural theoreticians who read Vitruvius after Renaissance. Some scholars considered the hut to be a reductive model in search of an ideal structure to derive the fundamental elements of architecture rather than considering it as model for an archetypal building that could be both generative and ecological.

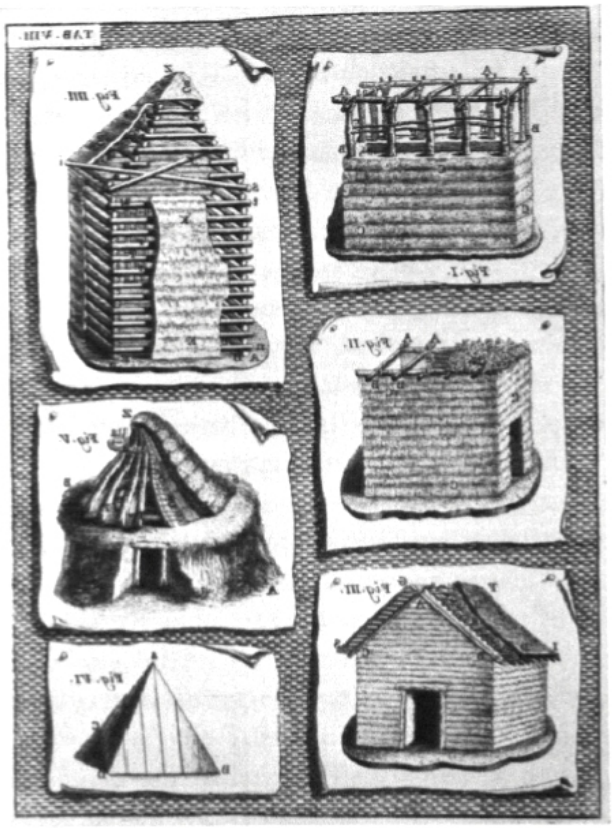

Figure 3.1.3.2 – The six models for the primitive huts (Reprinted from Poleni, *Exercitationes vitruvianae primae,* 1826).

Figure 3.1.3.3 – The frontispiece of Marc-Antoine Laugier, *Essai sur l'Architecture*, second ed. 1755 by Charles-Dominique-Joseph Eisen (1720-1778).

The first example of a rationalist primitive hut model was produced by Marc Antoine Laugier [1713–1769] in his *Essai sur l'Architecture* [An Essay on Architecture] in which he outlined his general principles of architecture by considering the primitive hut as a typological structure erected by mankind.[752] The treatise was written during a time when the Baroque style was highly influential in France and Laugier suggested seeking an alternative to the excessive decorative practice of architecture by going back

[752] Laugier, Marc-Antoine, *Essai sur l'Architecture* [An Essay on Architecture], trans. Wolfgang and Anni Herrmnan (Los Angeles: Hennessey & Ingalls, 1977).

to origins to seek fundamental laws. The frontispiece designed by Charles Dominique Eisen highlighted the main premise of the book, showing an allegorical image of a woman, representing architecture, pointing towards a wooden hut made comparable to the ancient ruins admired during that time (Fig.3.1.3.3). Laugier narrated the birth of this primitive hut in chapter I titled “General Principles of Architecture” as the first ideal structure erected by a savage man seeking shelter in open nature following his departure from early habitable caves.

> He wants to make himself a dwelling that protects but does not bury him. Some fallen branches in the forest are the right material for his purpose; he chooses four of the strongest, raises them upright and arranges them in a square; across their top he lays four other branches; on these he hoists from two sides yet another row of branches which, inclining towards each other, meet at their highest point. He then covers this kind of roof with leaves so closely packed that neither sun nor rain can penetrate. Thus, man is housed. Admittedly, the cold and heat will make him feel uncomfortable in this house which is open on all sides but soon he will fill in the space between two posts and feel secure.[753]

The primitive hut model gave three basic architectural components to Laugier, “the pieces of wood set upright have given us the idea of a column, the pieces placed horizontally on top of them the idea of the entablature, the inclining pieces forming the roof the idea of the pediment.”[754] For each element he outlined main properties, design principles and common faults that when used correctly presented the essential

[753] Ibid., 11.
[754] Ibid., 12.

composition of architecture that produced beauty. In *The Writings of the Walls,* Anthony Vidler considers Laugier's theory of origins as "a manifesto for aesthetic judgment" where the hut "assumed a paradigmatic status for all architecture: if art, in general 'imitated' nature, then architecture might be demonstrated to imitate in its turn not the outer appearances but the inner procedures of nature–the cause and effect of physical sensation and need."[755] Vidler bases this criticism on the depiction of the hut not as a construct of mankind, but as an idealized product of Nature presenting preformed ideas for a triad system that leads to the conviction that imitation of nature in architecture was mainly based on constructive reasons only. Among the criticisms Laugier received in the eighteenth century, the most troublesome was the reduction of architecture to a common single origin that became a standard model of comparison. Furthermore, contrary to Vitruvian hypothesis of congregation, Laugier chose to eliminate "the *social* roots of dwelling, preferring architectural criteria derived from the internal logic of architecture to the external influences of customs or mores."[756] In its later reception, Laugier's work became an epitome of the reductionist approach towards architecture where "the elements of building were first and foremost constructional and logical; their assembly followed a law of geometry; architecture was not a language but a construct."[757] Laugier even extended his reductionist approach towards architecture by discussing Maison Carrée as an example that captured the ideal principles for an architectural type (Fig.3.1.3.4).[758]

[755] Anthony Vidler, *The Writings of the Walls: Architectural Theory in the Late Enlightenment* (Princeton : Princeton architectural press, 1987), 18-19.
[756] Ibid., 20.
[757] Ibid., 21.
[758] Laugier, *Essai,* 13. "We still have in France a beautiful ancient monument, which in Nimes is called the Maison Carree. Everybody, connoisseur or not, admires its beauty. Why? Because everything here accords with the true principles of architecture: a rectangle where thirty columns support an entablature and a roof – closed at both ends by a pediment – that is all; the combination is of a simplicity and a nobility which strikes everybody."

This also eliminated traditional and symbolic meanings attached to buildings that could be found in religious and secular structures.

Figure 3.1.3.4 – Maison Carrée in Nîmes completed in 2 AD.

In order to produce similar classical buildings in his time, Laugier revisited and reviewed the principles behind the three main column styles, Doric, Ionic and Corinthian along with composites proposed by Vitrivius and variations of these models discussing materials, proportions, details and ornaments. For the practice of architecture he considered the parts of a building to be derived from the whole, thus imposing restrictions on the variability of parts to proportional relationship only. For him, the rules or natural principles behind these proportions remained a mystery; instead, he relied on the acquired taste and experience of the architect that had to work within a limited repertoire.

> The proportions of each part must correspond to the whole with the same precision. The determination of the stories, doors, windows, and of all attending ornaments are to be regulated by the length and height of the whole building and must be so well balanced that the resulting whole pleases. About all this we really have no rule which is well established.[759]

Van Eck considers Laugier's organicism to avoid "taking as the focal point of *mimesis* the teleology of nature as it crystallized for instance in Alberti's use of *concinnitas,* Laugier shifts the attention to the imitation of the laws of nature, such as those of dynamics and statics."[760] By borrowing a historical model of antiquity for its usage of proportions and typological elements, Laugier establishes his own version of a Vitruvian authoritative model where architecture "was guided by and joined to the cosmological order of nature" dictated by the three orders considered as the "modification of human proportions as between man, woman and girl served as a model for the sequence of proportions for the three Greek Orders."[761] However, the main problem resides in the "normative function" associated to the primitive hut, as it becomes "the great principle from which it now becomes possible to deduce immutable laws."[762] Thus, Laugier turns the primitive hut into "an archetype: his origin myth suggested that man, left to his own devices, would inevitably come up with this particular solution, which was therefore the most 'natural' and 'rational' type of building."[763] In this sense, his construction was "a-historical", non-ecological and a-temporal where he failed to

[759] Ibid., 64.
[760] Eck, *Organicism*, 92.
[761] Wolfgang Herrmann, *Laugier and Eighteenth Century French Theory* (London : Zwemmer, 1962), 44.
[762] Ibid., 48.
[763] Delbeke et al., "Reconfigurations of Vitruvius' Origin Myths in the Eighteenth Century," 509.

achieve some "universality of his hut by pointing to examples all over the globe."[764] As a result, the rationalist vision of the primitive hut as a fixed type appears highly problematic due to its failure to adapt to different climates, cultures, construction methods and social needs.

While Laugier's treatise became highly popular in the eighteenth century promoting neo-classicist trends in architecture, it's typological and authoritative agenda became a target for Goethe's discussion of the stylistic development of architecture in his famous essay "On German Architecture" [Von deutscher Baukunst] in 1773.[765] While the central topic of the essay is Goethe's aesthetic description and admiration of Strasbourg Cathedral as a high achievement and example of Gothic architecture, Goethe criticizes Laugier's description of the primitive hut as a crystalline reductive model.[766] Similar to his frustrations with Newton's work on color that he considered as the authoritative model closed to criticism, he warns against postulating a fixed form for the primitive hut [*Urhütte*] that turns architecture into an authoritative profession closed to artistic expression.

> Principles are even more damaging to the genius than examples. Individual artists may have worked on individual parts before him, but he is the first from whose soul the parts emerge grown together into an everlasting whole. Yet school and principle fetter all powers of perception and activity. Of what use to us is the

[764] Ibid.
[765] Johann Wolfgang von Goethe, *Essays on Art and Literature*, ed. John Gearey, trans. Ellen von Nardroff and Ernst H. von Nardroff, Goethe's collected works: Suhrkamp Edition in 12 volumes (New York: Suhrkamp, 1986), 4.
[766] Purdy, *On the Ruins of Babel, 165.* Purdy considers the "assertion that the Strasbourg cathedral should be understood as distinctly German has become the essay's most famous and controversial thesis." Goethe's struggle with French and Italian styles during that era and the overall prejudice that "northern European architecture was barbaric, filled with disguising ornamentations and lacking all sense of proportion" made him defend this style and view it more in formal terms.

knowledge, you philosophizing expert of the new French school, that the first man, inventive in his need for shelter, rammed four stakes into the ground, joined them with four poles and made a roof of branches and moss? From this you derive the appropriateness of our own buildings, as if you wanted to rule your new Babylon with a simplistically patriarchial attitude![767]

Goethe becomes critical of the typological model advocated by Laugier that advocates a stylistic approach to advance architecture through its usage of fixed elements and proportions. In contrast, Goethe's vision for the primitive hut appears more morphological as he questions the primitive hut proposed by Laugier to be "not the first in the world" and contrasts it with an alternative version that has "two poles crossed at the top in front, two in the back and a fifth as a ridgepole, as we can see everyday from huts in fields and vineyards, that is clearly a far earlier invention."[768] Furthermore, he disregards the structural usage of columns in modern examples due to their placement as pilasters for columns that either overlap with walls or are connected with interconnections that makes them non-structural additions.[769] Compared to Laugier's crystalline model that redefines architecture through the usage of structural members as

[767] Goethe, *Werke*, S. BA19:31. "Schädlicher als Beispiele sind dem Genius Prinzipien. Vor ihm mögen einzelne Menschen einzelne Teile bearbeitet haben. Er ist der erste, aus dessen Seele die Teile, in *ein* ewiges Ganze zusammengewachsen, hervortreten. Aber Schule und Principium fesselt alle Kraft der Erkenntnis und Tätigkeit. Was soll uns das, du neufranzöscher philosophierender Kenner, daß der erste zum Bedürfnis erfindsame Mensch vier Stämme einrammelte, vier Stangen drüber verband und Äste und Moos drauf deckte? Daraus entscheidest du das Gehörige unsrer heurigen Bedürfnisse, eben als wenn du dein neues Babylon mit einfältigem patriarchalischem Hausvatersinn regieren wolltest." Translation taken from Goethe, J.W.von, *Essays on art and literature*, ed. John Gearey, trans. Ellen von Nardroff and Ernst H. von Nardroff, Goethe: Suhrkamp Edition in 12 volumes (New York, NY : Suhrkamp Publishers New York, 1986), 4. Although Goethe does not mention Laugier's name explicity, he addresses to a French connoisseur who becomes the center of his aesthetic attacks. Scholars such as Dorothea von Mücke have considered this this figure to be Laugier in "Beyond the Paradigm of Representation: Goethe on Architecture," *Grey Room* (Spring 2009), No. 35, 6-27.

[768] Goethe, *Essays on art and literature*, 5.

[769] Goethe, *Werke* , S. BA19:108. Bis: S. BA 19: 109. Goethe also develops this idea in a separate text titled "Architecture" [Baukunst] where he uses Palladio's *Quatro Libri* to develop a morphological-structural relationship between the base, pilaster, column and steps. He applies the concept of polarity towards the classical elements of design by drawing on the relationship between base and columns. When base expands, columns and steps contract, and when base contracts pilasters expands to the ground. Although he does not discuss Palladian Villas, his application of polarity towards architectural elements could be extended towards other morphological elements and massing. Lowe and Sharp, *Goethe and Palladio*,90. Lowe and Sharp considers Goethe's view of classicism to accommodate his views on metamorphosis where during his trip to Vicenza he writes on the "fundamental polarity to be seen in architecture, that between wall and column."

columns, Goethe postulates a formal version that is defined by walls that close the structure on four sides.

> The column is by no means a natural component of our dwellings, on the contrary, it contradicts the character of all our buildings. Our houses did not develop from four columns in four corners, but from four walls on four sides. The wall are in place of columns and exclude columns, and where columns are tacked on, they are superfluous encumbrance. This is also true of our palaces and churches, with a few exceptions, on which I need not elaborate.[770]

For Goethe, the primitive hut offers a morphological model that cannot be understood through a typological discussion that either fixates the proportions of structural elements used, or advocates the search of a new style that is influenced by antiquity. In contrast, Goethe's primitive hut remains primarily formal, defined by its sloped walls on four sides that gives it a spatial closure and an abstract model that can develop morphologically. In considering Goethe's essays on architecture, van Eck states that Goethe's application and development of morphology of forms drew him close to the views of Alberti who aimed at developing a relation between architecture and living nature through *concinnitas*. For Goethe "the 'naturalness' of architecture consists not so much in the adoption of vegetal ornament" but in the use of "proportion and symmetry" that were "formal expressions of the autonomy" of every living organism.[771] The formulation of morphological laws aimed at redefining intrinsic properties of development for organisms that also regulated proportion and symmetry. These laws

[770] Goethe, *Essays on art and literature,* 5.
[771] Eck, *Organicism*, 110.

were based on a "teleological unity, rather than on rules that regulate the selection of proportion or ornament by reference to some external consideration such as *decorum."*[772] Such autonomy gave architecture the right to be considered as a work of art that was formulated during the Renaissance through Alberti's concept of *concinnitas*. Yet, Alberti considered teleology that is practiced and imitated by the artist or architect external to natural organisms. However, Goethe opened up the possibility to consider "architecture as an art that *develops* structurally."[773] This also replaced the a-temporal fixed attitude towards establishing standard models for architecture with a dynamic architectural morphology that developed over time through historical styles and diverse rhythms of symmetry.

3.1.4 Polarity and Body-Limb Duality I

Among the historical styles of architecture, the animal body-limb relations are mostly applied towards the development of plans to establish relationships and circulation among parts of buildings.[774] To visualize these morphological tendencies, residence structures from Baroque Palaces and Palladian Villas are chosen that display a polar relationship between the main house and supplementary wing structures that occupy services, leisure spaces or rooms for guests and events.[775] Since these structures are

[772] Ibid.
[773] Ibid., 111.
[774] Goethe, *Werke*, S. BA19:108. Bis: S. BA 19: 109.Goethe mentions how polarity in plan is related to the harmonical doctrine of proportions in his essay on Architecture [*Baukunst*] in 1795 where "the purpose of the mechanical movement of the human body" is associated to the aesthetic relations of the spaces that are experienced by moving along the plan of a house blindfolded. Purdy, *On the Ruins of Babel*, 204. Purdy considers Goethe to be influenced by Palladio's work where "symmetry and organic integration of parts serve as model not only of the autonomous artwork but also for the reeducated idealist subject" leaving more harmonical impression on the subject of *Bildung*
[775] For a discussion of the functional spaces of Villa Rotonda see Christian Goedicke, Klaus Slusallek and Martin Kubelik, "Thermoluminescence Dating in Architectural History: The Chronology of Palladio's Villa Rotonda," in *Journal of the Society of Architectural Historians*, Vol. 45, No. 4 (Dec., 1986): 396-407. Goedicke et al. highlight that the ground floor of Palladian Villas were reserved as "a service floor, both for domestic and for agrarian functions carried on in the main building" whereas upper floors were used "both for living and for entertaining." This requires the villa main floor to be accessed often via staircases extending from the house.

mostly found in open landscapes, the environment doesn't impose limitation to the development of structures that can progressively grow by adding segments to the wings. Between the two styles, the main difference is found in sizes with palaces showing expansive and villas showing contractive tendencies. These aspects will be explored by comparing six case studies among each group to discuss various polarities between architectural bodies and limbs. To analyze these structures, the stylistic details have been omitted to develop abstract diagrams along three body planes to discuss how polarity is distributed among the architectural body.

3.1.4.1 Polarity and Baroque Palaces

Baroque Palaces are often located in open landscapes with views that enable progressive structural extensions of the main house (Fig.3.1.4.1). An example of this tendency could be seen in The Palazzina di Caccia of Stupinigi (1729) that was designed as a hunting lodge for the King of Sardinia that expanded the original castle predating 1418 (Figs.3.1.4.2).[776] The plan of the palace shows an "X" scheme where two groups of wings are attached to the main castle that further bifurcate and rotate along the landscape while surrounding the courtyard space leading to the main entrance. In Stupinigi, the contractive castle is compensated with highly expanded wing structures that spiral around the courtyard. This vegetative quality in plan is similar to the growth pattern of mosses where the horizontally expanded wings often remain contractive in their vertical development and remain closer to the ground.

[776] The analytical polarity diagrams are drawn along three planes showing development in plan and two sections. The relationship between adjacent parts is visualized using diagonal lines to draw proportional measurements between bodies and limbs by considering their lengths as an index of development. The triangles emerging from the diagonal lines define two shorter edges for various body-limb polarities.

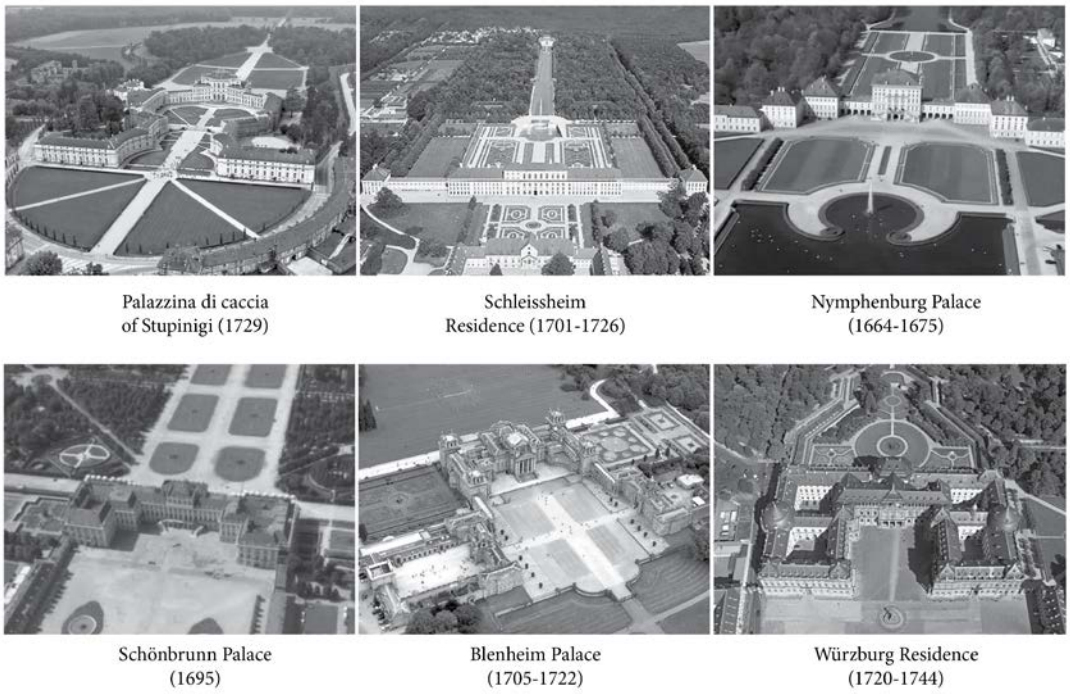

Figure 3.1.4.1 – Six Baroque Palace precedents for body-limb analysis.

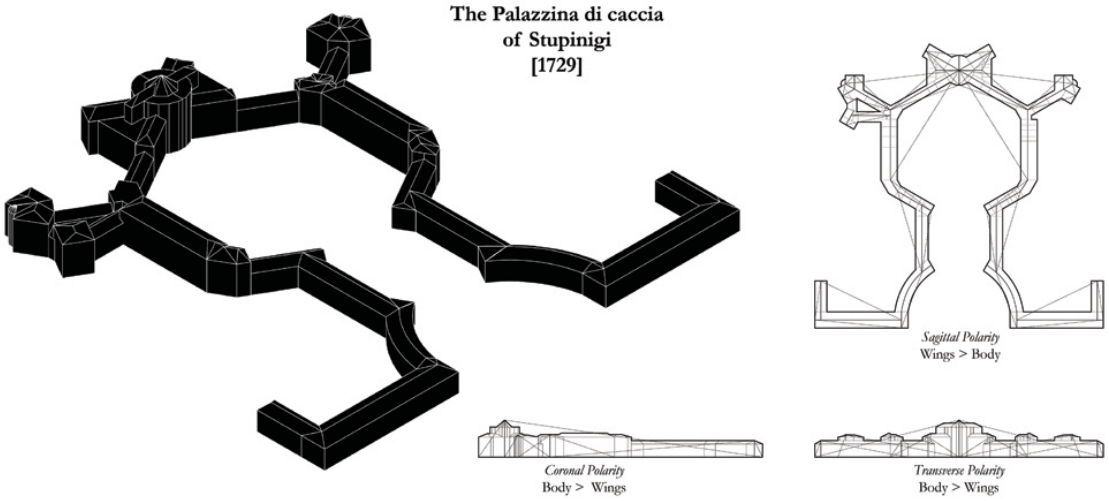

Figure 3.1.4.2 – Body-limb polarity diagram of The Palazzina di caccia of Stupinigi (1729) showing expansive wings compared to contractive torso.

In Schleissheim Residence (1701–1726) polarity lacks radial tendencies in plan and instead produces a linearly expanded structure with wings stretching along a lateral

axis (Figs.3.1.4.3). In this structure the wings are terminated with galleries that resemble the polarity between arms and hands. While the proportions show that the wings remain contractive compared to the laterally expanded torso of the house, the contraction of the corridors is compensated with expanded galleries at the distal ends.

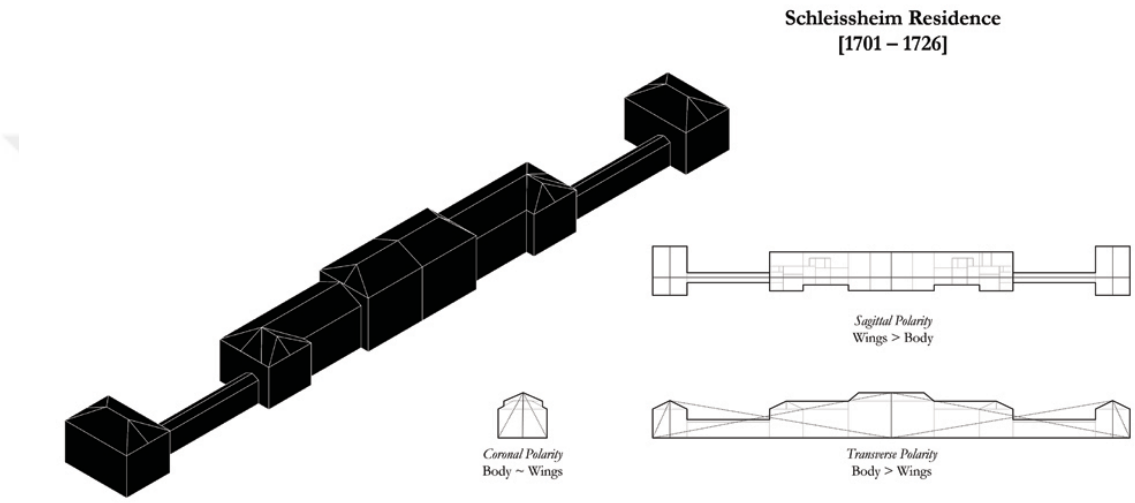

Figure 3.1.4.3 – Body-limb polarity diagram of Schleissheim Residence (1701-1726) showing expansive lateral wings attached to a laterally expanded torso.

In Nymphenburg Palace (1664–1675) a similar development yields to more radial tendencies in plan where the corridors of the wings are broken in a zigzagging manner with gallery structures separating them (Figs.3.1.4.4). Here, polarity is more expressed in the overall massing distinguishing the housing and circulation structures with expansive and contractive tendencies. This shows that when the wings expand, they can house larger programs; however, with contraction they solely embody circulation spaces that can become galleries accessible to views of the landscape.

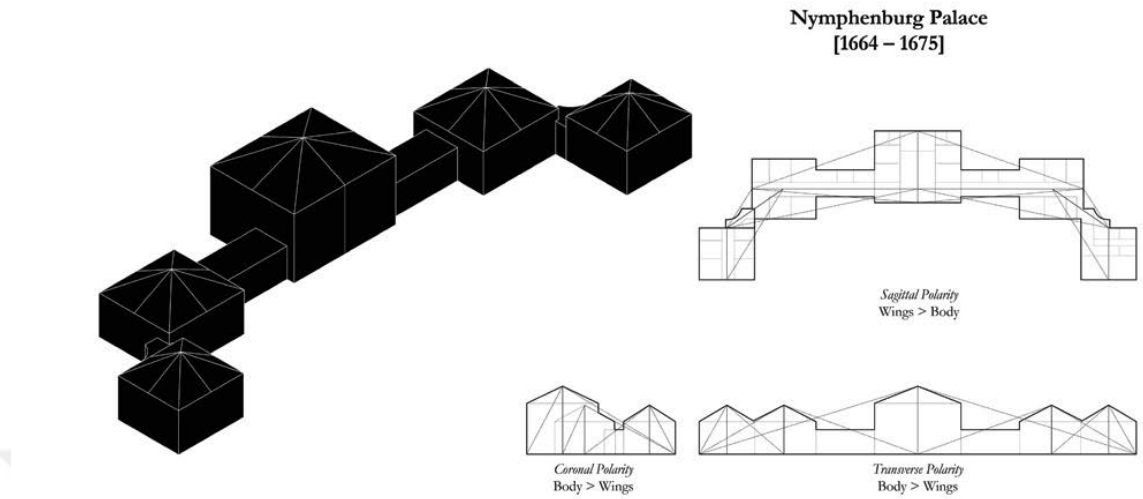

Figure 3.1.4.4 – Body-limb polarity diagram of Nymphenburg Palace (1664-1675) showing expanded wings attached to a contractive torso (Additional wing structures are omitted in this diagram).

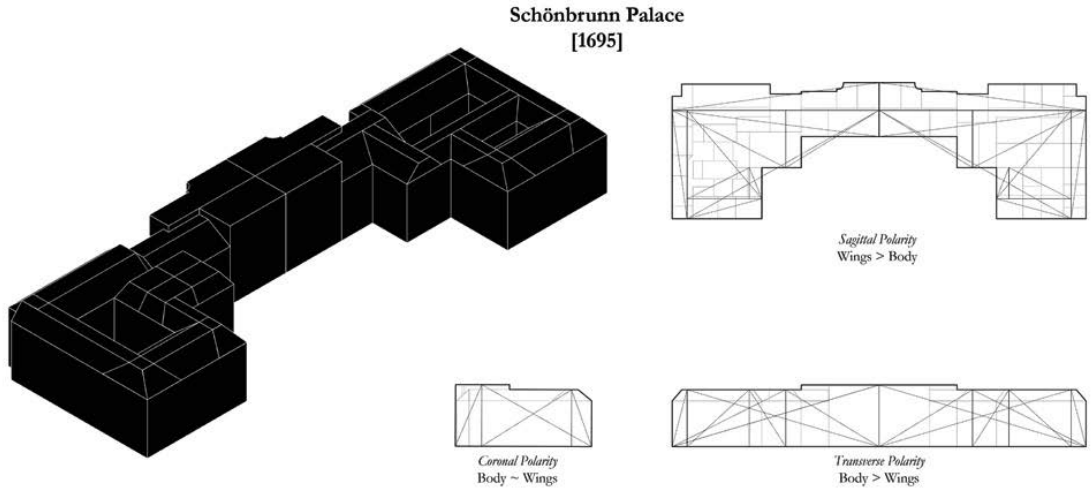

Figure 3.1.4.5 – Body-limb polarity diagram of Schönbrunn Palace (1695) showing spiraling wings attached to a contractive torso.

The radial development of expansive wings could be further exemplified in three other palace structures. In Schönbrunn Palace (1695) the main house merges with the spiraling wings that continually make orthogonal turns in its growth pattern and close the

spaces on itself around courtyards (Figs.3.1.4.5). This transforms expansive limbs into completely anastomosed structures with adjacent spaces connecting them through circulation. This tendency often yields to the production of courtyards in wing structures due to the overall expansion of the wings. Examples of these could be found in Blenheim Palace (1705–1722) and Würzburg Residence (1720–1744) that both show expansive anastomosed wings with courtyards (Figs.3.1.4.1.6-7). This shows that when there is excessive expansion for wing structures, these are often hollowed to produce additional outdoor spaces among them. With excessive expansion, the wing often produces joining structures that are morphologically emphasized with domes or roofs expanding further than the surrounding structures. These distinctive structures are often used to establish local symmetries within a progressively growing structure to enable new directions of expansion.

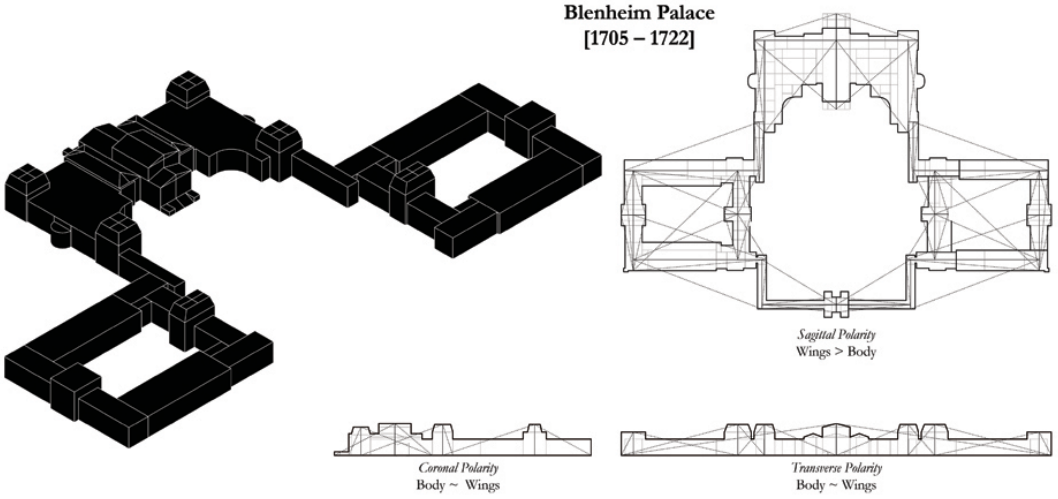

Figure 3.1.4.6 – Body-limb polarity diagram of Blenheim Palace (1705–1722) showing highly proliferative expanded wings attached to a contractive torso.

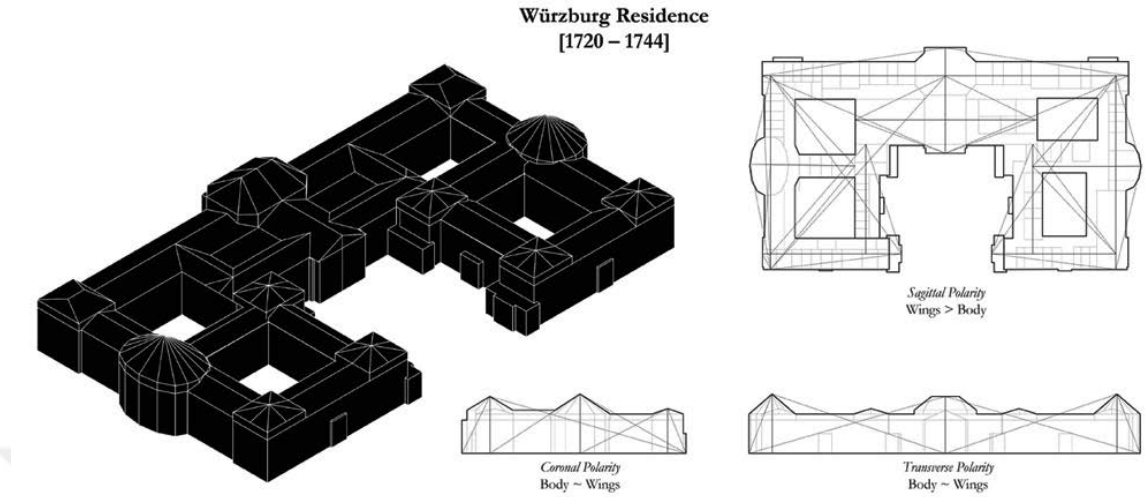

Figure 3.1.4.7 – Body-limb polarity diagram of Würzburg Residence (1720–1744) showing spiraling wings attached to a contractive torso.

These case studies show that among the Baroque palaces, polarity is mainly expressed in planar development between the main house and its attached wings where the former remains contractive and the latter takes on various linear and radial expansive roles. Although there is excessive ornamentation of structures, the vertical polarity does not produce articulations on the massing level. This could be visualized by tracing the development of The Palazzina di caccia of Stupinigi.

Figure 3.1.4.8 shows the metamorphic formal development of The Palazzina di caccia of Stupinigi using the primitive hut model that primarily establishes a model of planar development using the polarity between torso and limbs. This is defined as a contractive sequence that determines the overall proportions of the massing and the organizational development of the plan. The resulting geometries are then expanded vertically to produce roofs, gables, spires, sculptures and ornaments. In Stupinigi, contraction overwhelms expansion due to the excessive horizontal growth of limbs that

are attached to a contracted torso. The sequencing confirms the amount of polarity breaking required for the planar development of the palace compared to the underdeveloped expansion that primarily lifts the forms up to generate roofs for massing.

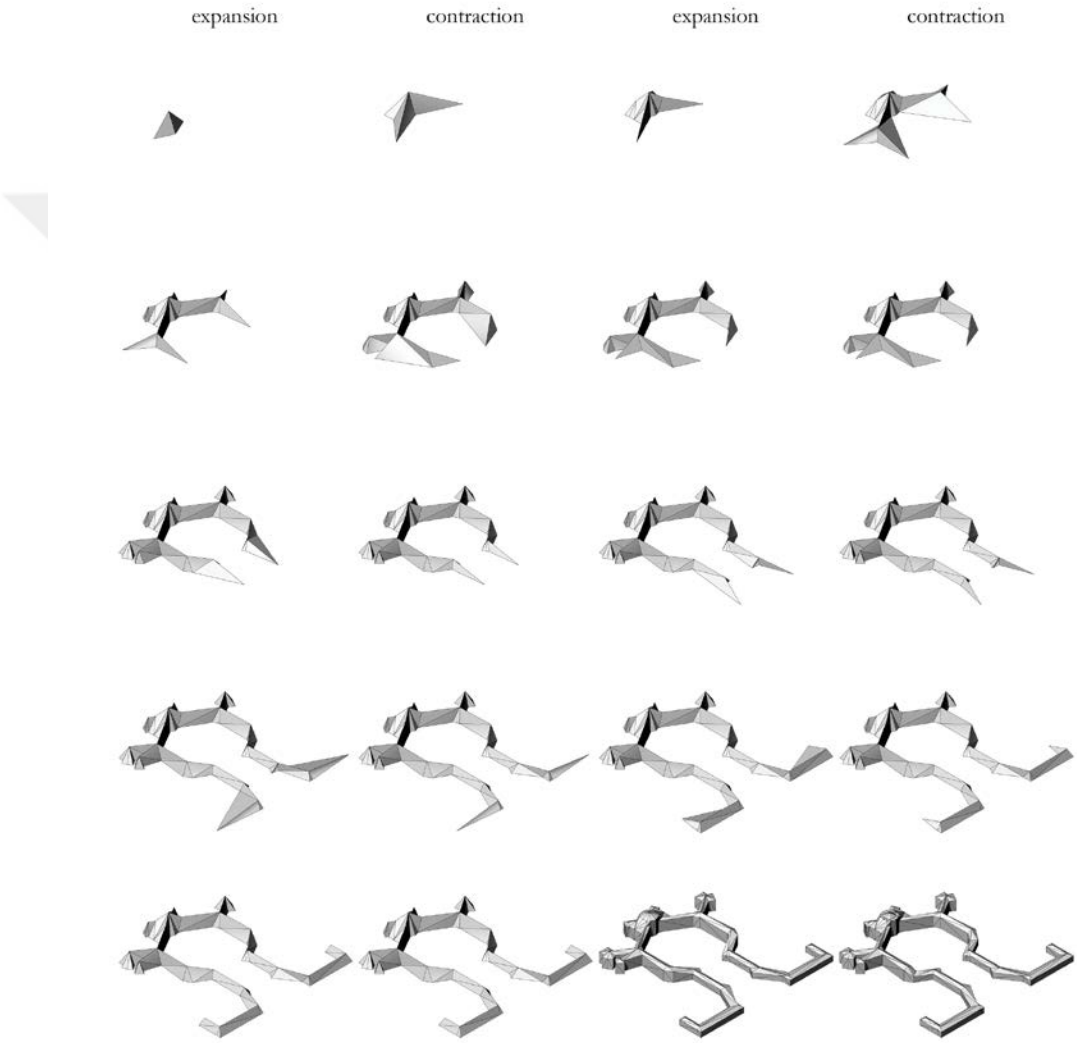

Figure 3.1.4.8 – Polarized development of The Palazzina di caccia of Stupinigi showing recursive addition of wing structures during contraction that are then expanded vertically to produce the massing.

3.1.4.2 Polarity and Palladian Villas

Palladio has always attracted interest among architects and historians due to his theoretical and practical contributions to architecture during the Renaissance.[777] There have been numerous studies on Palladian Villas that focus on the geometric proportions of plans, axial division of rooms or shape grammars of house plans.[778] These studies have been mostly focusing on the contractive houses that embody the main rooms while ignoring the extended wings from these structures in their analysis (Fig.3.1.4.9). Furthermore, Palladio's façades are often analyzed without a consideration for the placement of sculptures, vases, chimneys and ornaments that also partake on the proportional breaking of the massing. This aspect might stem from Palladio's most famous work, Villa Rotonda, which shows fully contracted wing development in a quadruple direction (Figs.3.1.4.10). While this symmetrical structure has often been labeled as a great example of Palladian architecture, it shows lack of polarity between the torso and limbs that could be found in Palladio's other villa structures. However, what lacks in terms of planar development in Villa Rotonda is compensated with its highly articulated façades that utilizes sculptures at corners where a polarity between pediment, sculptures and roof emerges. This way the sculptures could be considered as parts of the massing that resemble the contractive role of pinnacles in Gothic arches.

[777] Scholarship on Palladio is humungous, as mentioned in Deborah Howard, "Four Centuries of Literature on Palladio," in *Journal of the Society of Architectural Historians*, Vol. 39, No. 3 (Oct., 1980): 224-241. Howard points towards *Quattro Libri* as a good resource for architects who want to study Palladio and states the impossibility of providing a complete synthesis of Palladio's contributions due to the temporal, cultural and historical richness of his work.

[778] For an application of harmonic ratios to Palladian villa plans see Wittkower, *Architectural Principles in the Age of Humanism*, 56. Wittkower considers the plan to follow mathematical patterns of divisions and proportional relations of rooms. For a discussion of the proportional aspects of Palladio's plans and elevations and their comparison to Le Corbusier's work see Colin Rowe, *The Mathematics of the Ideal Villa* (MIT Press, 1976). Rowe considers Palladio's work to be schematic and relying on deviations of golden ratio and primitive forms. For a parametric shape grammar analysis of Palladian plans see George Stiny and William J Mitchell, "The Palladian Grammar," in *Environment and Planning B*, Vol. 5, Issue 1 (1978): 5-18. Stiny et al. consider Palladio's villas to follow a gridded pattern where 72 rules are defined to generate the wall structures, apertures and columns. They consider symmetry as one of the rules that apply a mirror reflection of the gridded distribution of rooms.

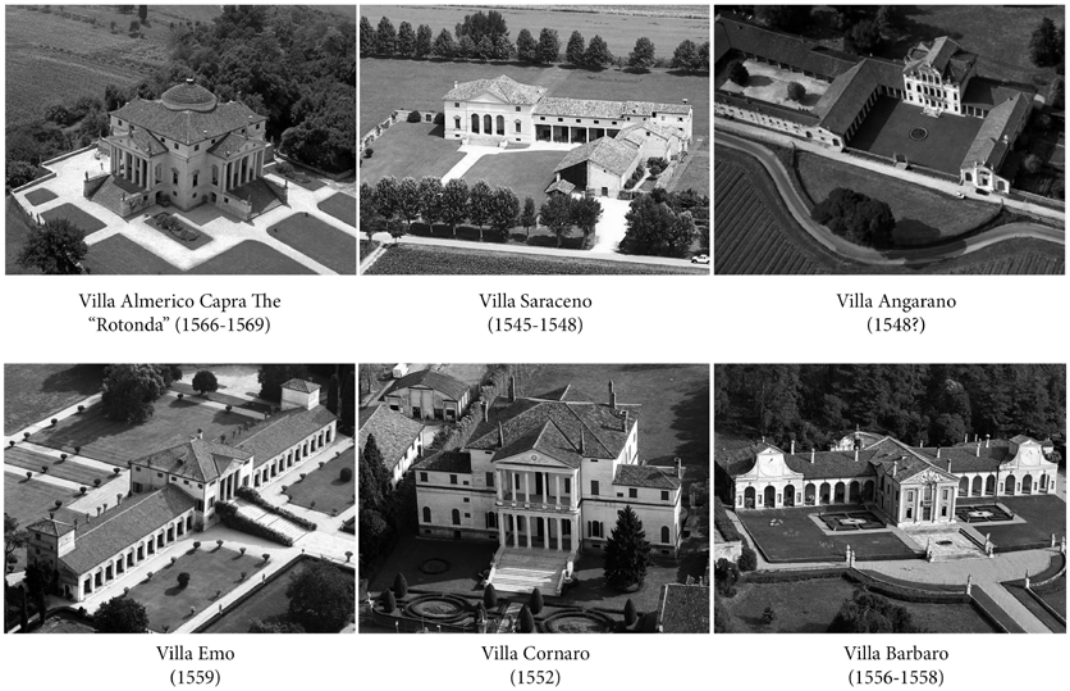

Figure 3.1.4.9 – Six Palladian Villa precedents for body-limb analysis.

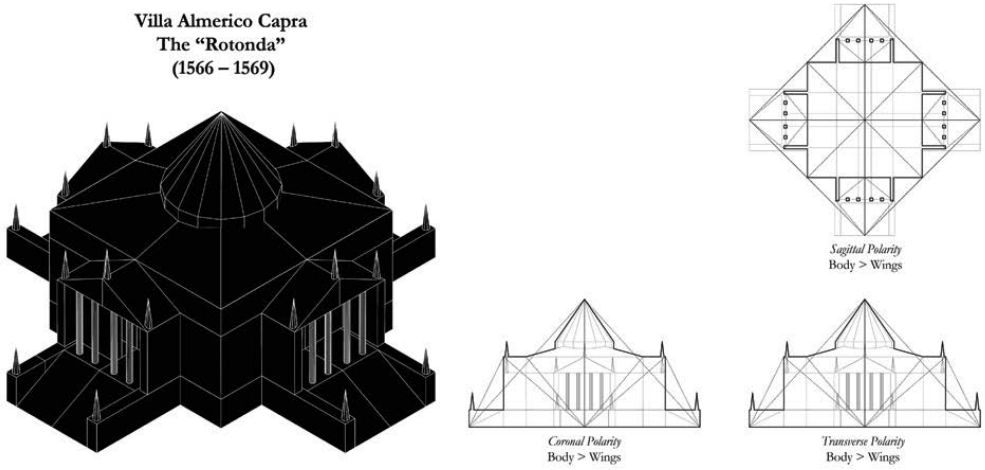

Figure 3.1.4.10 – Body-limb polarity diagram of Villa Almerico Capra, The "Rotonda" (1566-1569) showing contracted limbs attached to a symmetric torso. The massing is articulated with sculptures located at contractive points along corners of the pediment and stairs.

In Palladian Villas, polarity is not only limited to the proportional aspects of his house plans, but also extends towards the projecting wing structures that are in

contrasting relationships to the houses. Most of Palladian villas feature wing structures attached laterally to the main house that could also develop a spiraling tendency to circumscribe the inner garden, a tendency also found in Baroque palaces. Examples of these body-limb polarities could be found in Villa Saraceno and Angarano, where the lateral projections of wings are further turned in orthogonal directions to surround the front garden of the house (Figs.3.1.4.11-12). In these villas, the house uses its wings to differentiate the front from the rear as well as to circumscribe a private courtyard space. This model also enables an asymmetrical aspect of growth, where the wing structures could be erected in a picturesque manner depending on the needs and the agricultural economy of the owners. In Saraceno, such development remains asymmetrical with only one wing producing agricultural structures, while in Angarano, the full expansion of wings is balanced with a contracted torso. In this sense, Angarano distributes the material both towards the taller house and the expanded wings that can embody larger programs.

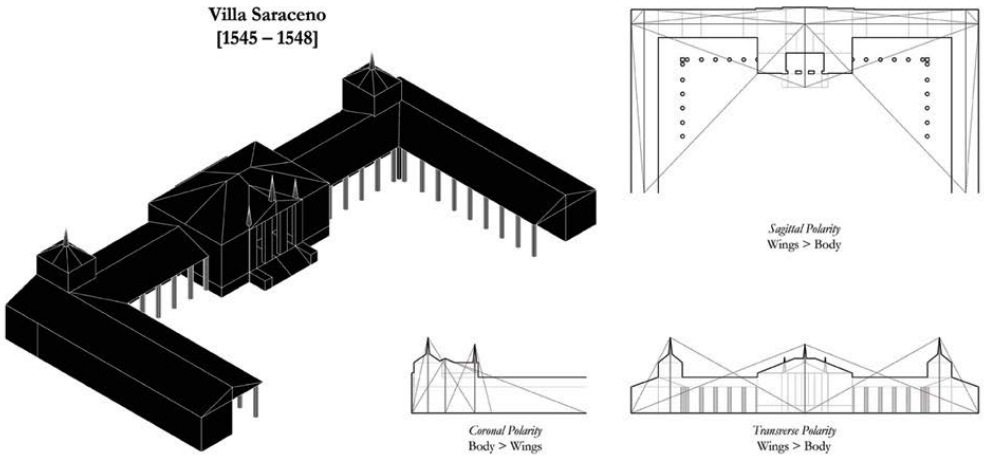

Figure 3.1.4.11 – Body-limb polarity diagram of Villa Saraceno (1545-1548) showing expanded wings attached to a contractive house.

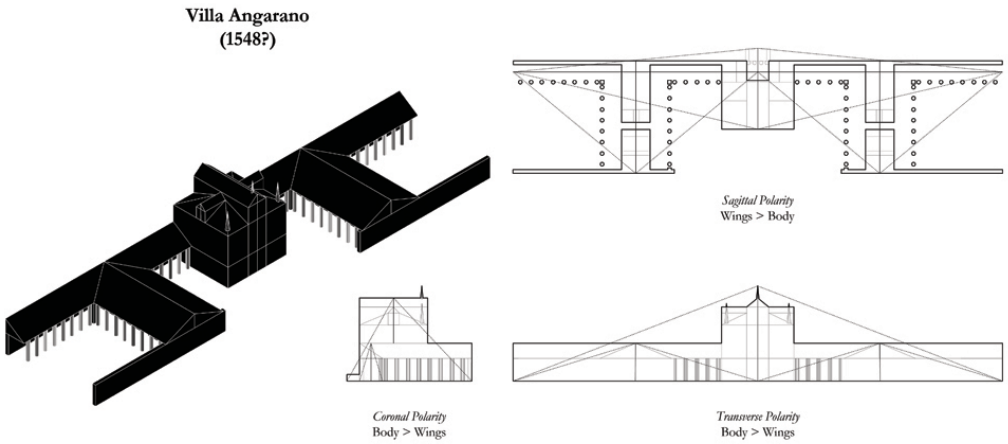

Figure 3.1.4.12 – Body-limb polarity diagram of Villa Angarano (1548?) showing expanded wings attached to a contractive house.

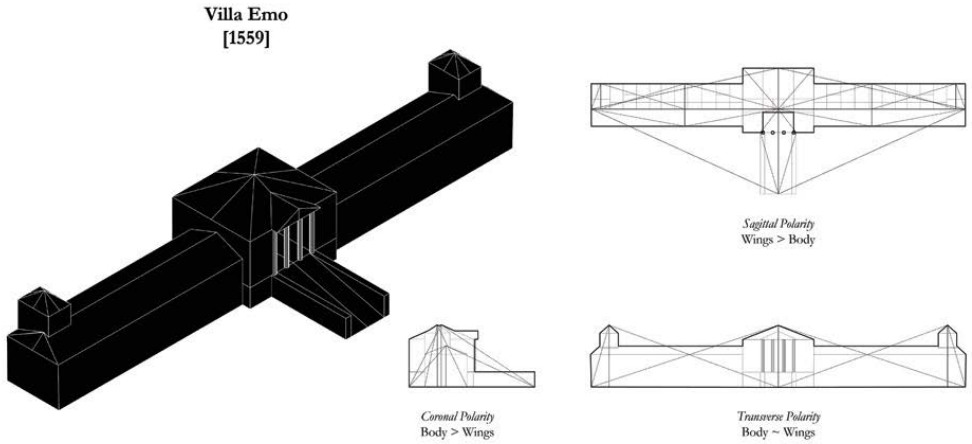

Figure 3.1.4.13 – Body-limb polarity diagram of Villa Emo (1559) showing expanded wings attached to a contractive house.

In contrast to spiraling Palladian wings, in Villa Emo, the appendages of the house define a frontality that is terminated with contracted spires that protrude from the roof of wings (Figs.3.1.4.13). Similar spires are also found in the design of Villa

Saraceno that mark a contractive joint for the expansion of the wings. In Emo, the main house remains more expanded compared to Villa Saraceno producing an expanded staircase as a tertiary appendage to the torso. In contrast to Emo, in Villa Cornaro, the wings remain contracted compared to the fully expanded house (Figs.3.1.4.14). This occurs due to the surrounding structures that impose a limitation on the planar development of the house. If this house were located in an open landscape, then these wings would be able to expand, while the house would contract to counter the overall polarity distribution of the architectural body.

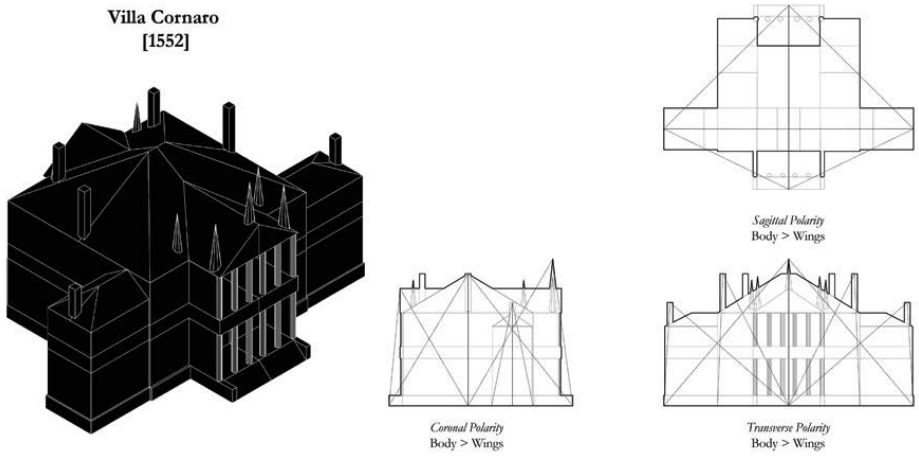

Figure 3.1.4.14 – Body-limb polarity diagram of Villa Cornaro (1552) showing contracted wings attached to a contractive house.

In Villa Barbaro the wings develop towards the expansive side of the house that shows a counter radial movement in plan contrasting Saraceno and Angarano (Figs.3.1.4.15). The wings that expand towards the private rear garden are complemented with contractive spires that develop artificial façades with pediments. In Barbaro, the lack of polarization between the house and the wings occur due to the expansion of the latter producing a thickness in massing that is relatively uniform throughout the structure. The

contractive spires remain hidden behind the pediments of the wings that reveal the contractive hinging relationship and rotation occurring on the planar development of the house.

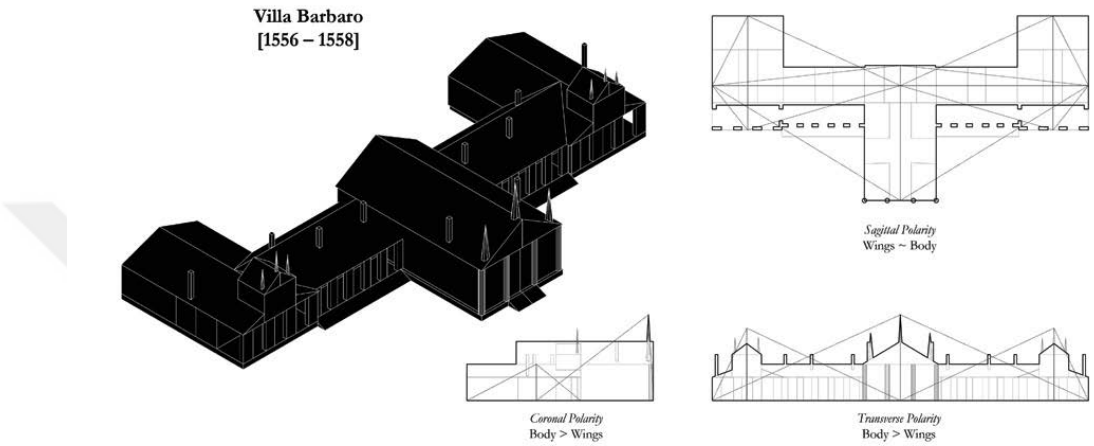

Figure 3.1.4.15 – Body-limb polarity diagram of Villa Barbaro (1556-1558) showing expanded wings attached to a contractive house.

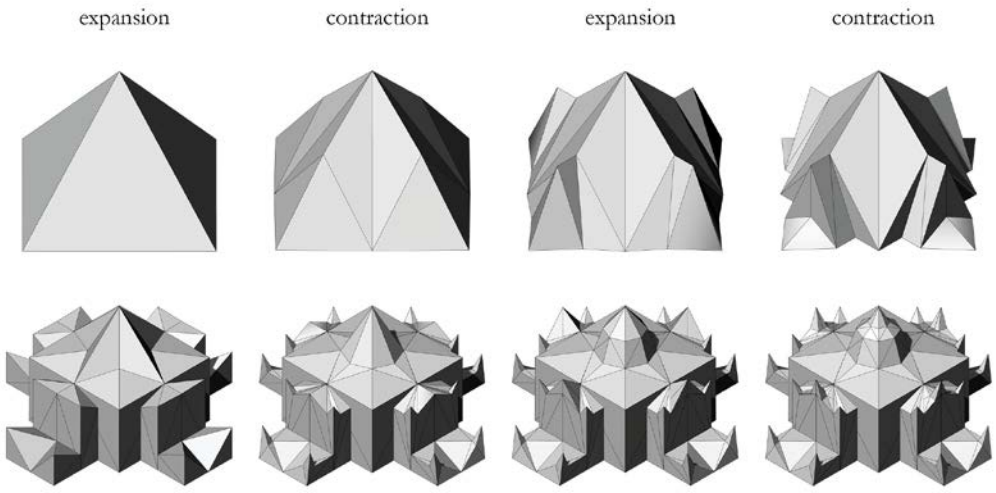

Figure 3.1.4.16 – Polarized development of Villa Almerico Capra the "Rotonda" showing polarity breaking of the Urhütte to produce quadruple contractive limbs that are then expanded vertically via sculptures and roof.

These case studies show that polarity is expressed in both planar and vertical development of Palladian Villas. In planar development, polarity establishes a relationship between the main houses and attached wings that can also produce contractive spires where rotation or termination in massing occurs. In vertical development, polarity is mainly found between the outline of the massing that reveals a proportional relationship between sculptures, pediments, spires and walls. In Palladian Villas, the polarity between planar and vertical development appears more balanced whereas the placement of sculptures and ornaments along the roof outline act as miniature formal expansions engaging in proportional relationships with the massing. This could be visualized by looking at the metamorphic development of Villa Rotonda that shows a recursive breaking of the plan before the volume is lifted upwards to distribute sculptures along the roof geometry via contraction (Figure 3.1.4.16).

3.2 Goethean Architecture I: Rudolf Steiner and Anthroposophical Architecture

Historically the first example of an architectural style influenced by Goethean morphology had been developed by Rudolf Steiner [1861–1925] who founded Anthroposophy and spiritual science in the early 20th century. Steiner's early participation in Theosophical Society and his later break off and founding of the Anthroposophical Society in Dornach culminated in the formulation of a spiritual and anthropocentric approach within various areas of the visual arts and natural sciences. Apart from research in medicine, agriculture and education, Steiner also built 17 architectural works, including first and second Goetheanums that are regarded as

significant works of architecture in the past century.[779] Through his architectural works Steiner established a new style called Anthroposophical architecture that still remains influential to this day presenting a holistic approach to design.[780] During his public lectures on arts, Steiner also presented many theories on the historical and stylistic development of architecture that needs a reevaluation devoid of his philosophical background or political influences.[781] In this regard the overall approach is to first decouple Steiner's architectural thought from his esoteric ideas and relations in Anthroposophy, and then to consider them separate from Goethean morphology to be able to critically reevaluate it. This approached will be followed by discussing key aspects of Steiner's architectural principles using the first and second Goetheanum as case studies that present sculptural, anthropocentric and schematic principles. After highlighting the main tenets of Steiner's methodology towards design, Anthroposophical architecture will be reevaluated through polarity principles developed under the rubric of Goethean morphology. The overall attitude of this chapter is to reinstate appraisal to Steiner as a forerunner of architectural innovation and an influential architect in the advent of Modernism, but then to consider Anthroposophical architecture as a practice of

[779] Steiner's recognition in the modern architectural scenery in late 1960s is discussed in Rex Raab, Arne Klingborg, and Ake Fant, *Eloquent Concrete: How Rudolf Steiner Employed Reinforced Concrete* (London: Rudolf Steiner Press, 1979), 11-22. Steiner gave many public lectures on architecture and arts from 1905 until his death that are collected in two main publications: *Architecture: An Introductory Reader*, compiled with an introduction, commentary and notes by Andrew Beard (Rudolf Steiner Press: 2004) and *Architecture as a Synthesis of the Arts* (Rudolf Steiner Press: 1999). These publications will be used to discuss his view on architectural theory and history as well as his approach towards design.

[780] On July 1978 an exhibition was held to celebrate the 50th anniversary of Goetheanum in Dornach that brought together works of architecture all around the world that were considered as part of Steiner's Antroposophical architecture. Examples of these works are presented in Hagen Biesantz and Arne Klingbord, *The Goetheanum: Rudolf Steiner's Architectural Impulse* (London: Rudolf Steiner Press, 1979). In recent years, several of the continuing anthroposophical architects in Europe have received international publicity, including Erik Asmussen in Sweden, Antonio Alberts in Holland, Rolf Gutbrod in Germany, and Imre Makovecz in Hungary. An example of how Steiner's approach was influential to the development of ecological principles could be found in Gary J. Coates, "Seven Principles of Life-Enhancing Design: A Study of the Architecture of Erik Asmussen," in *Design & Health: The Therapeutic Benefits of Design*, ed. Alan Dilani (Stockholm: AB Svensk Byggtjänst, 2001): 239-254. Coates defines seven principles of design in Asmussen's work that shows similarities to Steiner's writings on architecture.

[781] In a recent publication by Peter Staudenmaier, Steiner's anthroposophy has been considered as having strong links with the development of Nazism in Germany after the first world war due to Steiner's highly influential figure in Germany in *Between Occultism and Nazism: Anthroposophy and the Politics of Race in the Fascist Era* (Leiden: Brill, 2014). While it is not the topic of this dissertation to focus on the socio-politic ties of Steiner, this chapter aims at revisiting works and writings of Anthroposophical architecture as separate from his ideas on politics and races.

"organic functionalism" that stands as a barrier to advance Goethean morphology as a generative, rule based and abstract framework.[782]

3.2.1 Rudolf Steiner and Anthroposophical Architecture

Rudolf Steiner was born in 1861 in a small town located in the Austro-Hungarian Empire (now part of Croatia). His early life and intellectual development is often viewed in two contrasting periods. The first part spans until the late nineteenth century, where Steiner develops an interest in the natural sciences and philosophy that begins with him receiving a scholarship to study at the Vienna Institute of Technology from 1879 to 1883 where he shows an interest in mathematics, physics, chemistry, botany, biology, literature, and philosophy. At Vienna, he also discovers Goethe in 1882 and becomes an editor of Goethe's scientific writings that are published until 1901.[783] After completing some editorial work on Goethe's scientific writings under Joseph Kürschner, he was invited to work on the Goethe and Schiller archive in Weimar, where he remained until 1896. During this time he received a doctorate in philosophy from the University of Rostock for his thesis on Fichte in 1891. Afterwards, he "published a series of philosophical books-primarily on epistemology, ethics, and Goethe's world view, but also on Nietzsche, Hegel, and Haeckel."[784] During this productive period Steiner also wrote his own philosophical treatise, *The Philosophy of Freedom* in 1894, where he developed a monistic view of nature that combines material limitation with spiritual freedom to avoid

[782] David Adams, "Rudolf Steiner's First Goetheanum as an Illustration of Organic Functionalism," in *Journal of the Society of Architectural Historians*, Vol. 51, No. 2 (Jun., 1992): 182-204. Adams notes that Steiner had a major influence on twentieth-century painters and sculptors as Kandinsky, Malevich, Mondrian, Kupka, and Beuys. Through the designs and publications of Kenji Imai, Yoshiro Ikehara, Yuji Agematsu, and others, Steiner's buildings have continued to influence postwar Japanese architecture. Le Corbusier visited the site of second Goetheaum and was "speechless" of the work. Rochamp Cathedral, which was erected in a two hour car drive distance to the site shows some reminiscent aspects to the building.

[783] These publications could be found in Johann Wolfgang von Goethe, *Goethens Naturwissenschaft Schriften*, ed. and intro. Rudolf Steiner,4 Volumes, reprint of volumes first published in Kürschners Deutsche National-Literatur (Stuttgart, Berlin, and Leipzig: 1884-1897).

[784] Adams, "Organic Functionalism," 185.

absolute determinism in the form of Metaphysical Realism.[785] In the book Steiner highlights the shortcomings of dualism in philosophy that presents a separation between objects and subjects that can never be reconciled as a boundary between knowledge and thinking emerges. Instead, he considers an alternative monistic worldview, that rather than posing limitations on thought processes, it tries to liberate engagement with the world through intuitive thinking that first starts as sense-perceptions and later leads to ideas.[786]

Steiner's philosophical view shows a drastic change after he joins the Theosophical Society in Germany in 1902 and remains as its leader until 1912. During this time he shows an interest in mystical teachings and esoteric ideas of the community drawing interest on "gospels, reincarnation, and occult physiology, as well as economics, education, history, science, agriculture, medicine, and the arts."[787] Later he develops his distinct views on esotericism and leaves the society in 1913 to establish his own Antroposophical Society in Berlin. The Antroposophical society was shaped around Steiner's ideas on "systematically heightening powers of conscious cognition" that he regarded "as fully scientific, as a 'spiritual science" while also developing "practical applications of anthroposophy in diverse fields, including education, agriculture, economics, medicine-and architecture."[788]

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[785] Rudolf Steiner, *The Philosophy of Freedom: A Modern Philosophy of Life Developed by Scientific Methods,* trans. Hoernlé and Hoernlé, ed. Harry Collison, (London and New York: G. P. Putnam's Sons, 1916), 89. These ideas are elaborated in Chapter 8: Are there any limits to knowledge?, where Steiner combines the dichotomy in dualist philosophy under Monism, "Metaphysical Realism merges when it discards its contradictory elements, Monism, because it combines one sided Realism and Idealism into a higher unity. In Chapter 11: Monism and Philosophy of Freedom, Steiner elaborates on this merging in man's inner activity of feeling and thinking, "man's action is partly free, partly unfree. He is conscious of himself as unfree in the world of percepts, and he realizes in himself the spirit which is free." p.118.

[786] While Steiner's philosophical world-view is not the concern of this chapter it would be necessary to highlight a key difference to Goethe's world view highlighted at the end of first part of his book. Compared to Goethe, Steiner's monistic world view relies on an absolute synthetic process, fully overlapping internal feelings and thoughts with external engagement with the world. While Goethe's epistemology highly depends on intuition, he doesn't solely consider synthesis. Instead he favors a combination of analysis and sythesis that combines scientific experimentation with intuitive judgments.

[787] Adams, "Organic Functionalism," 185.

[788] Ibid.

Although he had no prior architectural training, Steiner wrote extensively on the origin and development of the arts and built seventeen structures with the help of collaborating architects and constructors in Dornach, Switzerland.[789] Steiner's main views of architecture and the visual arts have been conveyed in his lectures given between 1905 and 1924 where he defines an intention to develop an "organic architecture" that does not "involve imitating the external appearance of natural forms but getting inside nature's skin and applying her methods to produce a unique solution to each problem."[790] Rather than considering an organic causal link between human body and architectural body, he considers architecture as an expansion, or envelope to the space around the human body that is directly shaped from it akin to the shell of walnut.[791]

> All architecture consists in separating from ourselves this system of forces and placing it outside us in space. Thus we may say: Here we have the outer boundary of our physical body, and if we push the inner organization, which has been impressed by the etheric body on to the physical body, outside this boundary, then architecture arises. All the laws present in the architectural utilization of matter are also to be found in the human body. When we project the specific organization of the human body into the space outside it, then we have architecture.[792]

[789] These structures could be found in Werner Blaser, *Natur im Gebauten* / *Nature in building: Rudolf Steiner in Dornach* (Basel; Boston, Birkhäuser: 2002).
[790] Steiner, *Architecture*, 7.
[791] Raab et al., *Eloquent Concrete*, 31-32. When asked about the design of Goetheanum on "how the single form emerging from the whole is to be experienced," Steiner responds by comparing architecture to a shell developing around an organic body as it happens in the case of walnut: "The walnut has a shell. The nutshell is formed around the nut, around the kernel, by the same laws as brought the nut itself into being. You could not imagine the nutshell other than it is, once the kernel itself is as it is."
[792] Steiner, *Architecture*, 23. Steiner, *Architecture as a Synthesis of the Arts*, 22. Steiner gives a similar definition for architecture as the art of enveloping the space through projecting inner creative activity towards space: "Architecture is the art of creating an enveloping, enclosed space, with the help of a variety of materials and by means of various shapes and forms, either for ordinary activities and dwellings or for religious purposes. Therefore it is connected with the soul life of human beings. It originates from the soul, and it can be comprehended to the extent that the soul can be comprehended."

Steiner's description of architecture as being an expansion of an organic body is first introduced in a lecture titled "The History of Architecture in the Light of Mankind's Spiritual Evolution," where he considers a historical argument on the development of architectural styles starting from the Egyptian pyramids, evolving towards Greek temples and Gothic cathedrals.[793] He considers architecture as way for mankind to fulfill their need to build structures for worship to unite spiritual forces with physical buildings. For the phylogenesis of architecture Steiner considers an esoteric route, uniting the evolution of architectural styles through acts of worship and reincarnation that places structures as a gateway between physical and spiritual dimensions. This tension also combines two opposite forces: an "upward striving luciferic element, a weighing and pressing down ahrimanic element, and a balance between the luciferic and ahrimanic which is divine quality."[794] For Steiner, architecture appears as the balancing of these vertical forces that relate structure to gravitational pulls. Among the structures discussed, the pyramid presents a primordial form that symbolizes how the tomb of the physical corpse is lifted through an "outer symbol of the soul which has left the body and is rising into higher realms."[795] In Greek temples the roles of physical and spiritual dimensions are reversed, where instead of humans inhabiting architecture, the structures become the "dwelling place of the god whose statue may stand within."[796] Steiner contrasts the organization of the Greek temple with the later Gothic Cathedral that presents a reversal of this relationship where "architecture gradually adapted to the human being's need for individuality" and produced a form "which reveals that the congregation belongs inside it; and gradually separated from the congregation was the part set aside for the priests and

[793] Ibid., 37-53.
[794] Ibid., 26.
[795] Ibid., 40.
[796] Ibid., 43.

the teachers" as it took place in Greek temples.[797] While Steiner considers craft as an important part of the design and construction of these structures, he considers them as modified versions of a crystallized temple that not only acts as a space of congregation but as structures that represent the union of physical and spiritual powers.

Another historical discussion of architecture provided by Steiner focuses on the usage of decoration and motifs particularly placed on column capitals and walls. An example of these figures is found on Egyptian columns that show an alternating pattern of plant and tree forms where "the palms represented the sun forces, and bud-forms running upwards to a point, the earth forces."[798] Steiner proposes that the same motifs are used in the decoration of Doric, Ionic and Corinthian capitals, where in the last stage "the 'palm motif' when sculpted becomes the so-called acanthus leaf."[799] Steiner disregards the motif as an imitation of an actual leaf added to the column as "the acanthus leaf did not arise out of naturalistic representation at all, but out of a metamorphosis of the ancient sun motif, the 'palm motif', being sculpted instead of painted."[800] For design, he considers artistic creativity and spiritual feelings over naturalist imitation of figures that he considers as a materialist attitude. Drawing from the alternating figures of sun and earth motifs, Steiner views primordial art forms to "have also sprung from the human soul and not from imitation of external phenomena."[801]

In *Problems of Style*, Alois Riegl considers the origin of the Egyptian motif to be derived from a lotus blossom; however, he doesn't consider them to be imitations of "an ancient custom of winding festive garlands of lotus around the column shaft" that "is too

[797] Ibid., 47.
[798] Ibid., 84.
[799] Ibid., 91.
[800] Ibid., 92.
[801] Ibid., 93.

farfetched and inconsistent with the basic character of Egyptian art," instead, he considers them to follow a "basic artistic idea, akin to the principle of symmetry" where the column shaft's "unattached termination demands some sort of artistic articulation."[802] On the origin of the acanthus motif used in Greek column capitals, Riegl questions the direct imitation of leaves advocated by Vitruvius.[803] He views the acanthus ornament not as a "direct imitation of a model found in nature but rather from an essentially artistic development process within the history of ornament."[804] Riegl draws similarities between the acanthus and the ancient palmette, where the former is seen as an artistic modification of the latter in an attempt to create new artistic models to decorate the columns. While Steiner considers architectural ornament through the design of motifs as an artistic and abstract medium with no naturalistic influence or imitation, Riegl sees them as part of an artistic process, where the motif is not an absolute imitation, but it is still naturalistic as it resembles the palmette. Thus, acanthus is viewed as a modified palmette where it is abstracted and metamorphosed and still appears leaf-like.

3.2.2 Polarity and Goetheanum

The development of the concept of metamorphosis in Steiner's architectural work stems from his early engagement in the theosophical society conferences and his later engagement with the design and construction of seventeen structures in Dornach, Switzerland that house the Antroposophical society. The chronological development and origin of his ideas on architecture are presented in *The Goetheanum: Steiner's*

[802] Alois Riegl, *Problems of Style: Foundations for a history of ornament*, trans. Evelyn Kain (Princeton, N.J.: Princeton University Press, 1992), 60-61.
[803] Vitruvius, *Ten Books on Architecture*, 104. In book four chapter one titled "The Origins of The Three Orders, And The Proportions of The Corinthian Capital" Vitruvius names Callimachus, a Greek architect and sculptor, as the inventor of the Corinthian order after seeing a woven basket covered by sprouting acanthus leaves left on the grave of a young girl.
[804] Ibid., 191.

Architectural Impulse, showing a consistency of principles guided by esoteric influences.[805] Among these, the early artistic works feature mostly decorative arts while in later works these ideas are transferred to the design of large structures to house activities and gatherings of the society. An early example could be found in one of the Theosophical Society meetings that took place in Munich conference in 1907 where the congress hall was decorated with "a row of seven columns painted on tall, rectangular boards, which alternated with painted *tondi* (circular pictures) of the seven planetary seals."[806] This decorative treatment was later repeated in ellipsoid spaces with columns in Malsch and Stuttgart buildings that housed the society's meetings. Biesantz states that these early spatial applications "already revealed what was later to be accomplished in the first Goetheanum in the form the double-domed building: the establishment of an organic relationship between the longitudinal character of an axial building (basilica, cathedral) and the circular character of a central building (Pantheon)."[807] The Munich Project (Johanness Building), as an early proposal for the Theosophical Society in 1911 already featured "the concept of a twin-domed building with two interpenetrating cupola segments" that "comprise auditorium and stage."[808] Steiner had the concept of a double domed building with two intersecting cupola segments in 1908 but did not mention it until 1909 in private conversations. The early building in Malsch was intended as a temporary structure where "the ellipsoid was thus an intermediary stage on the way leading to the double-cupolaed edifice."[809] This concept was first proposed in Munich project that aimed at reviving the cross plan of religious structures while transforming it

[805] Biesantz et al., *The Goetheanum.*
[806] Ibid., 10.
[807] Ibid., 12.
[808] Ibid., 15.
[809] Ibid., 16.

with the idea of a double cupola along an axis that combined "a fluctuating equilibrium with the longitudinal axis effect" where the "central building emanates peace and security in the harmony of a cosmos whereas the axial building provokes activity and movement."[810] While the project was not realized due to Steiner's departure from the Theosophical Society, these formal ideas were brought into the design of the Goetheanum that acted as a prototypical structure for his later founded Anthroposophical Society (Fig.3.2.2.1).

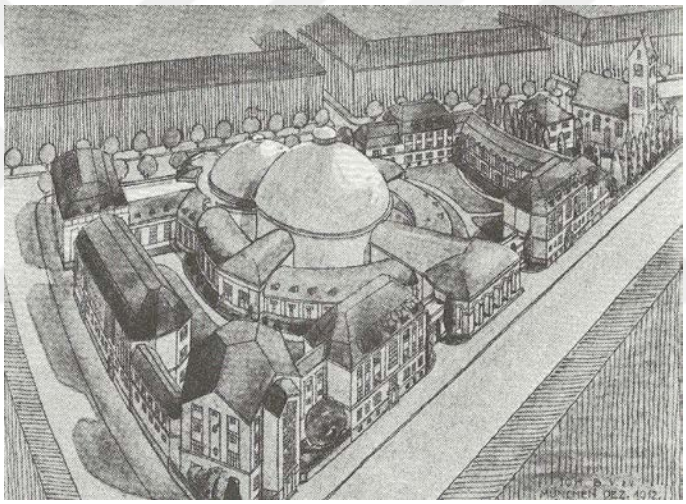

Figure 3.2.2.1 – Model sketch of the Johannes Building in Munich (1912) (Reprinted after Biesantz, H., Klingbord, A., *The Goetheanum: Rudolf Steiner's Architectural Impulse* (London: Rudolf Steiner Press, 1979), 16).

The first Goetheanum was designed in 1914, and featured two perpendicular axes producing a structure by two intersecting spherical domes. Steiner considers the formal operations of design used in the Goetheanum "as the transition from previous geometrical, symmetrical, mechanical, static-dynamic architectural styles into an organic style."[811] Constructed mainly out of wood, these two intersecting domes were organized

[810] Ibid., 18.
[811] Steiner, *Architecture*, 153.

in the shape of a lemniscate–that draws the physical, temporal world (larger dome–auditorium) with the spiritual, eternal world (small dome–stage). The interior surfaces of the two cupolas were covered with flowing-patterns of colorful imagery that presented esoteric images of space, time, life, and death using contrasting color schemes.

In a lecture titled "A New Architecture as a Means of Uniting with Spiritual Forces" Steiner discusses the geometrical derivation of the ground plan while relating the Goetheanum to Greek temples and Gothic cathedrals. He explains the evolution of the lemniscate plan through the geometric modification of "a perfect circle" that represents "a sense of egohood, of selfhood" and becomes a "sphere in space."[812] In order to avoid fixed geometrical elements of design, he discusses the transformation of the circle first into an ellipse then into a lemniscate by separating the two circles along an axis (Fig.3.2.2.2). This operation yields four geometric shapes that are transformable to each other: two circles, an ellipse, two hyperbolas and a lemniscate that are used in the overall design of the structure either in portions or as a whole. Among these the lemniscate organizes the overall division of the building along a primary axis that combines two spherical domes representing physical and spiritual realms where the former "corresponds to everyday life while the other is connected with the whole cosmos."[813] Thus, the dual-geometrical transformation of the circle, as an individual space of rest, not only generates movement along an axis through its union, but also associates form with thematic spaces for spiritual sciences through its division (Fig.3.2.2.3).

[812] Ibid., 58.
[813] Ibid., 69.

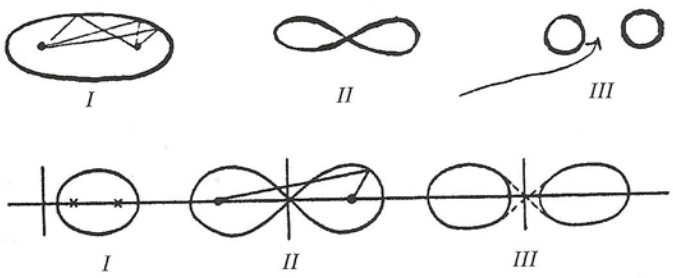

Figure 3.2.2.2 – Steiner's sketches for the evolution of the Lemniscate plan for the Goetheanum (Reprinted after Steiner, R., *Architecture: An Introductory Reader*, compiled with an introduction, commentary and notes by Andrew Beard (Rudolf Steiner Press, 2004), 66.).

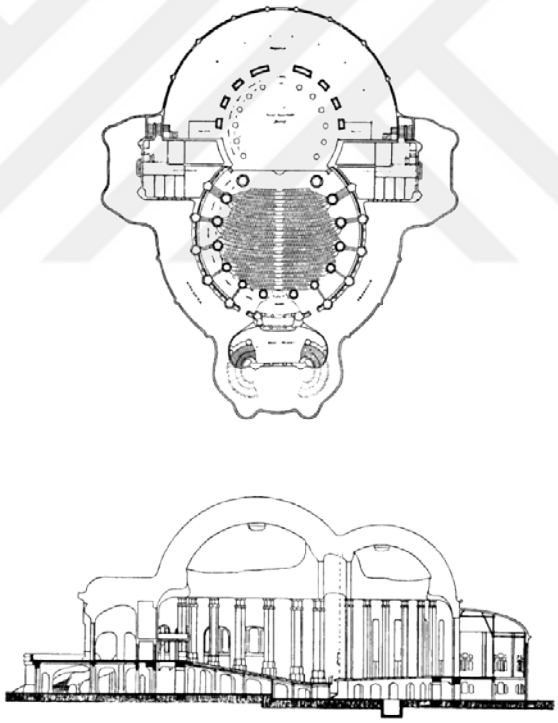

Figure 3.2.2.3 – First Goetheanum showing plan at auditorium level and longitudinal section. (Reprinted from Goetheanum Archives, Dornach (Verlag am Goetheanum, Dornach)).

While the overall plan of the Goetheanum shows a symmetrical and axial organization, the interior space materializes through asymmetrical arrangement and

articulation of structural elements. In his first lecture in Dornach in 1914, Steiner describes how the design of interior details such as the capitals of sequential columns and walls arose from the overall design of two cupolas using the concept of metamorphosis that leads to the sequential placement of structural columns. For instance, the large dome housing the auditorium is supported by seven columns that show a progression of different capital designs guided by a transformative character of sequential motifs that is seen as a "living progression, not symmetry."[814] This property "is a necessary consequence of having two cylinders of the building–one smaller, one larger–surmounted by the two intersecting domes," so that if their proportions were changed everything inside must change as well: "if one form were changed the whole building would have to be different, for the whole is conceived as a living, organic form."[815] Steiner considers the columns as an integral part of the whole structure and their form generated by the asymmetry caused by the intersection of domes (Fig.3.2.2.4).

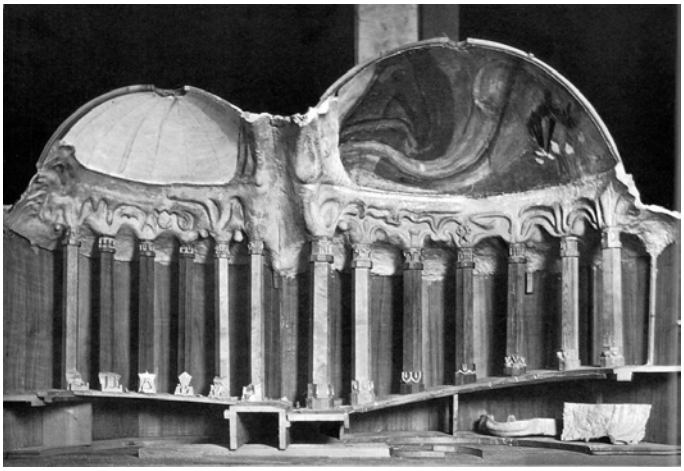

Figure 3.2.2.4 – Scale section model of the interior halls. The study is of the capitals and sculptural motifs in particular. (Reprinted from Goetheanum Archives, Dornach (Verlag am Goetheanum, Dornach)).

[814] Steiner, *Architecture as a Synthesis of the Arts*, 72.
[815] Ibid.

Among the details used in the Goetheanum, Steiner attributes the sequential arrangement of columns to a transformative treatment driven by Goethe's concept of metamorphosis. These columns are decorated with changing abstract capital motifs that are observed in a sequential order to represent a time process observed in space. In his lectures, Steiner's description of the design of the seven columns and capital motifs shows changing explanations that are first related to evolution and planetary conditions,[816] later to the temporal development of a human being through seven cyclic years, and then as "etheric legs" projecting from earth's surface.[817] But in a later lecture he doesn't consider their origin "because of any mystical significance, but simply from artistic considerations."[818] Their origin is considered in relation to the whole building where "a certain principle of symmetry is maintained, but linked with artistic asymmetry," where the inner details and particularly the walls acquire a dynamic and plastic quality "that makes the building artistically satisfying, and creates a great deal of variation."[819] The columns also participate in this overall movement, to produce a sequence of evolving form–"from the simple to the complex–and then again to simplification."[820] To perceive this movement, the onlooker must consider a predetermined polarized motif that varies among the sequence of columns producing complementary forms along the capitals.

[816] Steiner, *Architecture,* 99. These remarks are mentioned in a lecture titled "Metamorphosis in Architecture dating back to 190 where Steiner discusses the esoteric significance of the seven columns as representations of seven planetary qualities and the so-called Post-Atlantean periods of human evolution that are shaped by polar forces where "all evolution depends upon a progression in seven stages" representing "Saturn, Sun, Moon, Mars, Mercury, Jupiter, Venus – seven columns representing seven planeteray conditions.
[817] Ibid., 70-74. Steiner attaches various symbolic functions to the seven columns as representing seven years of development that are cyclic. When repeated five times they produce a fully grown adult at age 50 is reached. He describes the columns as etheric legs representing the forces radiating form earth outwards that are perpendicular to the horizontal forces on earth's surface. He states that "first we live in the horizontal; subsequently we stand up and become vertical." This vertical tendency is an imprint of "uniting ourselves with the forces of will rising up out of the earth."
[818] Ibid., 157.
[819] Ibid., 163.
[820] Ibid., 167.

> The same motif (or theme) goes through all seven capitals: a force from above, and a force from below, that first of all strive towards each other, then, reaching each other work together. The fullness and inner life of these forces have to be felt and then the soul itself has to experience how, shaping themselves in a living way, they spread, draw together, embrace or clasp each other, entwine or engulf each other, open up or unfold and so on. It is possible to feel this complexity of the forces in the same way one feels the 'self-shaping' of the plant out of its vital forces, and one can sense how the line of force first of all goes up vertically in the column, how it unfurls below in the sculpted shapes of the capitals that open themselves up towards the forces approaching them from above, so that a meaningful supporting capital may arise.[821]

Steiner compares the design of this motif to the elements used in Greek temples and Gothic structures that he considers as "static", "complete" and "vertical" producing crystalline walls.[822] In contrast, he considers the design motif used in the Goetheanum to be "organic" not "just a static wall but allows things to 'grow' out of it. Here the wall is not merely a wall, it is alive, just like a living organism that allows elevations and depressions to grow harmoniously out of itself."[823] However he doesn't consider the organic behavior of the motif as a figural, rule based variation; instead, the plasticity of the motif occurs due to its "etheric" and "spiritual" nature that makes it "come alive."[824] From Steiner's drawings, the shape of this motif appears as a "T" figure that produces a polarity between its vertical and lateral components. For instance, on the west front of the

[821] Ibid., 100.
[822] Steiner, *Architecture as a Synthesis of the Arts*, 88.
[823] Ibid.
[824] Ibid., 89.

Goetheanum the vertical part of the motif segments and expands while its lateral parts contract. On smaller windows surrounding the north and south wings, the same motif appears in a polarized fashion, with contracted verticals, and expanding and curling laterals embracing the window outlines (Fig.3.2.2.5-6). The variability of the motif occurs with alternating topological proportions of vertical and lateral axis that can also segment, stretch and collapse to surround every aperture on the façade.

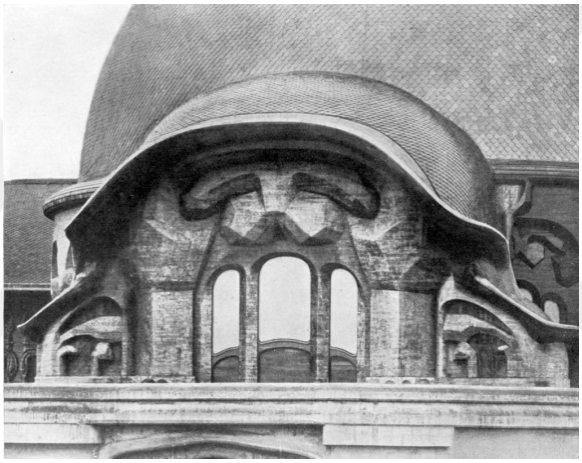

Figure 3.2.2.5 – Upper portion of the west portal of the First Goetheanum circa 1921 (Reprinted from https://rudolfsteinerweb.com/galleries/First_Goetheanum/Exterior).

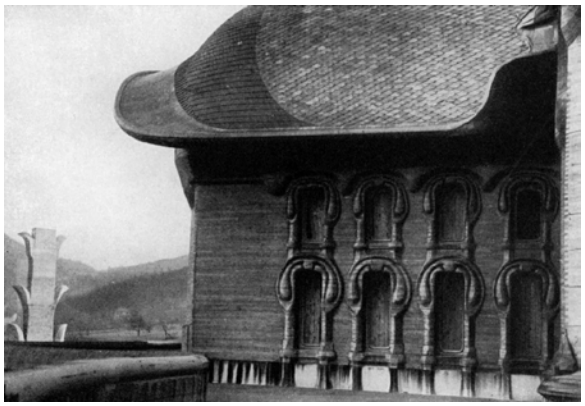

Figure 3.2.2.6 – The north wing of the First Goetheanum circa 1921 (Image taken from https://rudolfsteinerweb.com/galleries/First_Goetheanum/Exterior).

After the destruction of the first Goetheanum by arson in on New Year's Eve 1922/23, Steiner designed a second building to replace the original on the same site. The second Goetheanum was completed in 1928, built mainly out of reinforced concrete. Although Steiner did not see the completion of the building, he arranged plans, drawings and models that were used by artists and constructors to complete the work (Figs.3.2.2.7-8).

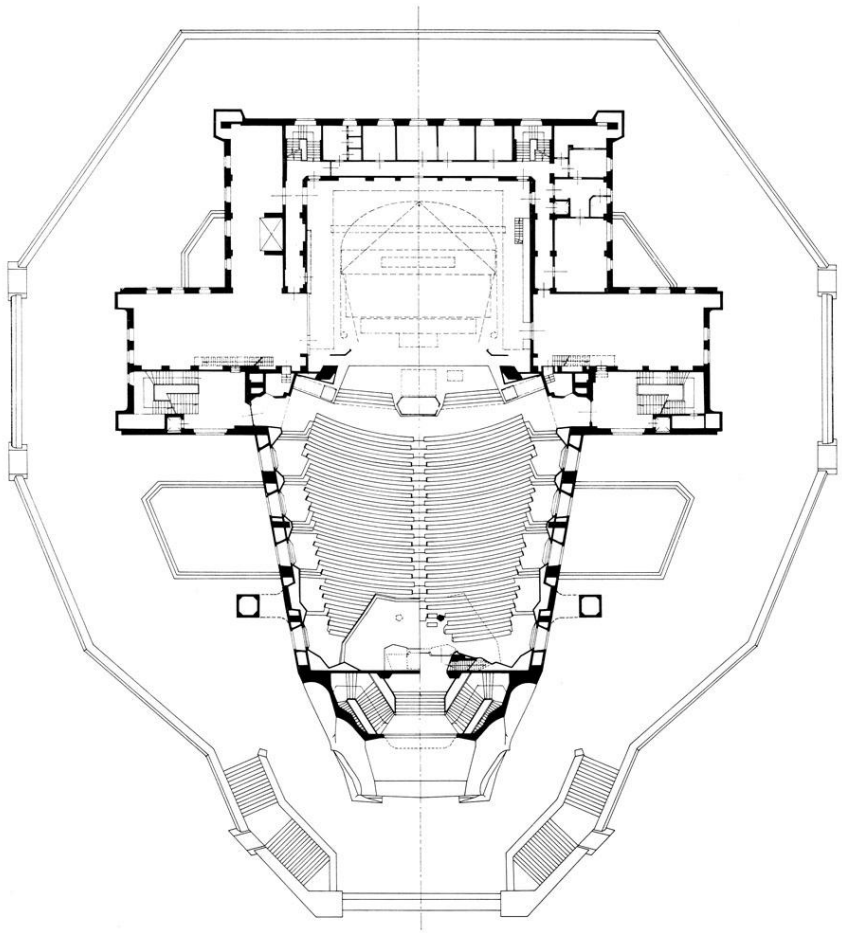

Figure 3.2.2.7 – Second Goetheanum plan at auditorium level. (Reprinted from Goetheanum Archives, Dornach (Verlag am Goetheanum, Dornach).

Figure 3.2.2.8 – Second Goetheanum view from west (Image taken from https://rudolfsteinerweb.com/galleries/Second_Goetheanum).

The second building used a similar axial schema, however the form of first the Goetheanum, built out of wood, where "form arises from a concave, hollowing-out treatment of the main surface" was transformed into a "convex, a bulging-out of the main surface defining the boundary of the space."[825] The construction material also brought a polarity to the design process: the first Goetheanum was designed from inside outwards; whereas the second was first sculpted out of wax models to develop interior space from the volume of the outer form. The interior was finished by other designers following Steiner's initial plans after the concrete construction for the building was completed. Compared to the first, "the second Goetheanum rates among many Anthroposophists and architectural critics as a lesser example of Steiner's architecture, lacking the resolution

[825] Ibid., 174.

and level of detailing that had been invested over many years in the first building."[826] However it still had an impact on the modern architectural scene as it was seen as an illustrative example of expressionism using concrete.[827]

3.2.3 Polarity and Anthroposophical Architecture

Despite Steiner's extensive involvement with architectural projects and lectures on arts, his works have only been recognized in the late 1960s and introduced in architectural discourse as part of the early expressionist movement in Europe.[828] However, due to his lack of prior architectural training and the esoteric nature of his Anthroposophical teachings, identifying Steiner's stylistic design approach has been a point of debate among scholars. Among these, Kenji Imai praised Steiner's work and compared it to the works of Antonio Gaudi and Le Corbusier, as having a complementary practice of painting, sculpture and architecture to "achieve the harmony and the unity of a living beauty in creating a structure;" however, he stated that "element of modern architecture dwelt more deeply and more intensively in Rudolf Steiner's Goetheanum than in the work of the other two."[829] Apart from its late recognition and praise, the stylistic classification of Anthroposophical architecture within the Modern architecture scene has been troublesome. Biesantz considers this new style as "spiritual functionalism" representing "the reconciliation of all art forms in an integrated work of art, as had been

[826] Fiona Gray, "Rudolf Steiner: Occult Crank or Architectural Mastermind?," in *Architectural Theory Revie*w, 15:1, (2010): 56.
[827] Raab et al. *Eloquent Concrete*, 15. Rex Raab notes that Le Corbusier was left "speechless (according to Ebbell) when he visited the unfinished shell of the vast 'House of Speech', as Steiner liked to call his project." Wolfgang Pehnt, *Expressionist Architecture*, (New York, N.Y.: Praeger Publishers, Inc., 1973), 148. Pehnt considered the structure as one of the most magnificent pieces of sculptural architecture of twentieth century. Its monumentality derives not from absolute dimensions but from the all-inclusive volumetric treatment of the building."
[828] Pehnt, *Expressionist Architecture*, 140. Pehnt states that Steiner's architectural theories present the aesthetics of Expressionism. He compares Steiner's schemes for the two-domes and arrangement of columns to be superior compared to "Bruno Taut's speculations on the effect of the numbers three and seven, the numerical mysticism of the early Bauhaus and the two series of measurements incorporated in Le Corbusier's Modulor."
[829] Kenji Imai, "The Goetheanum and the Ronchamp Chapel," in *Journal for Anthroposophy VIII* (Autumn 1968): 9.

the ideal of Art Nouveau artists" and opposing the "bald functionalism" of Adolf Loos and the functional structuralism of Bauhaus.[830] Ilse Meissner Reese wrote that "as a structure, the Goetheanum has always fascinated the design-conscious, and with the resurgence of interest in Art Nouveau and architectural expressionism, it has in recent years been subjected to closer scrutiny" however "stylistically" the building "is unclassifiable."[831] Reese concluded that if the building is "judged in terms of the 20's or the 60's, the Goetheanum is without doubt one of the purest examples of expressionist architecture, for seldom has a structure been designed more specifically to express, to interpret, to reflect a way of life, a philosophy."[832] While Anthroposophical architecture could be considered as part of the expressionist movement due to its plasticity and organic principles, the rules and principles behind its morphology and formal properties needs to be reconsidered devoid of style to evaluate it under the historical development of organicism in architecture.

An alternative and later reading of Steiner's work is presented by David Adams in "Rudolf Steiner's First Goetheanum as an Illustration of Organic Functionalism," where he revists Steiner's architectural body of work and considers it as an illustration of "individualizing functionalism, which held that every work of design should have its own functionally appropriate form or structural gesture" rather than being based on expressive subjective feelings.[833] While Steiner's new style aims to produce an ideal union of all arts that serve as an "artistic, experiential introduction to many of the concepts of the elaborate philosophical and metaphysical teachings of Steiner's anthroposophy", Adams

[830] Biesantz et al., *The Goetheanum*, 39.
[831] Ilse Meissner Reese, "Steiner's Goetheanum at Dornach," in *Progressive Architecture XLVI* (Sept. 1965): 6.
[832] Ibid.
[833] Adams, "Organic Functionalism," 188.

outlines five main principles that characterize Steiner's "'organic' architecture."[834] The first principle is about developing a "harmonious relationship between the building and its environment," where the rocky formation of the Goetheanum is attributed to the surrounding landscape of the Jura Mountains in Dornach.[835] This principle shows similarities to biological adaptation, where the outer form of the building is adjusted to fit to its environmental constraints such as climate, landscape, materials. In one of his lectures in Berlin, Steiner considers this principle as a contextual approach towards differentiating the forms of structures that emerge on different sites as each organic solution has to be varied to "be very individual in character" as "a house that would be right for one site would be wrong for another."[836] Rather than considering environmental influence as an ecological impetus for formal generation; Steiner considers it as an external input on the choice of material and formal features guided by the surrounding environment.

Adams defines Steiner's second principle as "holism" that shows "an essential interrelation of parts and whole similar to that which exists in natural organisms, where every form systematically develops out of its relation to the whole and is connected by inner necessity to every other form."[837] Steiner applies this principle as "transformations of one archetypal form" where "certain parts of the primary form become larger at the expense of others, and other parts become smaller; also various limbs expand, but not all to the same extent."[838] Among Steiner's built structures this archetypal form is attributed

[834] Ibid., 189.
[835] Ibid.
[836] Steiner, *Architecture as a Synthesis of the Arts*, 45.
[837] Adams, "Organic Functionalism," 189. Biesantz et al., *The Goetheanum : Rudolf Steiner's architectural impulse*, 39. Biesantz et al. considers the nature of Steiner's organicism through the differentiation between paratactical (parts to whole) and hypotactical (whole to parts): "This style differs from cubism with its *paratactically* assembled structural elements in that the entire building forms one organism. That is, every detail is *hypotactically* coordinated with the whole; totality creates individuality."
[838] Steiner, R., *Architecture: An Introductory Reader*, 113.

to the Goetheanum for its double domed structure as "an expression of the living element" because he states that "if there had only been one dome then in essence our building would have been dead."[839] This inherent duality is extended towards the annexe-subsidiary surrounding structures-particularly the boiler-house that is described as a metamorphic variation of the Goetheanum, where the former is shaped through the separation of the two domes as an expression of an "ahrimanic principle," while in the latter the two domes interpenetrate each other approaching the "luciferic principle."[840] In the boiler house the separation of the domes and contraction of the entrance enables the chimney on the opposite side of the structure to expand vertically, while in the Goetheanum the merging of the domes produces two laterally expanded wings on both sides (Fig.3.2.3.1-2).[841] For Steiner, the metamorphosis of the architectural body occurs along a double axis enabling the interpenetration or separation of domes on the primary symmetry axis that either curtails or eliminates the production of lateral or vertical appendages on the secondary, perpendicular axis. These variations are considered by the designer depending on the function of the building while the expansion or contraction of parts are mainly seen as large massing operations transforming a contractive architectural body structured along a cross plan. This treatment of duality as a modification of double-domed structures reduces Anthroposophical architecture to schematic designs only, where the parts of a whole are only varied through proportioned polarities that have topological effects on the whole.

[839] Ibid., 115.
[840] Ibid., 116.
[841] Ibid., 118. Steiner considers polarity in the shaping of the boiler house: "For if you imagine this [the chimney] getting smaller and smaller, that [entrance] coming out again, and the whole thing pushed together, then the boiler-house would be transformed into the main building."

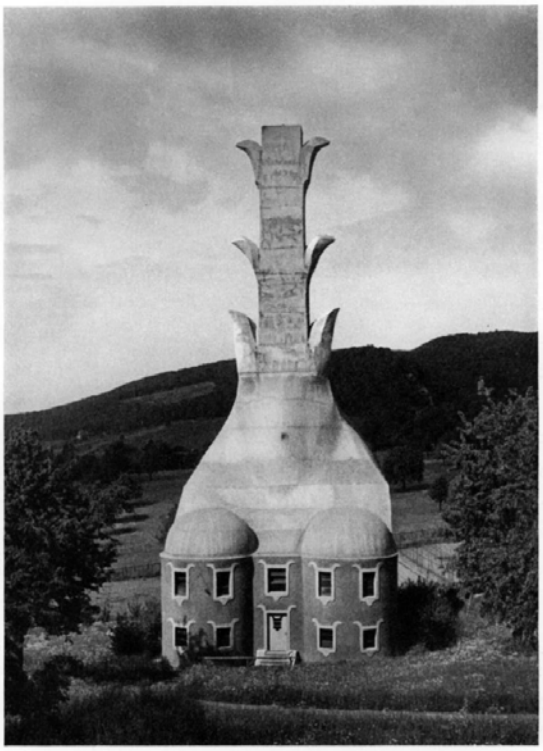

Figure 3.2.3.1– Boiler House in Dornach, 1914, (Image from http://www.rudolfsteinerweb.com/galleries/Other_Buildings).

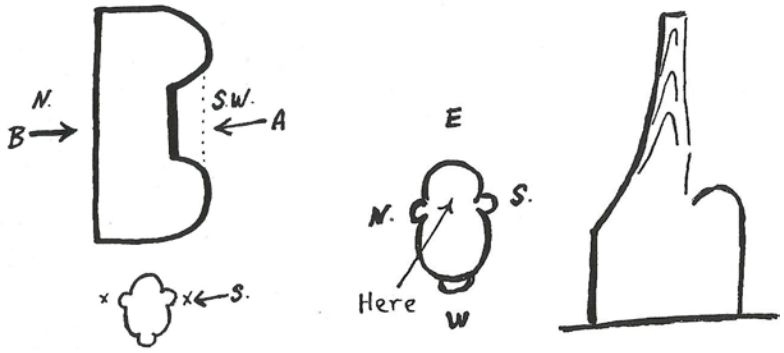

Figure 3.2.3.2 – Steiner's sketches explaining the polarity between boiler house and Goetheanum (Reprinted from Rudolf Steiner, *Architecture: An Introductory Reader* (Rudolf Steiner Press: 2004), 119-120).

For the third principle, Adams considers "living wall" as the expressive medium of Steiner's motif that are used on the "sculptural surfaces growing out of organic unity

of the entire building" defining "continuous surfaces expressing the play between polarities of concave and convex, above and below, right and left, load and support."[842] Rather than establishing any rule based techniques or axial symmetries for the organization of walls, Steiner develops these organic parts through topological freedom that replaces axial symmetries with ambiguous plasticity. This makes the forms of his designs highly indeterministic and sculptural, giving them an expressive character that does not follow neither the norms of organicism nor symmetry. A similar treatment is found in the fourth principle that extends the concept of metamorphosis towards the design of sequential forms that mainly appear in the arrangement columns and capitals, where Steiner "portrayed a full series of steps in an abstract metamorphic process, integrating the resulting sense of directional progression with specific architectural functions and structures."[843] Compared to Greek columns that present notions of symmetry, repetition and naturalistic ornamentation, the columns in the Goetheanum appear as highly abstract and formal where the figures are treated typologically and transformed continually and repetitively–no two columns or walls are alike but they are placed within a transformative sequence that reveals an underlying unity of the type. As a result, the movement or rhythm of transformation among the sequence does not occur as a result of individual organic growth, but as a serial relation among the liquid parts that express subordination to the whole.[844]

The fifth and last principle in Adam's text is Steiner's anthropocentric approach towards design that rather than relying on an "aesthetic theory of empathy," focuses on

[842] Adams, "Organic Functionalism," 189.
[843] Ibid., 190.
[844] Steiner, *Architecture as a Synthesis of the Arts*, 32. Steiner describes the column ornamentation as follows: "Each will be like a letter of the alphabet reaching out beyond itself to form a word with other letters. The columns will not be arbitrarily varied but will combine like individual letters to form a significant script pointing outwards to the cosmos, pointing outwards from within. This is how we shall build: from the inside outwards. As one capital forms from another they will combine to express a wholeness."

the psychological and spiritual aspects of perception "responsive and sympathetic to what might arise within human beings' own consciousness as they used and experienced the building."[845] Steiner considers buildings to relate to the living psyche of human beings to develop an immediate spiritual connection with physical structures. But this connection is not sought through sympathy or shared feelings with organic elements,[846] instead architecture as an art needs to be seen through projecting mystical ideas on forms.[847] Steiner's organicism forbids any imitation of nature, albeit does allow following hidden mystical laws to shape forms. These forms are restricted to those that are fluid and transformative, using expansive and contractive principles, although they do not produce any recognizable naturalistic forms due to their highly abstract and sculptural character.

> The forms in it are obviously nowhere to be found in the physical world. Any apparent resemblance in our building to shapes found in animals or in the human body arises from the fact that higher spirits, who work in nature, create in accordance with the same forces with which we are creating; nature is expressing the very things we are also expressing here in our building. It is not a question of imitating nature but of expressing what exists as pure etheric form. It is like asking how I would imagine myself if I were to leave the external world of sense-

[845] Adams, "Organic Functionalism," 191.

[846] Spuybroek, L., *The sympathy of things : Ruskin and the ecology of design*, (Rotterdam : V2_Publishing : NAi Publishing, 2011). In his third chapter titled "Abstraction and Sympathy" Spuybroek looks at the works of William James and Henri Bergson and relates them to the German aesthetic theory of *Einfühlung* developed through writing of Theodor Lipps and William Worringer. In aesthetics, sympathy first occured in 1778, through Herder who defined it as a feeling, transposition of our human self into a form through the indication of beauty. Later this term was defined as *Einfuhlung* and was translated to English as "empathy"-a psychological concept that passes between two people or things. It found its climax until the Expressionism in German art and architecture through the concepts of Theodor Lipps (psychologist interested in art and architecure-makes *Einfuhlung* a property of life-vitalist) and Worringer. Before elaborating *Einfühlung*, Spuybroek looks at the philosophical contributions of Henry Bergson (another vitalist) and William James in order to develop a structure involving time and psychology. He arrives to the conclusion that, sympathy is more than a psychological concept, which appears between both animate and inanimate things. Thus, it can even become an aesthetic relation between inanimate things as well to understand the Gothic ontology.

[847] Steiner, R., *Architecture: An Introductory Reader*, 105. Steiner develops this discussion through his theosophical ideas that start with the decorative motifs of the Munich conference in 1907. He writes: "Whoever can sense what comes to expression in these pillars of world evolution feels comprehensive laws of all existence that solve the riddles of life in quite a different manner from abstract 'natural laws'." And he considers only the theosophical ideas to penetrate through the organic nature of his designs: "One who looks at the pictures with theosophic ideas in his mind and theosophic feeling in his heart will receive the holiest impressions from them."

perceptions out of account and seek instead surroundings that would express in forms my own inner being.[848]

Steiner's organicism approaches not only the whole design process and organization of the massing using dual principles, but also tackles modification of inner structural elements such as columns, walls and windows through the usage of predetermined motifs and their variations. While Goethe himself warned against treating metamorphosis as formless, Steiner's design motifs follow highly abstract etheric principles, limiting his archetypal motifs to the sculpting of highly indeterminate forms by projecting artistic expressions. Fiona Gray criticized this overall approach towards design to be highly influenced by his early esoteric ideas containing artistic ambiguity, where the methods used in Antroposophical architecture "rather than presenting a formulaic approach to design, Steiner encouraged individual creative freedom" based on his philosophical teachings fused with esoteric ideas.[849] Morphologically, Steiner's designs consider duality as schematic and limit its variability to the merging and separation of circles along a symmetry axis. This approach mainly produces contractive architectural bodies that lack further proliferation in massing as they could only be complemented with two lateral or vertical wings protruding from the intersection of circles.

3.3 Polarity and Asymmetry: Plants and Architecture

Apart from its organic kinship to bilateral animal bodies, architecture also displays vegetal qualities that show an asymmetrical mode of growth. To establish a more

[848] Steiner, *Architecture as a Synthesis of the Arts*, 72.
[849] Gray, "Rudolf Steiner," 59.

scientific approach in the pursuit of asymmetry this part will first revisit two influential figures in biology of the late nineteenth century who offered different perspectives on the vegetal qualities of variation in organic bodies. Among them, Bateson focused on the contractive aspects of growth through diverse case studies of mutations that showed discontinuities in structures found in animals, plants and insects.[850] On the other hand, D'Arcy Thompson looked at the expansive aspects of growth, more oriented towards extracting physical and mathematical principles that are quantifiable and topologically continuous.[851] These two approaches will be compared to develop aspects of asymmetry and how they relate to certain variations through polarized halves during development. These ideas will be extended towards architecture to look at the Gothic as a style showcasing vegetal qualities of growth that is capable of producing polarization along symmetrically organized bodies. Goethe's organic views of the Gothic will be considered along with his morphological writings particularly focusing on his essays on spiral tendency in plants.[852] These aspects will be developed in three parts: firstly, investigating the role of polarization in biological variation; secondly, revisiting asymmetrical works of Gothic architecture as a style capable of vegetal growth; and finally, reconsidering Goethe's writings on spiral tendency as parallels to modern concepts of symmetry.

[850] William Bateson, *Materials for the Study of Variation, Treated with Especial Regard to Discontinuity in the Origin of Species*, (London; New York: Macmillan, 1894).
[851] D'Arcy W. Thompson, *On Growth and Form* (New York: Dover, 1992), 1094. Thompson develops the idea of continuity by comparing the skeletons and bodies of various specieus using topological diagrams. These studies show both the aspect of continuous variation among species as well as reveal points of discontinuity.
[852] Goethe, *Goethe's Botanical Writings*. Goethe wrote two essays on the spiral tendency in plants. These show ideas on a polar bases of spiraling motion in nature. Spiralling forms occur in many cases of natural phenomena such as galaxies, plants, animals, mathematics, Mandelbrot sets, shells, fluid dynamics, waves and vortices. A broader discussion of these themes could be found in István Hargittai and Clifford A Pickover, *Spiral Symmetry* (Singapore: World Scientific, 2000).

3.3.1 Polarity and Teratology: Vegetal Proliferation and Architecture

The historical development of biology presents a curious tale of symmetry where the principles of growth are not discovered through analysis of perfect forms that display expected symmetries, but revealed in cases of malformation. This has been the overall direction of Romantic biology in the eighteenth century, that contrary to the Renaissance appreciation of beauty and harmonic symmetry focuses on mechanical forces and material imbalances that could generate monsters. One of the first examples of this interest is found in Caspar Wolff's work after 1775 when he was handed a collection of monsters by the Imperial Museum to conduct research on generation. Wolff considered monsters such as the chicken with four legs [*De Pollo Monstroso*, 1780], as evidence for the mechanical causes of generation that led him to "the whole problem of variation and its relation to heredity" (Fig.3.3.1.1).[853] He developed a variable notion of organisms and considered three processes: "vegetation, mode of vegetation, and degree of vegetation"—the first establishing types of organisms, the second classifications or orders, and the last producing variation.[854] While his view on natural forms was infused with vitalism, considering a soul added to matter to make it dynamic and productive, Wolff emphasized mechanical principles of growth that could lead to the potential discovery of principles of growth. By combining notions of preformation and epigenesist, he arrived at a system of dynamic organisms that had "initial heterogeneity is of a potential nature, based only on physical factors like solidification and attraction and repulsion, which produce the structures of the organism through gradual, but automatic, sequence of events."[855] The science of teratology focusing on monsters and aimed at discovering these opposing

[853] Roe, *Matter, Life, Generation*, 126.
[854] Ibid., 129.
[855] Ibid., 147.

mechanical forces that produced variation, not as imperfect copies of an extraneous God, but as an intrinsic dynamic activity of nature.

Figure 3.3.1.1 – The four-legged chicken
(Reprinted from Caspar Wolff, *De Pollo Monstroso,* 1780).

The Romantic ideas on generation and form developed in the eighteenth century brought variation and malformation as a point of investigation in the field of morphology. This was explored by many succeeding biologist including William Bateson and D'Arcy Thompson in the late nineteenth century. While Thompson developed ideas of mathematical principles underlying growth mechanisms, Bateson undertook the mechanical principles guiding the organization of forms that produced variation of repetitive parts especially found in appendages of vertebrates and invertebrates. These two different approaches advanced the morphological understanding of biological forms, one through the expansive qualities of continual topological formation, the other through contraction that produces discontinuity and proliferation of organizational structures.

The topological study of variation is a central aspect in D'Arcy Thompson's seminal work *On Growth and Form,* in which the goal of the book is to "correlate with

mathematical and physical law certain of the simpler outward phenomena of organic growth and structure or form, while all the while regarding the fabric of the organism, *ex hypothesi*, as a material and mechanical configuration."[856] Throughout the book, Thompson's approach towards the study of morphology aims to define mathematical properties of variation that are manifested in continuous modification of parts and constant ratios extracted from the proportions among developing organs. These findings establish organisms as self-regulating mechanisms that are altered through topological polarities, such as surface-tension, that keeps the volume of an organism in check by altering its form through growth "whose varying rate in one direction or another has produced, by its gradual and unequal increments, the successive stages of development and the final configuration of the whole material structure."[857] This process of growth is linked to an alternation between symmetrical and asymmetrical tendencies inherent in the mechanical properties of matter. Quoting directly from Mach, Thompson considers temporal stages of equilibrium as the guiding factor to establish structural and formal regularities in morphology.

> In every symmetrical system every deformation that tends to destroy the symmetry is complemented by an equal and opposite deformation that tends to restore it. In each deformation, positive and negative work is done. One condition, therefore, though not an absolutely sufficient one, that a maximum or minimum of work corresponds to the form of equilibrium, is thus supplied by symmetry.

[856] Thompson, D.W., *On Growth and Form*, (New York : Dover, 1992), 14.
[857] Ibid., 58-59.

> Regularity is successive symmetry; there is no reason, therefore to be astonished that the forms of equilibrium are often symmetrical and regular.[858]

Thompson explores this mechanical property of growth that tends to break equilibrium between polarities through the mathematical analysis of inorganic structures. He lists shells and horns as cases of "*asymmetrical* growth" due to expansion "at one end only" that show the "remarkable property of increasing by *terminal* growth, but nevertheless retaining unchanged the form of the entire figure, is characteristic of the equiangular spiral, and of no other mathematical curve" such as *"spira mirabilis."*[859] Asymmetrical growth appears through the lack of mobility in the organic structure that is often found "not in the fresh mobile tissue whose form is constrained merely by the active forces of the moment; but in things like shell and tusk, and horn and claw, visibly composed of parts successively and permanently laid down."[860] These continuous or successive stages of growth that are quantifiable through logarithmic spirals are often a property of inorganic tissue found in snails, shells, horns and foraminifera where the growth rate is regular and the ratio between successive parts appears relatively constant.[861] Thompson considers how the expansive qualities of these forms could be studied through mathematical formulation as during growth the "figure increases in geometrical progression while the angle of rotation increases in arithmetical, and the

[858] Ibid., 357. Also quoted in Ersnt Mach, *The Science of Mechanics: A critical and Historical Account of its Development*, trans. Thomas J. McCormack (London: Open Court Publishing, 1919), 394-5.
[859] Ibid., 758.
[860] Ibid., 766.
[861] Schad, *Man and Mammals*, 148. Schad also describes a polarity between the horn and antler formation, the former placing growth at the base, while the latter towards its tip where the vegetal qualities where "the antlers need not be constrained by horny sheaths or bent into tight spiral formations. On the contrary, they branch out!" The polarity between metabolic and sensory activities guide the formation and expression of these appendages between species.

center of similitude remains fixed, the curve traced in space by corresponding points in the generating curve is, in all such cases, an equiangular spiral."[862]

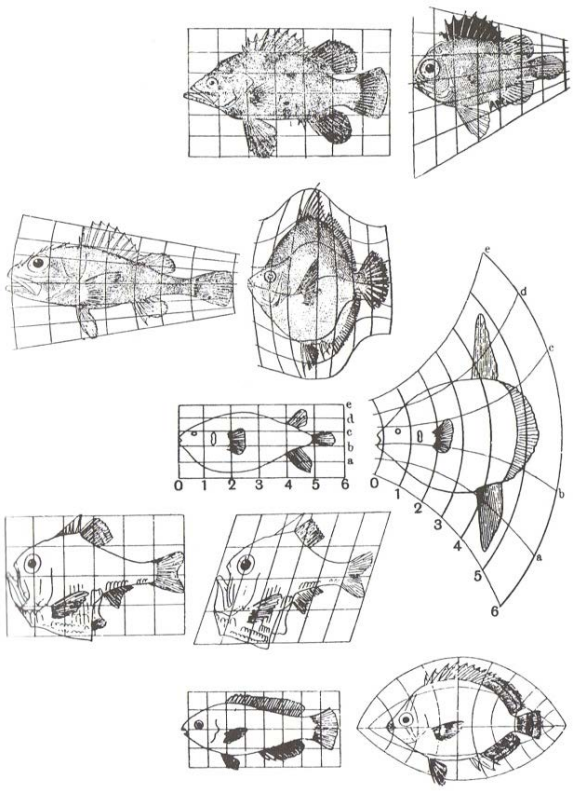

Figure 3.3.1.2 – Examples of Thompson's form matrices that are used to compare topological deformation among species showing correlation among types of fish (Reprinted after Thompson, *On Growth and Form*, 162-164).

The most famous study of variation found in Thompson's book is his last chapter "On the theory of transformations, or the comparison of related forms" that presents an extension to Durer's study of the proportions of the human face by using topological deformation matrices to extract typological correspondence between forms (Fig.3.3.1.2). These comparisons focus on fish anatomy, human and animal skulls, crab carapace, insects, horns and bones. By comparing various forms found in the same species,

[862] Thompson, *On Form and Growth*, 812.

Thompson aims to show "proof that variation has proceeded on definite and orderly lines, that a comprehensive 'law of growth' has pervaded the whole structure in its integrity, and that some more or less simple and recognizable system of forces has been in control."[863] The deformation of the field matrices shows that there is variation among types of organisms and correlation between constant mathematical ratios of growth. Furthermore, the fields also show limitations or constraints to "which limit and determine the action of the expansive forces of growth that would otherwise be uniform and symmetrical."[864] While the coordinate matrix diagrams enable topological comparison among species, the method also highlights various discontinuities among series that appear "divergent, rather than of continuous variation."[865]

Another aspect of growth is presented in *Materials for the Study of Variation* where William Bateson not only relates the formation of various organic structures in animal bodies to symmetry, pattern formation and repetition of similarities as universal characteristics of organic beings but also lists eight hundred eighty six cases of mutant formations that display how variation occurs through morphological principles.[866] Contrary to Darwin's prior work on the *Origin of Species*, an advocate of the gradual evolution of species, Bateson argues that morphological principles of variation "are not homogeneous but heterogeneous, consisting of organs or parts which in substance and composition differ from each other."[867] This differentiation of parts is closely related to symmetry, where even discontinuous series reveal certain orders and repetition of parts

[863] Ibid., 1037.
[864] Ibid., 1049.
[865] Ibid., 1085.
[866] Bateson, *Materials for the Study of Variation*.
[867] Ibid., 18. Charles Darwin, *The Origin Of Species*, annotated by James T. Costa (Cambridge, Mass.; London : Belknap, 2011, orig. 1859), 280. For his theory of evolution Darwin considers there to be a geological record of "intermediate form" however considers this be a "wholly false view" as the attention to be directed towards a "common but unknown progenitor; and the progenitor will generally have differed in some respects from all of its modified descendants."

that appear as deviations from symmetrical conditions, a property highlighted by D'Arcy Thompson's topological matrices that also show discontinuity among species.

The study of variation advocated by Bateson considers symmetry and pattern to be the universal principle of forms and he proposes two types of variation for their study: the *Meristic*, the quantitative and geometrical, and the *Substantive* that is qualitative and transformative.[868] The two types are always found coexisting in various parts of the body, such as teeth and vertebrae, where the *Meristic* behavior displays continuous variation that is often recognizable among molars and the vertebrae along the spinal column, and the *Substantive* transforms repeated parts as in the case of incisors and appendages that produces discontinuous bone formation.[869] Bateson also applies this principle to the expression of variation among species. In the case of *dimorphic*, genetic expression among the community displays two polarized tendencies and in the case of *monomorphic*, "the whole community, grouped according to the degrees in which they display a given character, forms one Curve of Error" that all variation falls under.[870] For instance, this dimorphism could be found in Hercules beetles, where the expansive-male form displays two types of long horns projecting from head and thorax producing high and low tendencies, whereas in female-contractive forms the horns do not exist (Fig.3.3.1.3).[871]

[868] Ibid., 22-23.
[869] For an example of a Goethean Meristic variation see Suchantke, *Metamorphosis*, 16-17. Suchantke uses variation along vertebral column as displaying polarities between the spinal cord and vertebral body that changes along the axis of the body. An example of Goethean Substantive variation could be found in Schad, *Man and Mammals*, 30-37. Schad develops a threefold classification for the development of teeth in animals that divided into Incisors, Canines and Molar, exhibited by Rodents, Carnivores and Ungulates.
[870] Ibid., 37.
[871] Ibid., 39.

Figure 3.3.1.3 – Male and Female tendencies in Hercules Beetles showing horn development in male (expansion) and lack of appendage in head or thorax in female (contraction). The polarity is also reflected on the size of the insects (Image taken from http://scienceblogs.com/myrmecos/2010/02/05/friday-beetle-blogging-dynastes-granti-the-western-hercules-beetle).

Bateson also discusses two types of discontinuity in meristic variation that are either radial, in the case of actinomorphic flowers such as the tulip, that can produce three or four segments, or linear as exemplified in the cockroach tarsus that has four or five segments. In the latter case, the measurement of proportions of the joints to the whole appendage shows similar ratios for both four and five segmented variations. Bateson considers these as morphological expressions and not issues of selection or fitness, since both forms function appropriately and their generation occurs mechanically, through the expression of polar forces.

> …there is, I think, a fair suggestion that the definiteness of these variations is determined mechanically, and that the patterns into which the tissues of animals are divided represent positions in which the forces that effect the division are in equilibrium. On this view, the lines or planes of division would be regarded as lines or planes at right angles to the directions of the dividing forces; and in the lines of Meristic Division we are perhaps actually presented with a map of the

lines of those forces of attraction and repulsion which determine the number and positions of the repeated parts, and from which Symmetry results.[872]

Bateson speculates that meristic variation could be "a strictly mechanical phenomenon" and it points towards a system of division that can relate all forms of symmetry—radial, linear and bilateral—to a common origin.[873] As a morphologist he relates forms of symmetry to patterns of polarity, where in successive series "the adjacent parts of any two consecutive members of the series are not homologous, but the severally homologous parts of each member or segment form a successive series, alternating with each other," while in bilateral, "each member of the pair presents to its fellow of the opposite side parts homologous with those which its fellow presents to it, each being, in structure and position, an optical image of the other," and in radial series parts are produced "by radial divisions of the first kind, producing segments whose adjacent parts are homologous, and related to each other as images."[874] These symmetries are described in mutant cases of insect wings, antenna and appendages, animal horns, teeth, nipples, ribs, vertebrae, limbs, patterns and special cases in various invertebrates and plants.[875] Among these the most particular ones occur in the variation of digits in animal fore and hind limbs discussed under the "Cases of Polydactylism Associated with Change of Symmetry."[876] These cases show both abnormalities in digit segmentation as well as expression of various radial and bilateral symmetries found in the polarized relationship

[872] Ibid., 70.
[873] Ibid., 71.
[874] Ibid., 88-89. Bateson uses letters to denote the rhythmic occurrence of attractive and repulsive forces for symmetrical systems. In linear series, the polarity alternates in the form of EC, EC, EC, in bilateral series polarity is mirrored: E…C, C…E, and in radial series the parts are produced in alternating forces of the first order, that then acquire local minor symmetries of the second order.
[875] A variety of these expressions are discussed in Philip Ball, *The Self-Made Tapestry: Pattern Formation in Nature*, (Oxford: Oxford University Press, 2004), 78-94. Ball discusses various morphological expressions in pattern formation by looking at leopard skins, zebra patterns, butterfly wings, angelfish, snails and shells. Among he draws a correlation between tail patterns of leopards towards the size and shape of the form. Greg Turk, "Generating Textures on Arbitrary Surfaces Using Reaction-Diffusion," in *Computer Graphics SIGGRAPH 91*, Vol. 25, No. 4 (July 1991): 289-298. Turk uses an algorithm based on reaction and diffusion coefficients to develop patterns that resemble various expressions of striped and spotted morphologies of leopards and zebras skins.
[876] Ibid., 326

between the thumb and fingers of the hand. Three illustrated examples show that symmetry could multiply the digits of a hand by two principles that could either add supernumerary digits through contraction or expand the digit by adding more phalanges (Fig.3.3.1.4).

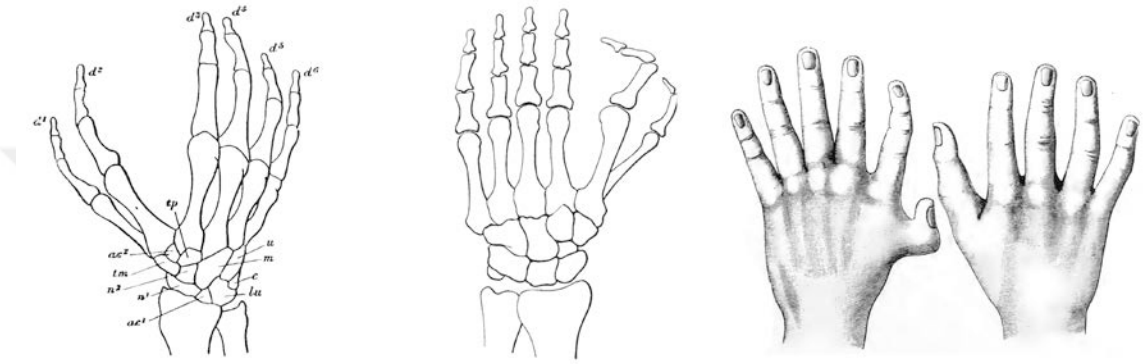

Figure 3.3.1.4 – Cases of hand polydactyly in humans. Mutant # 488 (left): right hand with six digits (two thumbs and four fingers) with thumbs having three phalanges each. Mutant # 486 (middle): left hand with six digits, thumb with three digits and a supernumerary digit. Mutant # 485 (right): right hand having a thumb with three phalanges, left hand with a thumb looking like a finger with an additional supernumerary digit (Reprinted from Bateson, 1894, 327-9).

Figure 3.3.1.5 – Mutant # 495, left hand with two groups of four digits (After Bateson 1894, 335).

Figure 3.3.1.6 – Mutant # 486, right hand with a double thumb that are joined in metacarpus bone of the hand (After Bateson 1894, 350).

Bateson discusses a polarity between the left and right sides of the hand using the three mutant cases. In these examples contraction relates to the organization or major symmetry of the hand and a polarity between the thumb and fingers, while expansion is responsible for mobility and elongation of each digit.[877] Hands often present two groups with different numbers of digits that produce symmetrical and asymmetrical distribution of fingers. In one of the extreme cases the hand produces eight digits in two groups of four fingers on a muscular arm that has limited mobility (Fig.3.3.1.5). Without having any distinguishable thumb, the hand appears as a union of two radial series of fingers that "could be opposed to each other and folded upon each other;" however, "the power of independent action of the fingers was very limited."[878] Another case looks at similar minor symmetry occurring in the thumb of a hand where "two radial digits together represent the thumb, the increase in number being achieved by duplication and not by

[877] Another discussion of the role of axiality and plane symmetry is discussed in Haraway, *Crystals, Fabrics, and Fields, 75-6.* Haraway looks at the work of Ross Granville Harrison (1870-1959) who was a devoted reader of Goethe and was one of the pioneers in the construction of modern organicism in distinction to old theories like vitalism and mechanism. Starting with his research on limb bud he developed a concept of field in 1930s. By means of the dissection of embryos followed by transplantation and rotation of the limb bud he demonstrated that the main axes of the developing limb are determined independently and at slightly different times depending on "location, side and orientation." His experiments showed that disharmonic grafting of limbs often yielded to multiplication and further establishment of symmetry among produced limbs.
[878] Ibid., 335.

successive addition" that happens in the case of radial symmetry (Fig.3.3.1.6).[879] This shows that even mutant cases fall under specific laws of morphology where polarity breaking among parts guides the types of variation to be manifest in form. In the case of the double hand (#495), the variation occurs as expansive expansion, that lacks any polarity between thumbs and fingers of a hand and multiplies the radial symmetry of fingers in a bi-lateral manner along the axis of the hand, whereas, in double thumb (#486), the variation is contractive expansive where the duplication of the digit supersedes the polarity between the thumb and fingers.[880] In his introduction to morphological writings titled "The Purpose Set Forth," Goethe considers organisms to express such polarity between similar parts that aids their movement and the perfection of their forms.

> The less perfect the creation the more its parts are alike or similar and the more they resemble the whole. The more perfect the creation the less similar its parts become. In the first instance the whole is like its parts to a degree, in the second the whole is unlike its parts. The more similar the parts, the less they will be subordinated to one another. Subordination of parts indicates a more perfect creation.[881]

[879] Ibid., 350. Stephen Jay Gould, *The Panda's Thumb: More Reflections In Natural History* (New York: Norton, 1992), 21. Gould also draws a similar conclusion on the development of the radial sesamoid bone of Panda's paw as part of the wrist, that is "greatly enlarged and elongated until it almost equals the metapodial bones of the true digits in length." The "panda's thumb" remains contractive and agile compared to the firmer and expansive digits of the paw to provide the mobility of grabbing.

[880] Greg Lynn, Jesse Reiser and Nanako Umemoto, "Computer Animisms (Two Designs for the Cardiff Bay Opera House)" in *Assemblage*, No. 26 (Apr., 1995): 8-37. In his essay titled "Renewed Novelty of Symmetry" Lynn considers symmetry as "sameness or lack of difference" while "disorganization is associated with absence of difference (information) and, therefore symmetry. In the double handed arm, difference is not introduced among parts during development thus the arm resorts to a prior equilibrium state producing a mirror axis between left and right digits.

[881] Goethe, *Scientific studies*, 64.

For Goethe, subordination is not related to the submission of parts under a whole, but about the expression of metamorphosis that is observed in plants and animals. In the former, the polar sequencing of parts along the axis of annual plants guides forms towards sexual production and differentiation of polarities, while in the latter it becomes related directly to the aspect of movement. Goethe explores this idea in a fragmetary essay written on beauty where he associates polarity breaking in an organism to express not perfection, but of beauty exhibited through the freedom of mobility of its parts.

> If the members of an animal are so formed that the creature can give expression to its being only in a limited way, we will find the animal ugly; limitation of organic nature to a single purpose will produce a preponderance of one or another of its members, rendering the free use of the remaining members difficult.[882]

Among the examples from the animal kingdom Goethe considers the mole to be "perfect but ugly because its form permits only a few, limited actions, and the preponderance of certain parts renders him misshapen," whereas in the horse "all members are so related that none hinders the action of another" as the "animal seems free to act and work just as it chooses."[883] Thus, the inner movement operating through polarities becomes a condition of asymmetrical expression in the animal that differentiates its parts and enables mobility. Seen in this light, Bateson's mutations found in hands show how the lack of polarity between the thumb and the fingers gradually limits the mobility and utility of the hand, yet still producing morphologically possible forms.

[882] Ibid., 22.
[883] Ibid.

3.3.2 Asymmetry and Architecture: Gothic

Among the most admired architectural structures built in history, Chartres Cathedral has always drawn keen interest among historians and architects with its "organic blending of the interior and exterior" achieved through the development of flying buttresses that gave it a "historical significance as the birthplace of the High Gothic style."[884] As one of the earliest and progressive works of Gothic architecture, Chartres also marks the birth of architectural asymmetry with its contrasting spires located at its west end. As Zee notes, while "architecture is founded on the tenet of bilateral symmetry," asymmetrical buildings like Chartres are often "regarded as oddities and demand explanation."[885] With its spires completed four centuries apart from each other, there is no other structure that represents such intricate relationships of temporality, growth and material construction to yield asymmetrical execution despite symmetrical beginnings (Fig.3.3.2.1).[886]

The structure of the Chartres Cathedral shows an organic approach towards architecture that enables later additions or alterations to be made with the invention of structural buttressing techniques. Following the 1316 excursion by French experts that culminated in the *Expertise*, the upper buttresses were added to provide structural support to the roof; however, "little is known of the technical functioning of Gothic structure and the architect's conception of the structural necessities" that resulted in the debate among scholars on the function of the expansion of structure.[887] Before the twentieth century,

[884] Paul Frankl, *Gothic Architecture*, revised by Paul Crossley (New Haven, CT : Yale University Press, 2001), 106-7.
[885] Anthony Zee, *Fearful Symmetry: The Search for Beuty in Modern Physics* (Princeton: Princeton University Press, 2007, orig. 1986), 22.
[886] Paul Frankl, "The Chronology of Chartres Cathedral," in *The Art Bulletin*, Vol. 39, No. 1 (Mar., 1957): 33-47. Frankl notes that after the destruction of the old Romanesque Cathedral, the new Gothic was built organically. Asymmetry is not only found in the towers of the west front but also in the development of the main body of the Cathedral where "the flying buttresses of the choir are different from those of the nave and stylistically more advanced."
[887] Alan Borg and Robert Mark, "Chartres Cathedral: A Reinterpretation of Its Structure," in *The Art Bulletin*, Vol. 55, No. 3 (Sep., 1973): 367.

many architects either tried to study these mystical structures to learn from their technical methods of construction or tried to revive the old medieval style as a salvation during stages of stylistic crisis. This presents two approaches in understanding the realm of the Gothic, one that considered it more in line with classicism and rational structural logic, the other involved more of an organic approach studying the variability and formal development of its structure.

Figure 3.3.2.1 – Chartres Cathedral with its asymmetrical spires. The 105-metre pyramidal spire was completed in 1160. The 113-metre spire on the left was added in 16th century (Photo by Tony Hisgett).

The first approach is presented in Eugene Emmanuel Viollet le-Duc's *Dictionnaire*, where the acclaimed but often criticized master of restoration tried to develop a scientific and rational approach towards considering the Gothic structure

through its elements.[888] For Viollet le-Duc architecture needs to be studied through scientific methods by analyzing constructive techniques as a whole to parts process. This approach was also followed by the comparative anatomist Georges Cuvier in France who studied organisms through the dissection of parts to reveal their mechanical organization and structural parts. Aron Vinegar draws a similar kinship in the methodologies between the anatomical work of Cuvier and Viollet-le-Duc's treatment of Gothic cathedrals as organisms, where the whole to parts strategy offered a "dissective methodology as applied to the study, excavation, and reconstruction of extinct fossil vertebrates: a methodology that Viollet-le-Duc imaginately adapted for his own architectural investigations and restorations" of the French Gothic that became "a laboratory for future architectural creation."[889] However, what distinguished Viollet-le-Duc from his contemporaries was his emphasis on the standardized reduction of structural members and the typological synthesis of Gothic Cathedrals into an ideal form.

In the second volume of the *Dictionnaire,* Viollet-le-Duc took his scientific approach even further and presented his famous illustration for an "ideal cathedral" where he depicted a structure with completed symmetrical spires at the end of transepts and a large spire projecting from the crossing representing a fully symmetrical and expanded structure that was never built in history (Fig.3.3.2.2). While this "Ideal Cathedral" offered a comparative study to relate all Gothic forms to one cruciform structure with the potential development of all seven spires, this picture presented problems to understand the proliferative nature of Gothic architecture that can also

[888] Eugène Emmanuel Viollet-le-Duc, *Dictionnaire in The Foundations of Architecture: Selections from the Dictionnaire Raisonné*, intro. Barry Bergdoll and trans. Kenneth D. Whitehead (NewYork: George Braziller, 1990).
[889] Aron Vinegar, "Memory as Construction in Viollet-le-Duc's Architectural Imagination," in *Paroles Gelées* 16, No. 2 (1998): 46.

produce asymmetry.[890] In this vein, Viollet-le-Duc represents the French rationalist approach by considering the Gothic in classical-reductive terms, where any Cathedral could be dissected, studied and compared to an ideal form to reveal its deviations.

Figure 3.3.2.2 – "Bird's-eye view of an Ideal Cathedral"
(Reprinted from Eugene Viollet-le-Duc, *Dictionnaire Raisonne*, Vol.2, 1854).

In *Gothic Architecture and Scholasticism*, Erwin Panofsky looks at the synchronous development of architecture and scholasticism in the medieval ages to consider parallel principles of generation that originate in philosophy and literature that

[890] An biological example of this could be found in Richard Owen's conception of the vertebral archetype explained Brady, "Form and Cause in Goethe's Morphology," 265.

influence the development of the High Gothic style.[891] In his analysis of the era, Panofsky focuses on the concentration of knowledge and training in the urban monastic schools and cathedrals that develop an approach to writing that organizes literature as a system of division of whole into parts. A similar structural logic is found in Gothic vaults where the "arrangement according to a system of homologous parts and parts of parts" is most graphically expressed in the uniform division and subdivision of the whole structure."[892] Compared to the early Romanesque style organized by contrasting vaults, the ground plan of cathedrals show how this organic principle is manifested in the configurations of rib vaults that "are all triangular in ground plan and in that each of these triangles shares its sides with its neighbors."[893] Panofsky considers this to be a sign of a "principle of progressive divisibility" where each structural member is first divided from larger parts and then transformed such as "supports were divided and subdivide into main piers, major shafts, minor shafts, and still minor shafts; the tracery of windows, triforia, and blind arcades into primary, secondary, and tertiary mullions and profiles; ribs and arches into a series of moldings."[894]

The idealization of the Gothic Cathedral advocated by Viollet le-Duc was no exception to the studies of comparative anatomy that tried to establish common types to compare organizational structures of organisms in the eighteenth century. In *The Strategy of Life*, Timothy Lenoir looks at the development of biological thought during Romanticism that he terms as "Vital materialism" that considers organizing forces in

[891] Erwin Panofsky, *Gothic Architecture and Scholasticism*, Wimmer Lecture, 1948, (Latrobe, Pennsylvania: The Archabbey Press, 1951).
[892] Ibid., 45. Webster and Goodwin, *Form and Transformation*, 241.Goodwin outlines two main properties of homology: "(1) the generic or typical quality of the generative process, whose invariant features define the equivalence property of the class of structures generated (their homology); (2) its robostness, which underlies the persistence of the generated forms over a diversity of taxonomic groups." The first property draws a continuity between parts in a whole, while the latter enables a comparative study over discontinuous wholes. In this sense, the repetitive structures of the Gothic make its parts necessarily homologous to each other.
[893] Ibid., 46.
[894] Ibid., 48.

matter as "not to be conceived as some independent entity but rather as an emergent property dependent upon the specific order and arrangement of components."[895] Cuvier's Theory of Types that is based on comparative anatomy and physiological dissection presents two aspects that fit to this trend, firstly, "various orders of taxonomic division are real divisions representing different levels of generality in the organizational powers operative in nature" and secondly "organism must be viewed as a functional whole conditioned simultaneously by specifically biological laws of internal organization and the external relation of the individual to the conditions of it existence."[896] Cuvier's reduction of species as fixed types consider organisms as cut off from gradual transformational series because "*subordination of functions* and the *correlation of parts* had as a necessary consequence the rejection of the possibility of a continuous series of increasingly complex forms."[897] Lenoir considers Cuvier's types to allow for comparison among members of a species, but lacking any morphological discussion of transformation as "historical and materialist dimensions are completely absent."[898] As Goethe would argue, reducing biological phenomena to fixed types would be to abandon the overall agenda of morphology that aims to formulate laws of formal development common to all organisms.

Goethe's view of architectural morphology, particularly looking at Gothic cathedrals, could be found in two main essays that are written fifty-one years apart from each other.[899] The early essay published in 1773 titled "On German Architecture"

[895] Lenoir, *The Strategy of Life*, 9.
[896] Ibid., 63.
[897] Ibid., 64.
[898] Ibid.
[899] Susan Berstein, "Goethe's Architectonic Bildung and Buildings in Classical Weimar," in *MLN*, Vol. 114, No. 5, *Comparative Literature Issue* (Dec., 1999): 1020. Bernstein draws on differences between the two essays: "If the later essay is structured by a kind

presents an aesthetic admiration for Gothic style and shows almost a nationalist tone of defense against the architectural styles of the south that are practiced in France and Italy during that time.[900] In the text Goethe not only criticizes the adjacent stylistic developments in Europe and their inclination to imitate ancient styles through monotonous repetition, but he also praises Edwin von Steinbach, the architect of Strasbourg Cathedral, who displays a fine example of the new style of architecture, a style that contrasts the classical system of columns with a formal development of walls that shows proliferative quality akin to plant growth (Fig.3.2.2.3).

Figure 3.3.2.3 – Strasbourg Cathedral, engraving by Wenceslas Hollar.

of representational mastery, the earlier one can be characterized in terms of a certain extravagance. The late essay promotes measure or proportion, a product of the spirit, while the earlier text favors the materiality of ornamentation and detail."

[900] Goethe, *Essays on Art and Literature*, 5.

> Your buildings present mere surfaces which, the further they extend and the bolder they soar to the sky, inevitably oppress the soul with ever more unbearable monotony. Fortunately, Genius came to our aid and inspired Erwin von Steinbach, saying: Diversify the immense wall raise it toward heaven so that it soars like a towering, widespreading tree of God. With its thousands of branches and millions of twigs and as many leaves as sand by the sea, it shall proclaim to the land the glory of the Lord, its master.[901]

Compared to its classical adversaries that try to organize scattered elements through a system of proportion, Gothic architecture presents an inherent harmony between its parts that leaves a sympathetic and melancholic impression on Goethe. In his long praise for the details of Strasbourg Cathedral "that elevated the arbitrary vastness to harmonious proportions," he describes polarities between every part and detail of the cathedral: between "main portal dominating the two smaller ones on either side," the circular window "harmonizes with the nave," the polar forces "which were to raise two towers high into the air" that are surrounded by "five crowning pinnacles."[902] Contrary to the modern critiques of his time that believe fine arts to follow an anthropocentric origin, he considers the Gothic to follow natural principles of growth where all forms produced by polarity aim to find beauty in return.

> This characteristic art is in fact the only true art. If it springs from a sincere, unified, original, autonomous feeling, unconcerned, indeed unaware of anything extraneous, then it will be a living whole, whether born of course savagery or

[901] Ibid.
[902] Ibid., 6.

> cultured sensitivity. You see endless variations of this in different nations and individuals. The more the soul develops a feeling for proportion, which alone is beautiful and eternal, whose fundamental harmony we can prove but whose mysteries we can only feel, in which alone the life of the god-like genious dances to blissful melodies, and the more deeply this beauty penetrates the mind so that both seem to have originated as one and the mind can be satisfied with nothing but beauty and produces nothing but beauty – then the more fortunate is the artist, the more glorious is he, and the deeper we bow before him and worship God's anointed one.[903]

As a system of architecture, Goethe considers the Gothic to follow internal principles as he "employed to understand the laws of growth and form in organic nature, he opened up the possibility of an understanding of architecture in terms of formal development."[904] Similarly, Augustus Pugin views Gothic as a melodic and highly variable system that is suitable for English architecture. In *An Apology for the Revival of Christian Architecture,* Pugin criticizes his contemporaries' admiration for antiquity, in its "perfect expression of imperfect systems" that he condemns as a tension between Christianity and paganism.[905] He considers the Gothic to offer a multipliable and highly variable system that is suitable for practice in England, which follows similar morphological rules of architecture and does not rely on the imitation of classical building, but the creation of new styles. The frontispiece of the book intends to summarize Pugin's premise and depicts a Gothic city crowded with expressive specimens

[903] Ibid., 9.
[904] Eck, *Organicism*, 105.
[905] Augustus Welby Northmore Pugin, *An Apology for the Revival of Christian Architecture* (Edinburgh, Grand, 1895), 5.

showing different polarities. Pugin considers the Gothic style to be inherently morphological and generative, not only presenting variation of sizes of structures through expansion, but also a reconfiguring organization that can produce asymmetrical spires, segmented naves, buttress systems and variable details (Fig.3.2.2.4). This image contrasts Viollet-le-Duc's reductionist approach and presents a whole array of morphogenetic variations for the Gothic that can produce different body-limb polarities as well as rhythms of formal development.

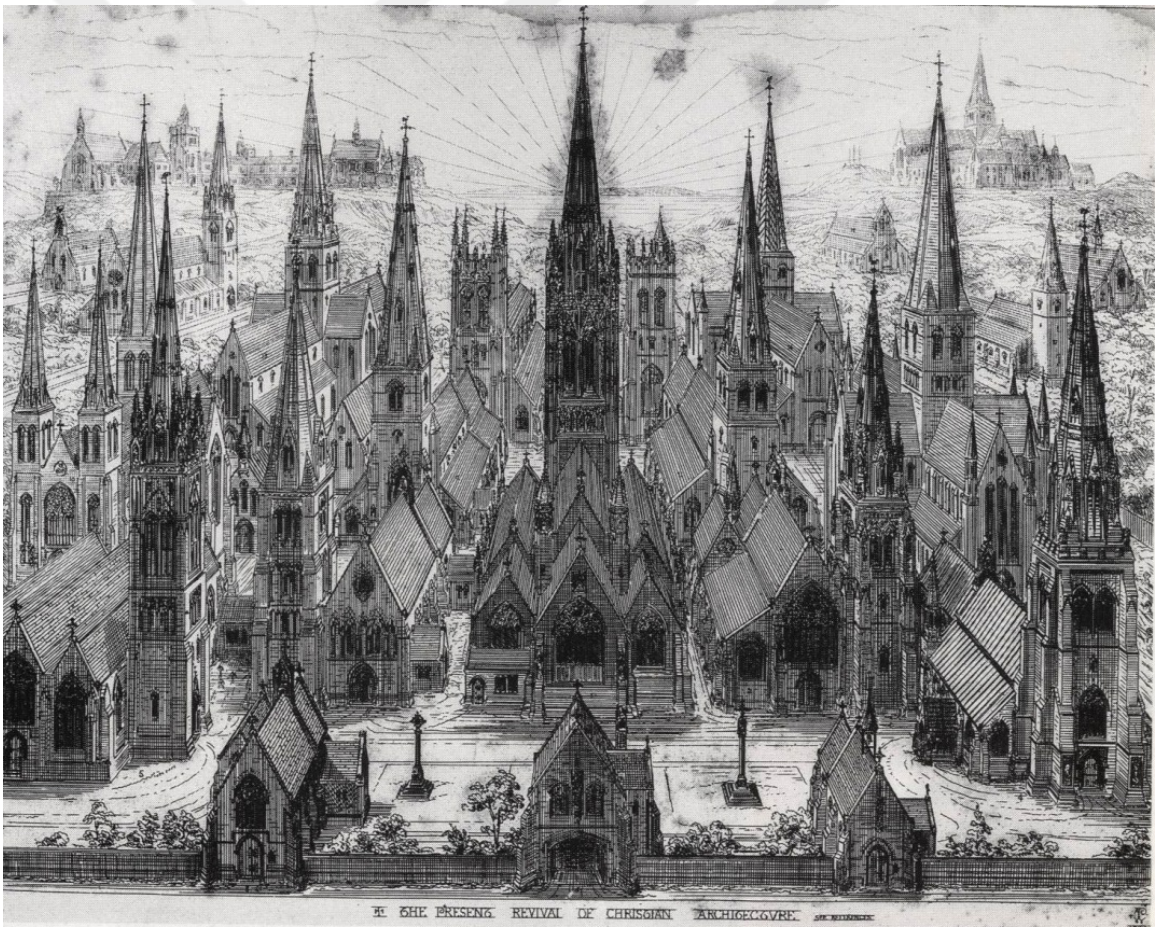

Figure 3.3.2.4 – Pugin's Frontispiece to *Apology*
(Reprinted from "The Present Revival of Christian Architecture" (1895)).

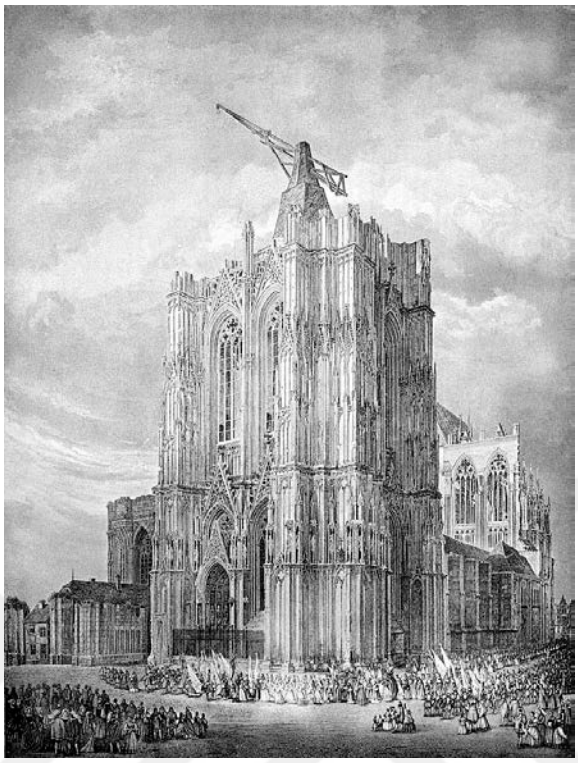

Figure 3.3.2.5 – Cologne Cathedral in 1824.

In his later essay titled “On Gothic Architecture” from 1823, Goethe defends his early appreciation of the German architectural style against the French architect François Blondel and develops an interest in the Cologne Cathedral as a structure worthy of appraisal (Fig.3.2.2.5). Although construction was begun in 1248 the Cathedral was halted in the middle of the sixteenth century. In 1818, Johann Sulpiz (1789–1854) and Melchior Boisserée (1786–1851) recovered the original plans and developed new illustrations for the complete structure. After Goethe’s essay was published, the public interest in the structure grew and the construction began again in 1842 to complete the Cathedral. Upon visiting the incomplete structure Goethe reawakens similar feelings that he encountered in his visit to Strasbourg Cathedral, that enable him to project the finished structure through intuition.

> I must admit that seeing the exterior of the Cologne Cathedral aroused a certain apprehension in me which I could not explain. A significant ruin has a venerable quality, and we sense and actually see in it the conflict between a noble work of man, and time that with silent force spares nothing. Here, on the other hand, we are confronted with an edifice which is unfinished and prodigious, and precisely its incompleteness reminds of man's insufficiency when he attempts the colossal.[906]

While Goethe praises the Cologne cathedral for its impression of growth, he shows disappointment in the renovation of the Milan Cathedral that displays contradicting aspects of formal development. In his essay on "Architecture" in 1788, he considers the detailing of Milan Cathedral to lack any principle of growth, but instead to present ornamentation in an infinitesimal treatment of multiplication that is found in the classical style (Fig.3.2.2.6).[907]

> A few people understood these petty forms as greatness in multiplied smallness; and thus such monstrosities such as the cathedral at Milan was born, where you can find a whole marble mountain with monstrous costs executed in the most miserable forms that still continues to torture the poor stones which can never be terminated by the invented nonsense, as if it was the cause of an endless plan.[908]

[906] Goethe, *Essays on Art and Literature*, 12.
[907] Goethe, *Werke*, S. BA19:72u.
[908] Ibid., S. BA19:75. Bis: S. BA19:76."Leider suchten alle nordischen Kirchenverzierer ihre Größe nur in der multiplizierten Kleinheit. Wenige verstanden diesen kleinlichen Formen unter sich ein Verhältnis zu geben; und dadurch wurden solche Ungeheuer wie der Dom zu Mailand, wo man einen ganzen Marmorberg mit ungeheuren Kosten versetzt und in die elendesten Formen gezwungen hat, ja noch täglich die armen Steine quält, um ein Werk fortzusetzen, das nie geendigt werden kann, indem der erfindungslose Unsinn, der es eingab, auch die Gewalt hatte, einen gleichsam unendlichen Plan zu bezeichnen."

Figure 3.3.2.6 – Milan Cathedral, view from the southwest (Picture by Steffen Schmitz).

The difference between the two Cathedrals is the notion of vegetal growth that permits application of polarity principles to not only the design of parts of the building, but also to their construction that can yield to unfinished yet satisfying results.[909] As Goethe states, the "modern alterations on the cathedral of Milan had changed its original character" where the classical multiplication removed any notion of growth or polarization from the structure that causes him to feel "alienated from this form of architecture."[910] While Milan Cathedral fails at achieving this principle due to its highly articulated yet triangular section that appears as apolarized with no sense of formal

[909] Berstein, "Goethe's Architectonic Bildung and Buildings in Classical Weimar," 1025.Berstein draws a similar conclusion on the aesthetic appreciation of forms of buildings where "experience itself thus becomes a kind of architectural drawing, a compulsive tracing that deepens the two dimensions of the facade into the three dimensions of a building constructed in the cognitive articulation of its interrelations-its 'plan'."
[910] Goethe, *Essays on Art and Literature* 11.

development, Goethe recalls his early impression of the Strasbourg Cathedral as one that invokes a sense of growth in continuum.

> I had been intuitively aware of the inner proportions of the whole, had grasped the natural evolvement of the ornamentations from this whole, and had concluded after lengthy and repeated observation that the single tower, although of sufficient height, was nonetheless unfinished.[911]

Compared to the classical system of imitation what Goethe proposes is a system of intuition that is primarily aesthetic and generative. When he considers "architecture as frozen music" he considers the form as the stoppage to a polarized rhythm of growth that could still leave an aesthetic impression.[912] This way his organic view differs from the rationalist approaches that restrict it to typological elements or scientific dissections for comparisons, but instead he extends his views of morphology towards architecture where temporality relates to construction, generation and aesthetic appraisal.[913]

3.3.3 Polarity and Asymmetry: Spiral Tendency in Gothic

If symmetry is pointing towards a temporal balance between polarized forces in form, what could be the cause for the same forces to take on separate expressive roles and produce asymmetry? While Goethe did not explicitly point towards this issue in his morphological writings, he came closer to highlighting the natural forces and behaviors

[911] Ibid., 14.
[912] Johann Wolfgang von Goethe and Johann Peter Eckermann, *Conversations with Goethe in the Last Years of His Life*, trans. S.M. Fuller (Boston: Hilliard, Gray and Company, 1839), 282. The full quote is: "I have found, among my papers, a leaf, in which I call architecture frozen music. There is something in the remark; the influence that flows upon from architecture is like that from music."
[913] Mücke, "Beyond the Paradigm of Representation," 20. Von Mücke also argues that Goethe's consideration of architecture as a form of art requires the application of "fiction" not for "mimesis or representation" of naturalistic forms but to invoke an "embodied aspect of the architectural experience" through the shared organic principles of growth.

in his two speculative essays on "The spiral tendency" in his botanical writings.[914] Although the spiral tendency hints at the scientifically acclaimed existence of phyllotaxic growth in plants, Goethe's aim is not on the formulaic description of how spirals occur in nature, but on the productive merging of two polarized forces that produce morphological tendencies during growth.

> We had to assume in vegetation a general spiral tendency, by means of which, in combination with a vertical force, all plant structures, all plant formations, are completed according to the law of metamorphosis.[915]

In his attempt to describe asymmetry in growth, Goethe defines the vertical tendency akin to the axial bases of animal morphology that acquires a "solidifying function" during growth and "forms the axis of every flower formation."[916] This force is active from the early germination process "that enables the plant to take root and at the same time to lift itself upward."[917] It also produces a linear elongation process that is carried from node to node and escorts spiraling vessels along. In contrast, the spiraling tendency is regarded "as the actual reproductive life principle" that is "usually relegated to the periphery of plant growth."[918] It is usually seen in terminations of formal development producing tendrils, vrilles, forks and caprioles. Spiraling tendency predominates towards reproductive phases, while the vertical erects the plant from germ. These two could be overpowering each other or could be balanced. Goethe considers the spiraling tendency to be not only responsible for the progressive development observed in most plant formation, but also "these same principles will provide a basis for judging the

[914] Goethe, *Goethe's Botanical Writings*, 128.
[915] Ibid., 129.
[916] Ibid.
[917] Ibid.
[918] Ibid.

extremely diverse misgrowths that appear as deviations from the law of definite forms."[919]

Figure 3.3.3.1 – Spiraling tendency in plants.

Figure 3.3.3.2 – Spiraling tendency in animals.

In his supplementary second essay titled "On the Spiral Tendency in Plants" Goethe extends the initial observations towards formal examples and considers the speculation on the spiral tendency as a further development to the theory of metamorphosis. He considers a diagrammatic relationship between the vertical and spiral forces that coexist in plants where the "spiral tendency entwining itself around the

[919] Ibid., 130.

vertical" producing a polarized relationship. Vertical tendency is defined as an expansive force that elongates longitudinal fibers and gives the plant its structural rigidity by keeping the branches erect and enabling extension from node to node of the plant. In contrast, the spiral system as the contractive force is the "developmental, reproductive, and nourishing element" that is "temporary and almost independent of the vertical."[920] While the two systems work closely together they are also responsible for various individual morphological expressions. Due to their polarized structural roles, vertical tendency rigidifies leaves as staff or wood, while spiral tendency softens them, producing curling forms such as windings, crooks and twists found at terminations or truncated branches where it dominates over the vertical system (Fig.3.3.3.1-2). Just like his essay on metamorphosis Goethe defines a similar alternating relationship between spiraling and vertical tendencies that can produce radial and axial plant forms.

In *Metamorphosis: Evolution in Action,* Suchantke extends Goethe's definition of polarized forces in spiral tendency towards the study of morphogenetic activities found in animal horns, snails, vertebrae and plants.[921] Similar to Goethe, Suchantke considers "the tendency for radial forms to be subject to a superordinate spherical principle" that is primarily found in the formation of horns and cranium.[922] In his second chapter he revisits the vertebral structure of the spine that he considers to follow a two-fold organization that brings together a soft contractive neural arch encased inside a structural expansive vertebral body. Their polarized relationship appears varied along the vertical axis of the spine producing a contractive head and an expansive tail in animals. Suchantke also describes two polar tendencies for the polarized development of the

[920] Ibid.
[921] Suchantke, *Metamorphosis*, 23..
[922] Ibid., 278.

vertebral body and neural arch. The first one occurs from the chest towards the head where "the vertebral body becomes ever smaller and weaker, until, in the uppermost vertebra, the atlas, it disappears altogether."[923] Towards the lower half of the spine the opposite occurs, where in the lumbar region the vertebral body expands and the neural arch contracts. Each part of the skeleton rests within the stream of two morphogenetic principles: "*axial tendency*" that "is evident most clearly in the limbs, but also in the ribs, and especially in the columnar form of the spine" and a polar opposite "*spherical tendency*" that is mostly found in the formation of cranium and ribs.[924] The two principles also show polarized development as "ossification in the neck and chest vertebrae begins in the neural *arches*, whereas in the lumbar region it begins in the vertebral *bodies*."[925] For Suchantke the strongest morphological expression of the spherical tendency is found in the formation of the cranium that appears as a contractive unification of multiple vertebrae that houses the expanded brain as "an *intensification* of the formative tendency expressed in the neural arch."[926] The two formative polarities defined by the axial and spherical tendencies are either "inwardly oriented," that is "responsible for *spherical forms with and enclosing, protective function*" or "peripherally oriented" producing axial tendencies found in limbs.[927]

In *The New Ambidextrous Universe*, Gardner considers mirror symmetry as a division mechanism for related left and right halves in organic bodies and develops ideas on asymmetry by discussing popular topics in mathematics, physics, art, music, poetry,

[923] Ibid., 22.
[924] Ibid., 23.
[925] Ibid.
[926] Ibid.
[927] Ibid., 25.

biology and chemistry.[928] In chemistry, asymmetry is mostly found in organic compounds that exhibit left or right handed behavior when subjected to reactions. Similar behavior was also discovered in magnetism, where an experiment devised with a needle and electric wire shows that when a current is flowing away from the observer along the wire, the needle always turns left, in a perpendicular direction to the wire, thus conforming to one-sided behavior. Certain organic compounds or experiments also produce asymmetrical and deterministic results, choosing either the left or right side of the symmetry axis just like molecules. In plants the spiraling helical growth "cannot be superposed on its mirror image" displaying a right or left handed behavior.[929] This causes similar handed plants to coil around each other as opposites end up entangled. While in the plant kingdom the spiral is singular, in the animal kingdom it appears in a double fashion producing bilateral symmetry. When there is polarization between opposite halves then asymmetry is observed. Most interesting cases are provided by shells of snails and mollusks that produce both symmetrical and asymmetrical-spiraling forms. In animals, asymmetry is not found on the body but on the appendages that are attached to the body. For instance, fiddler crabs display asymmetrical limb development whereas the wry-billed plover of New Zeland shows a twisting beak. In the flatfish the young forms display symmetrical eye placement, while at the adult stage "one eye slowly migrates around over the top of the head until both eyes are on the same side."[930] The anableps show asymmetry in their sexual reproduction by employing a sinistral or dextral sexual organ in both male and female animals. Animal tusks also show asymmetry in their development as in the case of elephants and walrus. In the narwhal asymmetry manifests

[928] Gardner, *The New Ambidextrous Universe.*
[929] Ibid., 54.
[930] Ibid., 68.

as an extreme single tusk. In rare occasions both teeth could grow, but the tusks "invariably coil in the same left-handed way!"[931]

While asymmetry is one of the most popular topics of interest in the sciences, unfortunately it is one of the most underdeveloped or least revisited principles in architecture. While Gothic architecture presents cases of asymmetries among its various parts, scholars mostly use either comparative or chronological methods to discuss similarities or differences in the design, development and construction of cathedrals. An example of the comparative method is given in Paul Frankl's *Gothic Architecture* that explores the stylistic development of Gothic forms from earlier Romanesque churches that utilized arches, colonnades, vaults and buttresses.[932] Frankl argues that the Gothic formal system is based on the "the principle of vertical movement" that is developed "from the rib, and although aesthetic effect is of upward movement, historically it grew downwards from the apex."[933] He contrasts the horizontally organized English Cathedrals versus the vertical French ones that mark two approaches in early Gothic that were later united under late Gothic structures. He traces the early morphological trends by comparing Laon [1155–1230] and Noyon [1150–1290] Cathedrals that share similar four-storeyed choir and quadripartite vaults where the "systematic arrangement of the shafts to correspond to their respective ribs is common to both cathedrals."[934] Among the two, Frankl considers Laon Cathedral to follow a "picturesque" approach towards producing a "multiplicity of images" that is present in the towers and the polygonal apse that removes "the discrepancy between the curved window surrounds and the flat surface of the glass"

[931] Ibid., 69.
[932] Frankl, *Gothic Architecture.*
[933] Ibid., 83.
[934] Ibid., 76.

(Figs.3.3.3.3-4).[935] Historically, the apse has always been semicircular and is found in preceding styles to the Gothic, such as Byzantine and Romanesque. The apse brings two properties to the cathedral body that change the linear order and repetition of shafts to a radial symmetry, and acts as a termination of space and growth. In Noyon this radial order brings a termination not only at the end of the choir, but also along the transepts that rise to the height of the cathedral with small buttresses (Fig.3.3.3.5-6). Frankl writes that the cathedral "is characterized as much by its wealth of forms as by its lack of preoccupation with economy of materials or labour" as it reconfigures "multitude shaft-rings" into "monolithic sections."[936]

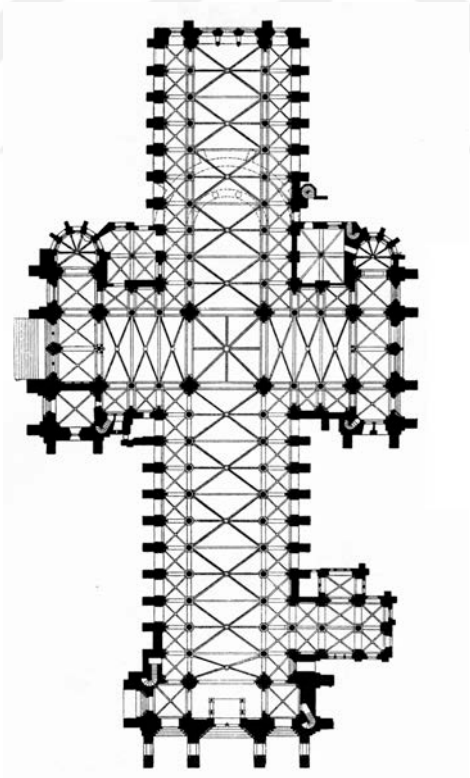

Figure 3.3.3.3 – Plan of Laon Cathedral.

[935] Ibid., 75
[936] Ibid., 72.

Figure 3.3.3.4 – View of Laon Cathedral showing expansive tendencies. Transepts are terminated with spires as well as the contractive ambulatory is replaced with expansive choir.

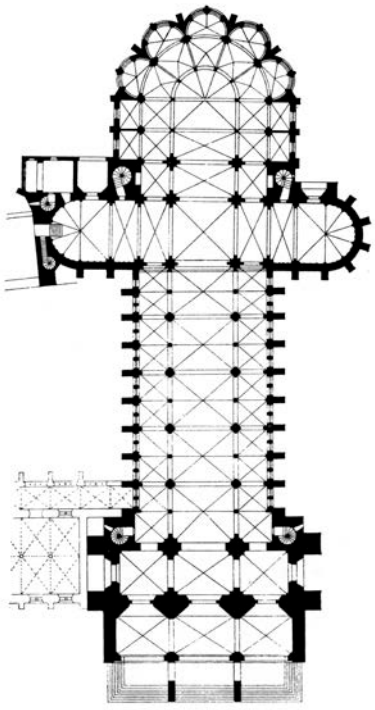

Figure 3.3.3.5 – Plan of Noyon Cathedral.

Figure 3.3.3.6 – Aerial view of Noyon Cathedral showing contractive transepts with contracted apses (Picture by Caroline Fontana).

While comparative and chronological methods offer stylistic parities between Gothic structures, there hasn't been any consensus among scholars on the morphological tendencies exhibited in Cathedral bodies that can produce both radial and bilateral symmetric forms and the asymmetries in between. Jean Bony outlines these two main contrasting tendencies as verticality and horizontality that are embraced by Parisian and Northern Gothic. [937] The latter tends towards more vertically expanded volumes and a "marked preference for compact plans, in the Northern group for articulated cruciform plans" that appear more expanded on the ground.[938] Bony also discusses the mass of the structural elements as a driving factor for this polarity where the "spatial concept at Chartres is based on the elementary contrast between a tall central nave and lower spreading aisles."[939] The vertical tendency in the Gothic tends to produce lighter structure

[937] Jean Bony, *French Gotic architecture of the 12th. and 13th. Centuries* (Berkeley : University of California, 1983).
[938] Ibid., 131.
[939] Ibid., 221

whereas shorter parts act mainly as support with their load bearing capacity.[940] While he doesn't discuss the asymmetry of the spires, similar polarity concepts could be expanded to consider the north spire as expanded, taller and lighter and the south spire as contracted, shorter and heavier components of the narthex that still provide a structural equilibrium (Fig.3.3.2.1).

The polarity between Noyon and Laon Cathedrals could be better understood not through a comparative study of their stylistic details, but by discussing their morphologies that exhibit radial and linear symmetries (Figs.3.3.3-6). In Laon, the appendages are highly proliferative and produce expansive spires as the axial vertical development. In contrast the limbs of Noyon are terminated with radial ambulatories that prohibit the formation of towers or entrances through the transepts. Interestingly, in Laon, the expansion is so dominant that the chancel is terminated without an ambulatory thus lacking the radial, spiraling tendency in its morphology. However, the polygonal apse still shows two contractive spires that are reduced drastically in size compared to the towers sprouting at the end of the transepts and nave. While the spiral tendency is missing in the planar development of Laon cathedral, this tendency reoccurs in the termination of the spires that show a radial distribution of tabernacles.[941] In Noyon, the towers lack the spiral tendency as they are terminated with a square pyramid and four pinnacles; however, the ambulatory shows an excessive development of radial symmetry akin to Ground Ivy leaf.

[940] Ibid., 256. Bony develops this remark by looking at the vertical section of Chartres Cathedral that shows a reduction in material as the structure gets taller: "Chartres type of elevation becomes extremely light in its structure, the piers being reduced to a tall column, often with the addition on the nave side of a single shaft, to mark by that vertical accent the division of bays and sometimes without any shaft at all."

[941] Ibid., 134. Bony discusses symmetry among the transepts, nave and choir for this termination where the transepts could either mimic the expansive nave or contractive choir. "In the most perfect Gothic form it meant that each transept had not only a semi-circular termination but was further surrounded by an ambulatory like the choir itself, and all three were given the same depth." Frankl, *Gothic Architecture*, 91.

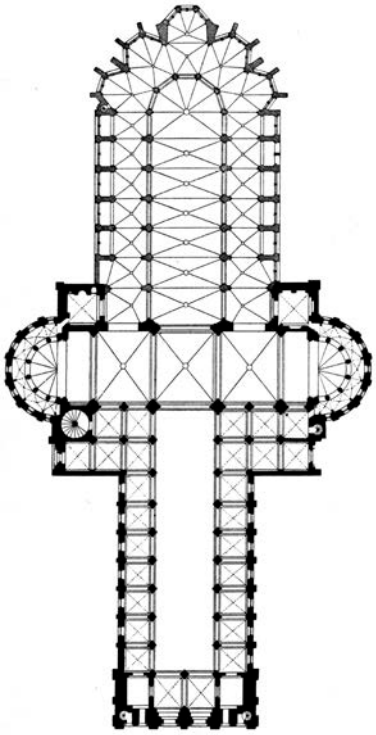

Figure 3.3.3.7 – Aerial view of Tournai Cathedral showing transepts with both spiraling and axial tendencies.

Figure 3.3.3.8 – Aerial view of Tournai Cathedral showing transepts with both spiraling and axial tendencies.

The spiral and axial tendencies also show hybrid formations among early cathedrals. In Tournai the limbs exhibit both expansive and contractive tendencies producing spires on both sides of the transepts that are terminated with radial ambulatories (Figs.3.3.3.7-8). Tournai also shows polarity to the Laon, where the termination of the nave of the former shows similar organization to the polygonal apse of the latter with contracted spires. While most cathedral plans display symmetrical organization along transepts, the two polar tendencies can also produce asymmetry among transepts, narthexes and ambulatories. In Soissons such polarity is distributed among transepts that magnetically oppose the expansive narthex with contractive apses producing asymmetry in plan and in elevation between the spires of the nave (Figs.3.3.39-10).

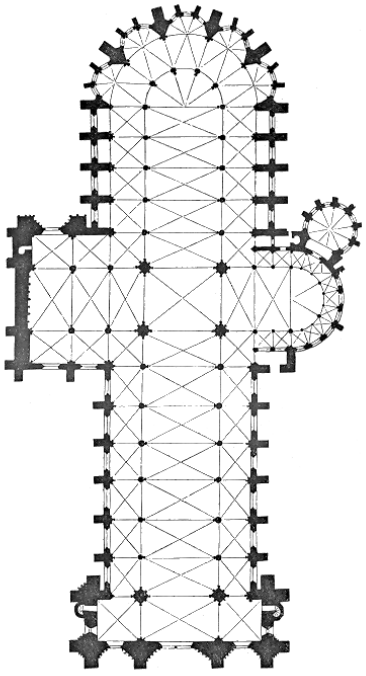

Figure 3.3.3.9 – Plan of Soissons Cathedral.

Figure 3.3.3.10 – View of Soissons Cathedral.

In Gothic morphology the polarized radial and axial tendencies show similar properties to plant morphology. The link could be made between the *spiral tendency* of the ambulatory and the calyx or petals of a flower that both mark the termination of growth in architectural and plant morphology respectively. In contrast, the *axial tendency* manifests itself mostly along the proliferative subdivision of the nave that develops buttresses and pinnacles and the spires that project vertically from narthex. In this sense, the Gothic morphology shows kinship to plant morphology while combining axial and radial tendencies in its formal development.

3.3.4 Polarity and Body-Limb Duality II

Among historical works of architecture, the expansive aspects of architectural morphology are often found in the vertical development of buildings.[942] While the plans can also display vegetative qualities with highly proliferative wings, these structures mostly develop towards the sky with characteristic stylistic elements and ornaments. Examples of these elements could be found in Victorian Manor houses and Gothic Cathedrals that establish various polar relationships between massing elements such as spires, roofs, gables, buttresses or chimneys. While the manor houses are often found in open landscapes, the Cathedrals could be positioned within cities that restrict their planar development.[943] However, this limitation often gives an impetus for vertical development to enable visibility of the structure throughout the city. Between the two styles, the main difference is found in size with cathedrals showing expansive and houses showing contractive tendencies. These aspects will be explored by comparing six case studies among each style to discuss various polarities between architectural bodies and limbs.

3.3.4.1 Polarity and English Manor Houses

Most English Manor houses rely on an organic notion of growth in planar development following a sedentary cottage model where the owner of the house progressively expands the space by adding wings to the main house.[944] This often results in asymmetrical development where the stables, guesthouses or agricultural programs of the main house

[942] Goethe attributes this vegetative aspect of vertical development mostly to Gothic architecture in his essay titled "On German Architecture" published in 1773 where he considers Strasbourg Cathedral like a "tree of God." Goethe, *Essays on art and literature*, 5.
[943] Spuybroek draws a contrast between the English and French Gothic, the former showing expansive development in open landscape whereas the French is more contracted due to being squeezed within the urban context. Lars Spuybroek, *The sympathy of things : Ruskin and the ecology of design***,** (Rotterdam : V2_Publishing : NAi Publishing, 2011), 63.
[944] Ibid., 220-221. Spuybroek uses the cottage as a model for picturesque growth to discuss how the farmer could expand his house via progressively adding rooms the initial house structure.

are attached at the end of a lateral axis (Fig.3.3.4.1). Among the chosen precedents, symmetry plays a major role in establishing a balanced development in plan whereas the vertical development shows various morphological expressions with gable roofs, chimneys and pediments. In the Swakeley house, the planar development follows a balanced distribution between the two orthogonal projections in opposite directions where the torso is terminated with contractive bay windows that show a development akin to ground ivy leaves (Figs.3.3.4.2). During the planar development, each bay simply bulges outwards by recursively breaking the orthogonal edge of the room expanding the window surface for views and sunlight. While the contractive planar development remains symmetrical, in expansion each wing gets a different expression with the shape and size of chimneys that articulate the proportions and asymmetry of the massing.

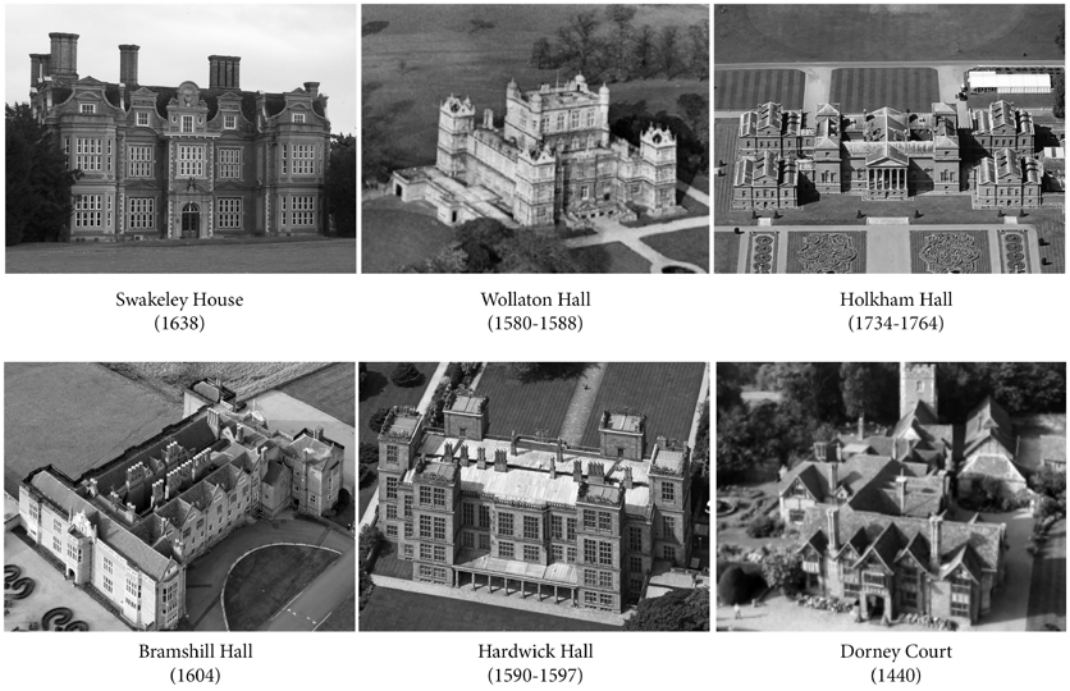

Figure 3.3.4.1 – Six English manor houses for body-limb analysis.

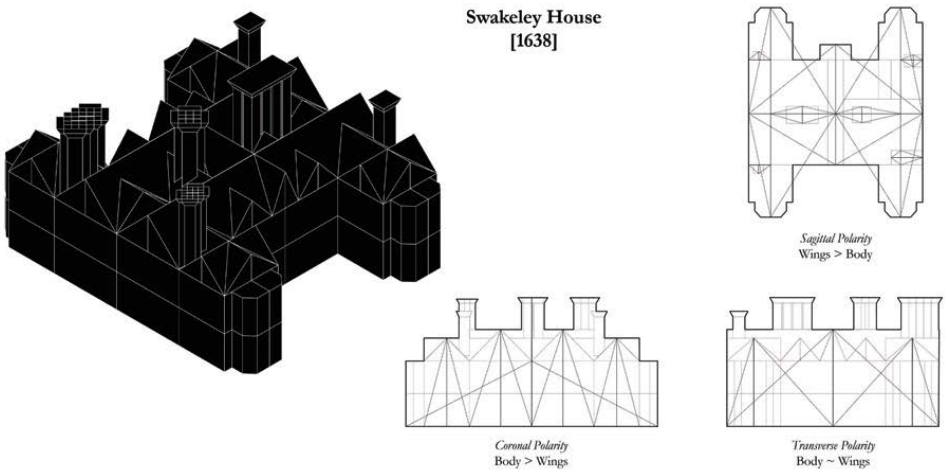

Figure 3.3.4.2 – Body-Limb polarity diagram of Swakeley House (1638) showing expansive wings with rounded bay windows attached to a contractive torso with expansive chimneys and gable windows

Compared to Swakeley, Wollaton Hall shows a more expanded torso with vertically projecting spires (Figs.3.3.4.3). The main feature of the building is the contractive spires located at the corners of both levels of massing. While the contractive plan of Wollaton remains underdeveloped, the vertical articulation of spires, ornaments, domes and pediments complement the polarity of the massing by differentiating separate parts. A more expanded version of this quadruple development could be found in Holkham Hall where the contracted vertical development is compensated with the horizontal expansion of wings (Figs.3.3.4.4). Here the house shows a development already exhibited in Wollaton Hall with four spires terminating the torso at each corner. These contractive structures are connected to four expansive wings that undergo similar polarized development with the polarity switching from the corner spires to the central halls that expand higher than the surrounding rooms in each pavilion structure. This English Palladian style house outlines certain morphological tendencies for the manor houses where the torso is often terminated with contractive structures at each corner that

could further expand into wings. In Bramshill Hall, the torso remains highly proliferative compared to a Gothic nave, however it is still terminated with contractive structures at each corner (Figs. 3.3.4.5). In this house, the wings have completely disappeared to favor an expanded torso that shows a polarized relationship between the main house and attached structures.

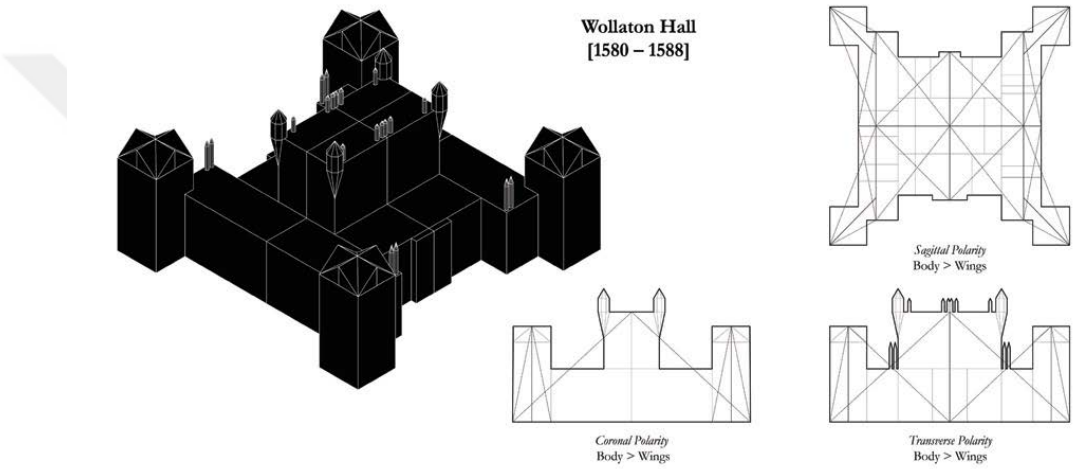

Figure 3.3.4.3 – Body-limb polarity diagram of Wollaton Hall (1580-1588) showing a contractive torso with contractive wings that are vertically expanded.

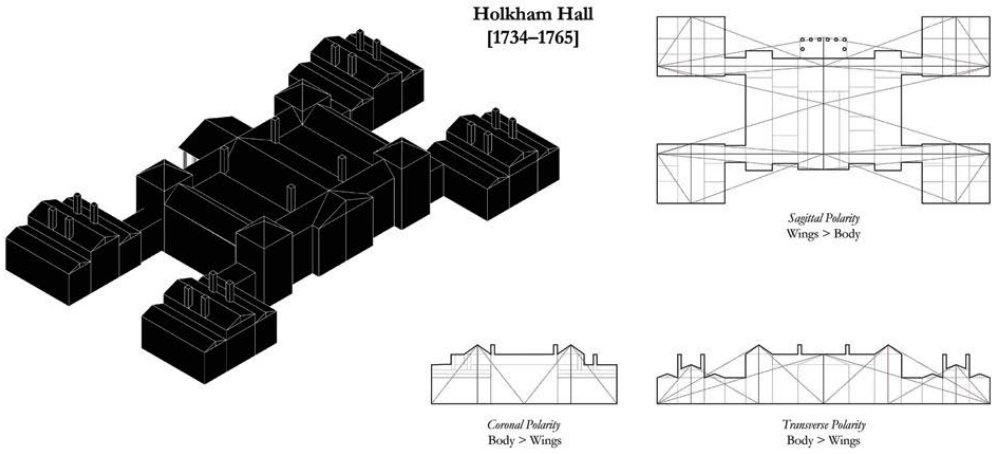

Figure 3.3.4.4 – Body-limb polarity diagram of Holkham Hall (1734-1764) showing symmetrical expansive wings attached to an expanded torso with expansive chimneys.

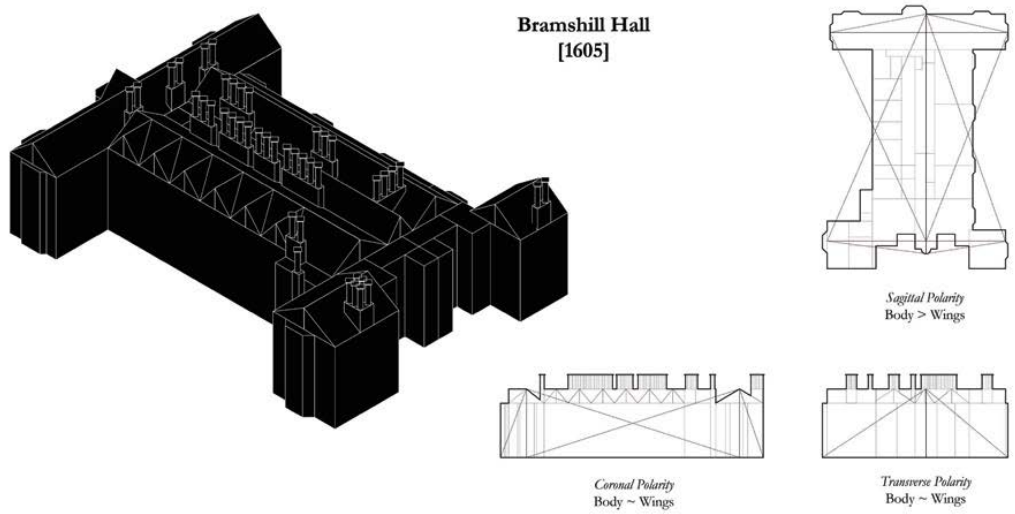

Figure 3.3.4.5 – Body-limb polarity diagram of Bramshill Hall (1604) showing contractive wings attached to an expanded torso with expansive chimneys and gables.

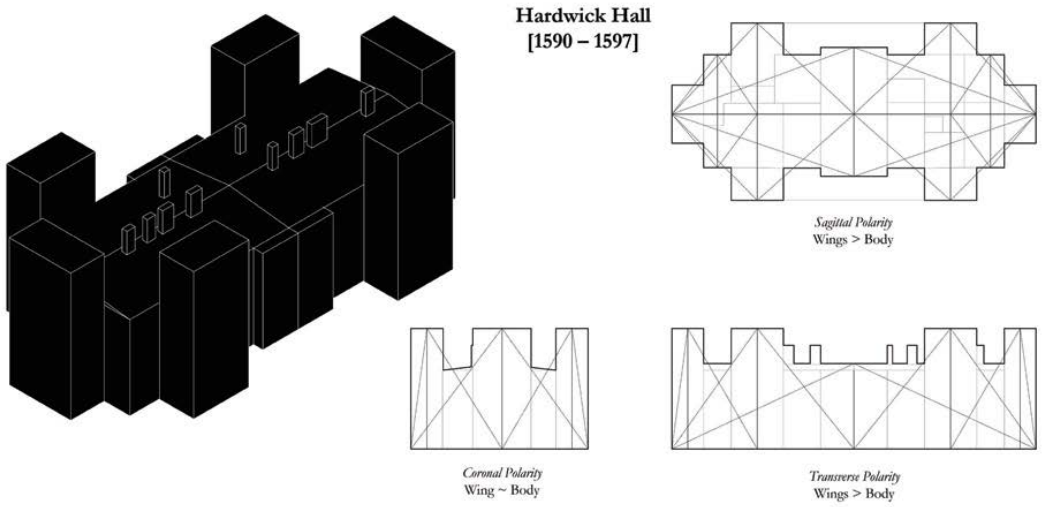

Figure 3.3.4.6 – Body-limb polarity diagram of Hardwick Hall (1590-1597) showing a contractive torso with vertically expanded wings and chimneys.

When the wings of the house remain contractive or underdeveloped they can often partake in the morphological development of the torso. In Hardwick Hall the contractive lateral wings resemble the four spires of the torso where the lack of horizontal

development is compensated with the vertical projection of spires and chimneys (Figs.3.3.4.6). In this sense Hardwick Hall is polarized to Bramshill Hall, where the former expresses an over extended torso with completely disappeared wings, whereas in Bramshill the torso contracts to produce two vertical wings that remain underdeveloped in plan, however partake on the vertical expression of spires.

Asymmetry in wing development could also be found in many English Manor houses. In Dorney Court a single over expanded wing forms alongside a contracted house where the spiraling motion of the wing results in anastomosed structures (Figs.3.3.4.7). Here the progressive addition of the cottage model follows certain morphological principles where each lateral segment is superseded with an orthogonal one resulting in a recursive spiraling motion in plan. Dorney Court also expresses polarization in its vertical development with its expressive roof structure and chimneys that project from each expanded space also yielding to asymmetrical expressions in massing.

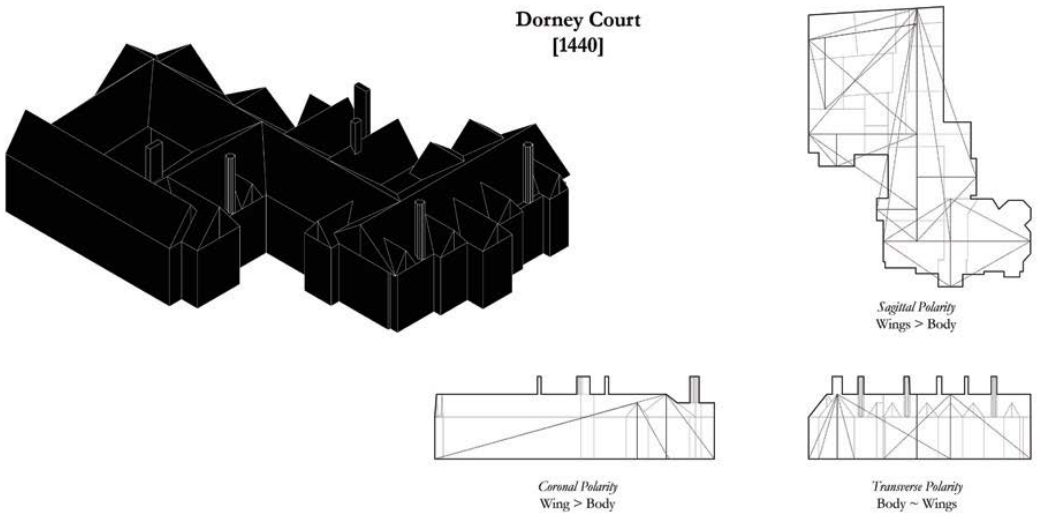

Figure 3.3.4.7 – Body-limb polarity diagram of Dorney Court (1440) showing a single highly expansive wing attached to a contractive house with expansive chimneys.

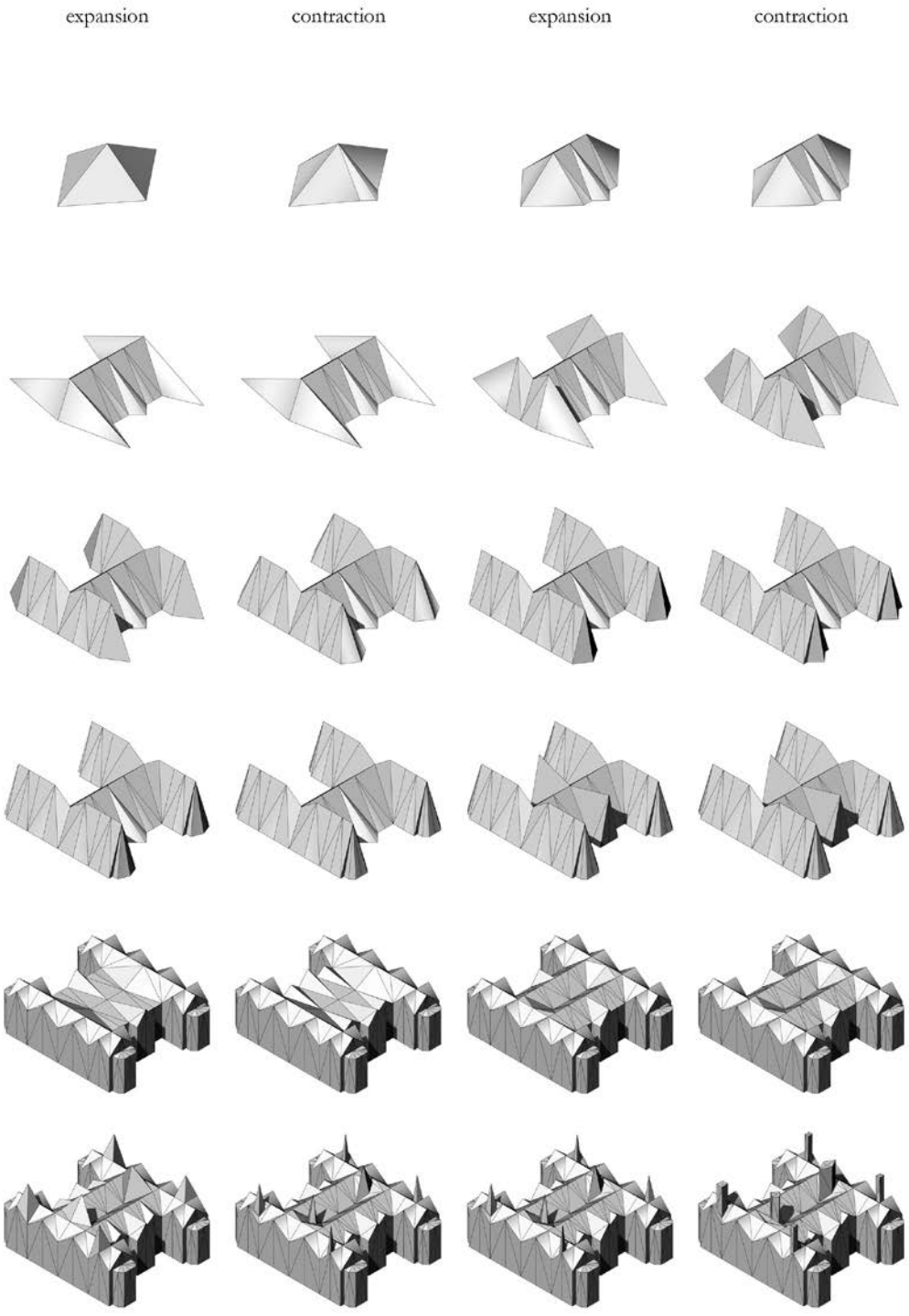

Figure 3.3.4.8 – Polarized development of Swakeley House (1638) showing recursive breaking of the main house that is then expanded vertically into gabled roofs and chimneys.

These selected case studies show that polarity could be found in both vertical and planar development of manor house structures. In plan, polarity relates torso to wings, where the former is often terminated with spires on all four corners that can further produce wings. When the wings are not formed, the torso often expresses some contractive termination using bay windows or spires. This could be visualized by looking at the polarized development of Swakeley house (Fig.3.3.4.8). During contraction, the torso recursively breaks into the required amount of rooms before being terminated with bay windows in the last steps. With expansion, each broken space is lifted upward to undergo further polarized development distributing expanded chimneys and contracted gable roofs.

3.3.4.2 Polarity and Gothic

Among the chosen historic precedents perhaps the Gothic shows the most expansive development displaying highly proliferative geometry. Although most of the cathedral structures exhibit symmetrical distribution of wings and spires along vegetative torso, due to its organic means of construction, the Gothic structures often exhibit various local asymmetries between buttresses, spires and wings (Fig.3.3.4.9). The first example of this could be found in Chartres Cathedral (1145–1220) where the two spires undergo polarized development located on the west end (Figs.3.3.4.10). The contractive south spire and the expansive north one both show polarity in their development with the former stacking six long segments to the tower whereas the latter stays with five and remains shorter. However, the contraction of the spires does not mean apolarization in terms of ornamentation as both spires still display highly articulated geometry with each

level yielding to various radial distributions of pinnacles until the towers are terminated with octagonal pyramids.

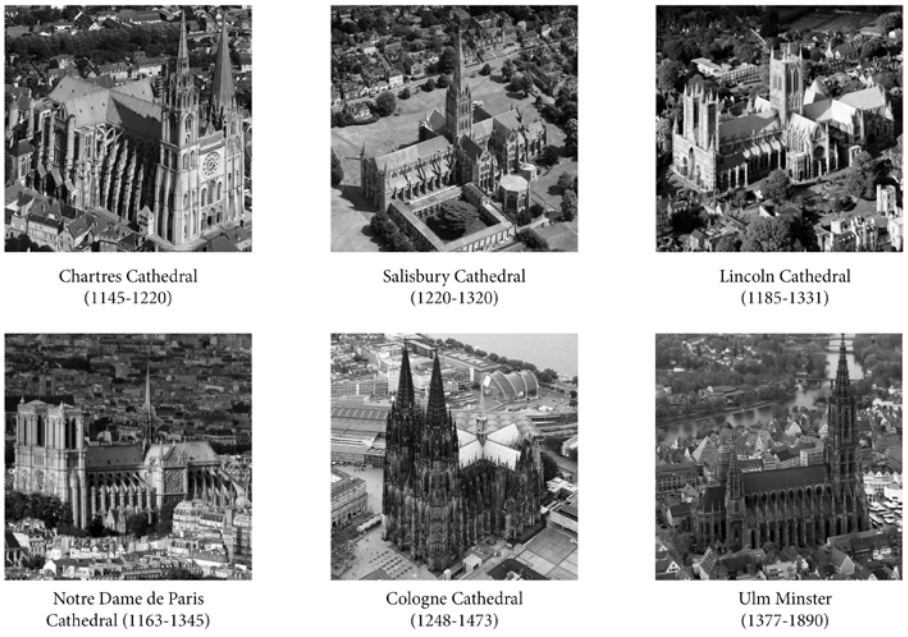

Figure 3.3.4.9 – Gothic Cathedral selected for body-limb analysis.

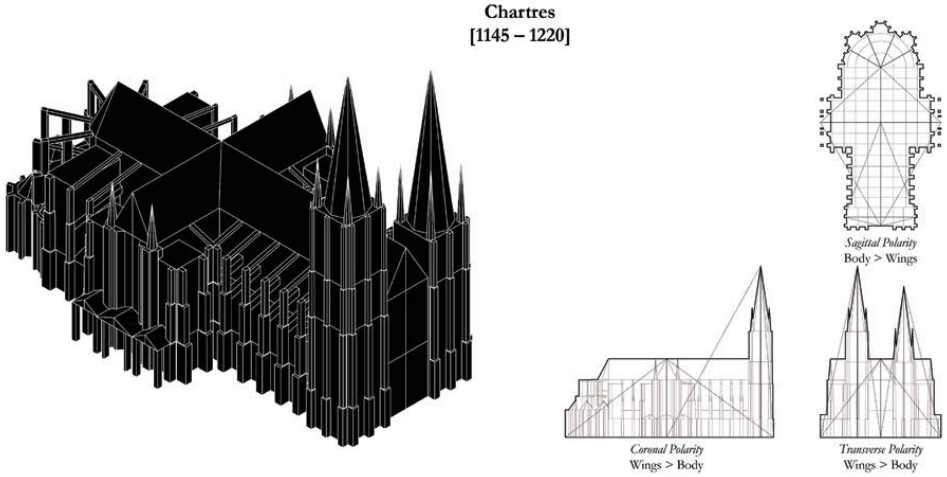

Figure 3.3.4.10 – Body-limb polarity diagram of Chartres Cathedral (1145-1220) showing expansive wings attached to an expansive torso with expansive asymmetrical spires.

In Gothic morphology, the massing evolves primarily along a vegetative torso that can laterally produce wings that are often terminated with spires. Additional spires could also form vertically at the joints where the limbs are attached to the torso. An example of this could be found in Salisbury Cathedral (1220-1320) where the wings are doubled contrasting the most common cross organization of cathedral plans (Figs.3.3.4.11). Due to the expansive spire at the first intersection of the wings, the spires at the end of the torso and wings remain fully contracted and underdeveloped. Furthermore, the ambulatory space also remains expansive lacking radial movement. In this sense, all the contractive forces of the cathedral are concentrated mostly on the single projecting spire, whereas the limbs and torso remain highly expansive and proliferative. Even though there are spires located at the ends of the torso and wings, they remain extremely small lacking further differentiation and polar development.

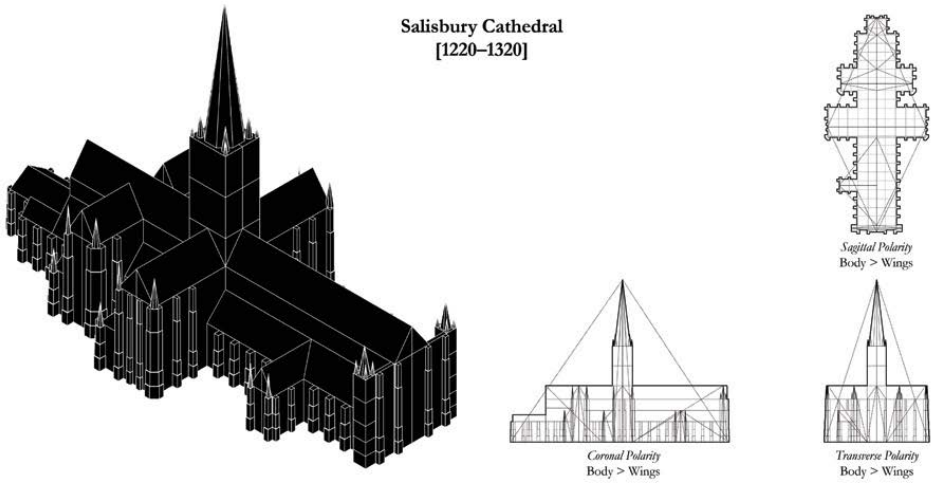

Figure 3.3.4.11 – Body-limb polarity diagram of Salisbury Cathedral (1220-1320) showing double wings attached to torso with expansive ambulatory and contracted spires located at the end of torso and limbs.

Similar to the double cross scheme of Salisbury, in Lincoln Cathedral the torso is expanded with two lateral wings and an orthogonal ambulatory (Figs.3.3.4.12). What differs mainly from Salisbury is that the tower at the transept is less expanded to enable the addition of two spires at the end of the torso to mark a contractive point of termination. In this sense the towers present a polarity to the torso where their vertical expansion is compensated with the lateral expansion of the wings that remain shorter compared to Baroque palaces.

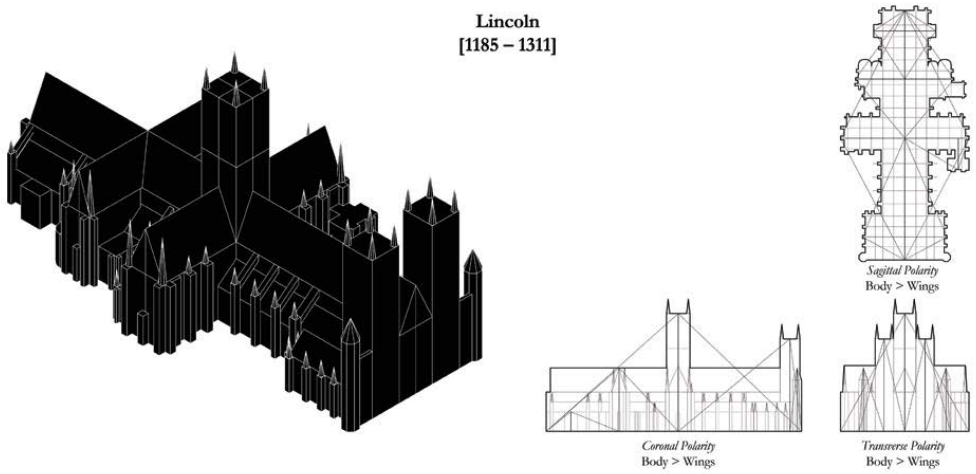

Figure 3.3.4.12 – Body-limb polarity diagram of Lincoln Cathedral (1185-1331) showing no wings attached to an expansive torso with a single expansive spire. A dual symmetrical spire is attached on the other side of the torso before the contractive ambulatory space.

In Notre Dame de Paris (1163-1345) the cathedral shows contractive tendencies (Figs.3.3.4.13). Since this cathedral is located within the city center, the surrounding structures render the development of transepts impossible, and they remain contractive or more closely attached to the torso. While the spire at the transept is less expanded compared to Salisbury and Lincoln, the development of the spires located at the entrance marks an expansive trait for this structure. Since the wings of the cathedral are

contracted, the vertical expansion of the spires at the entrance establishes a polarity for the cathedral. This is also found with the contractive ambulatory that shows a radial development towards the torso limiting growth of the structure in the opposite direction of its axis. In Cologne Cathedral a similar morphological development is evident with more expanded transepts and spires (Figs.3.3.4.14). In this structure the spire at the transept and the ambulatory remain more contractive compared to Notre Dame de Paris. The overall massing shows overdeveloped twin spires that show recursive stacking of levels and polarity breaking of parts. Along the spires the radial tendency distributes pinnacles at each level before they are terminated with the octagonal roof structure.

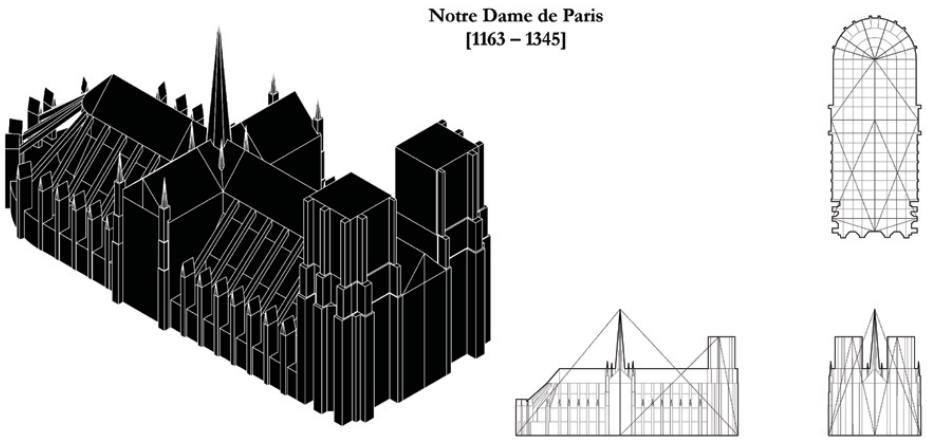

Figure 3.3.4.13 –Body-limb polarity diagram of Notre Dame de Paris Cathedral (1163-1345) showing contracted wings attached to an expansive torso with expansive symmetrical spires.

In the Gothic, the spire forming at the intersection of the transept could also be located at the end of the structure. An example of this could be found in the Ulm Minster (1377-1890) that shows a less developed torso bounded by a transept and ambulatory at both ends (Figs. 3.3.4.15). In this structure polarity organizes the plan in three main

segments with an expansive torso and two contractive appendages located at both ends. One of these results with the highly articulated and vertically expanded spire, whereas the other ones remain more contractive with the radially symmetric ambulatory space located in between two contracted spires. This shows that the lack of wings in this structure is compensated with an expansive torso and spire where the spiraling tendency predominates.

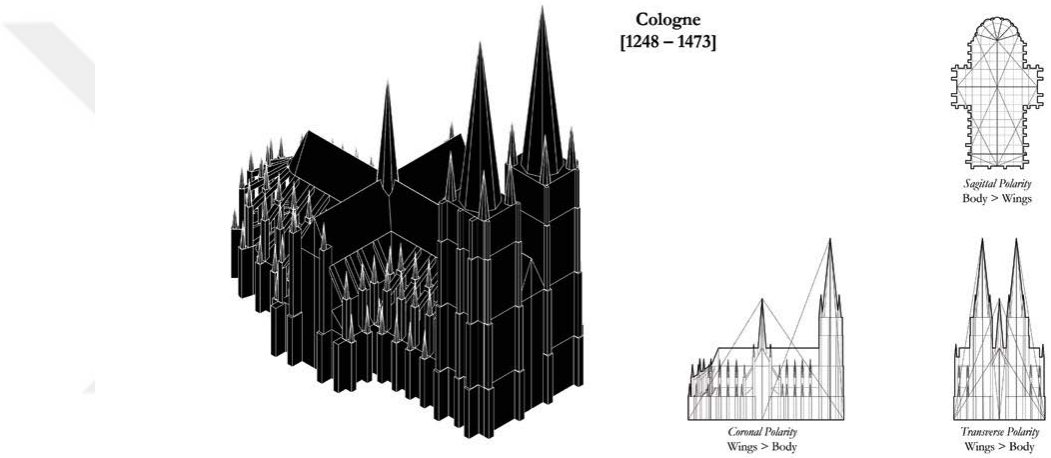

Figure 3.3.4.14 – Body-limb polarity diagram of Cologne Cathedral (1248-1473) showing expansive wings and spires attached to a highly proliferative torso.

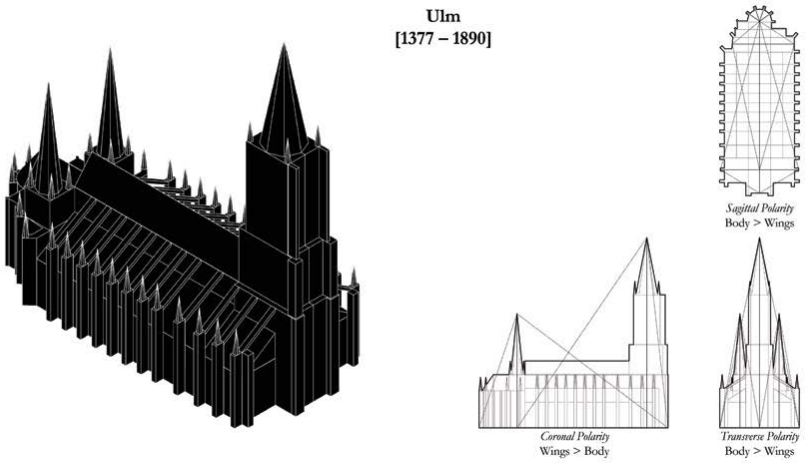

Figure 3.3.4.15 – Body-limb polarity diagram of Ulm Minster (1377-1890) showing no wings attached to an expansive torso with a single expansive spire.

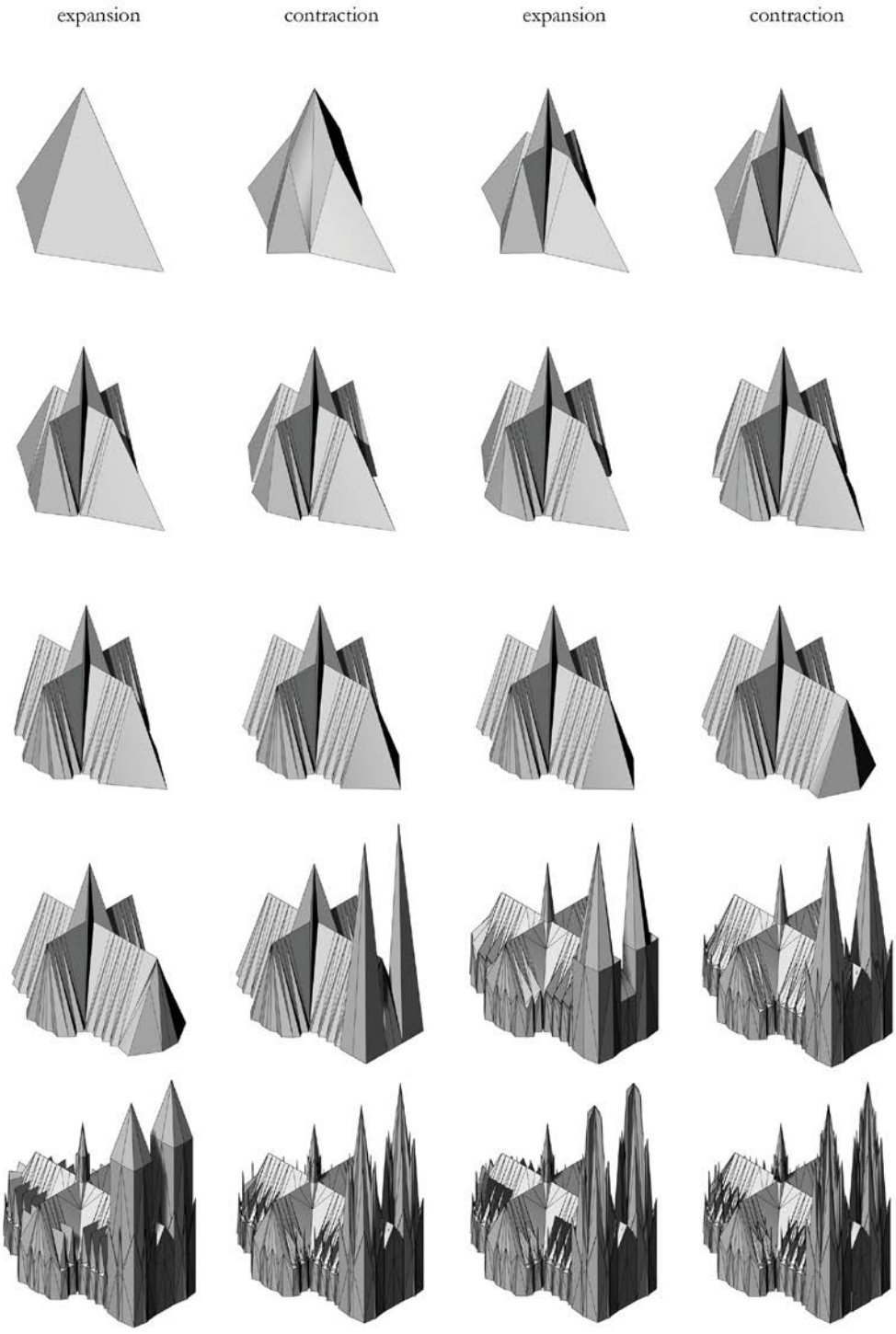

Figure 3.3.4.16 – Polarized development of Cologne Cathedral (1248-1473) showing polarity breaking of the *Urhütte* to produce quadruple limbs that are then expanded vertically into pinnacles and roof.

The Gothic case studies show that the torso remains mainly expansive and requires contractive termination at both of its ends that is provided by spires, ambulatory and façade walls. Most of the elements such as pinnacles, spires, roofs, and buttresses partake in the activity of polarized breaking of the massing. Here pinnacles and buttresses emerge when the initial roof structure contracts. Similar tendency is also found in the development of spires that recursively add segments before being terminated with polygonal roofs that resemble an expanded pinnacle. These tendencies could be visualized by looking at the morphological development of Cologne Cathedral that shows excessive articulation in both planar and vertical development (Fig.3.3.4.16). In this example the primitive hut first recursively breaks towards tips before adding the spire and ambulatory. These structures then shoot vertically and produce pinnacles and buttresses through contraction. After each sequence the resulting outline moves towards the tip of the local hut continually breaking the massing through polarity. In Cologne the development of plan shows kinship to a palm leaf whereas the segmentation between the spires and the torso produces a discontinuity in vertical development.

3.4 Goethean Architecture II: Polarized Morphogenesis

In this section the concept of polarity will be extended towards Gothic architecture to develop analytical diagrams and formal studies to develop the rules of its morphological development. This approach will expand on the principles extracted from the analysis of historical styles while focusing more specifically on the growth of architectural bodies to determine morphological tendencies that are analogous to leaf sequences. As an alternative form of Goethean architecture that aims to combine polarity and *Urhütte*, this approach will contrast Steiner's Anthroposophical style of design that is primarily

restricted to contractive-smooth bodies. To achieve this, a notion of polarized growth based on the symmetrical structure of *Urhütte* will be established that is divided among planar (animal) and vertical (plant) development of massing. Prior to developing rules of expansion and contraction for *Urhütte*, an axial basis of architectural morphology will be presented by looking at some of the early works of Gothic architecture. These examples will be used to define antagonistic tendencies in the morphological development of the Gothic that primarily express the termination of its formal growth. After establishing core principles of morphology, Gothic architecture will be explored through its parts by dividing its anatomy into expansive and contractive segments capable of metamorphosis. This will be used to develop a configurable notion of polarity to develop abstract forms that are comparable to selected Gothic precedents as well as mutant designs that showcase various formal tendencies. The overall discussion will neither use stylistic elements nor historic-cultural arguments, but instead will solely focus on technical dimensions of architectural morphology to discuss form through abstract geometric terms and basic formal principles of growth.

3.4.1 Gothic Anatomy

Among various historical works of architecture, the Gothic body perhaps displays the most proliferative application of animal body organized through a cross body plan due to its association of space to its ritualistic program.[945] This cross scheme gives the Gothic a primarily bilateral body plan that also establishes an overall plane of symmetry effecting how the parts of the form will be constructed. For instance, the chronology of Chartres Cathedral presents two contrasting theories among architectural historians that still yields

[945] Fingesten, "Topographical and Anatomical Aspects of the Gothic Cathedral," 13.

to an overall east-west orientation for its formal development placing the construction of the nave prior to the choir.[946] Similar to Chartres, Bourges Cathedral also embraces such axial development; however, its predominant torso shows no distinctive lateral transepts. Jean Bony describes such polarity between the two cathedrals, where the former shows a contractive torso with fully aligned choir and nave as an "extreme of nonarticulation", whereas Chartres shows a "clearly articulated plan composed of well differentiated elements" where a polarity between contractive nave and transepts is complemented with an expansive choir.[947] Seen in this manner, the Gothic body presents major segmentation and differentiation along its main axis that results in three main parts: the narthex occupying the main entrance and the towers, the nave that often establishes a cross plan with transepts and aisles, and the choir that often terminates the massing with the radial symmetry of an apse (Fig.3.4.1.1). These systems strikingly align with the morphological organization of the animal body that is also organized by three systems: sensory head, locomotive torso and reproductive organs.[948] In architecture, the three systems could be associated with various typological and programmatic roles.[949] Spires as contractive expansion have influenced the development of skyscrapers and vertical programs such as hotels, offices and housing. Apses as contractive contraction yield to more theatrical programs that require radial symmetry in form such as stadiums, operas and spaces of

[946] Frankl, "The Chronology of Chartres Cathedral."
[947] Bony, *French Gothic Architecture*, 201. Bony also describes such contrast between Notre-dame and Laon Cathedrals, the former showing contractive and the latter expansive tendencies. A similar morphological comparison of could be found in Spuybroek, *The Sympathy of Things*, 63. Spuybroek compares the "elongated morphology" of Salisbury with the "fat volume" of Bourges.
[948] Goethe, *Scientific Studies*, 119. Goethe describes the tripartite organization of animals and insects as an axial system in his morphological writings on the archetype.
[949] A typological and proportional discussion of architectural morphology could be found in Alejandro Zaera Polo, "The Politics of the Envelope: A Political Critique of Materialism," Volume 17 (2008): 76-105. Zaera Polo considers four types of buildings that are associated to various programs that pose a limitation on architectural morphology. These are defined as flat-horizontal, flat-vertical, spherical and vertical and variation is based on the proportional relationships of their volumes and given requirements of the program.

congregation. In contrast, the torso as expansive expansion is mostly applicable to horizontal programs such as hospitals, schools, train stations and malls.

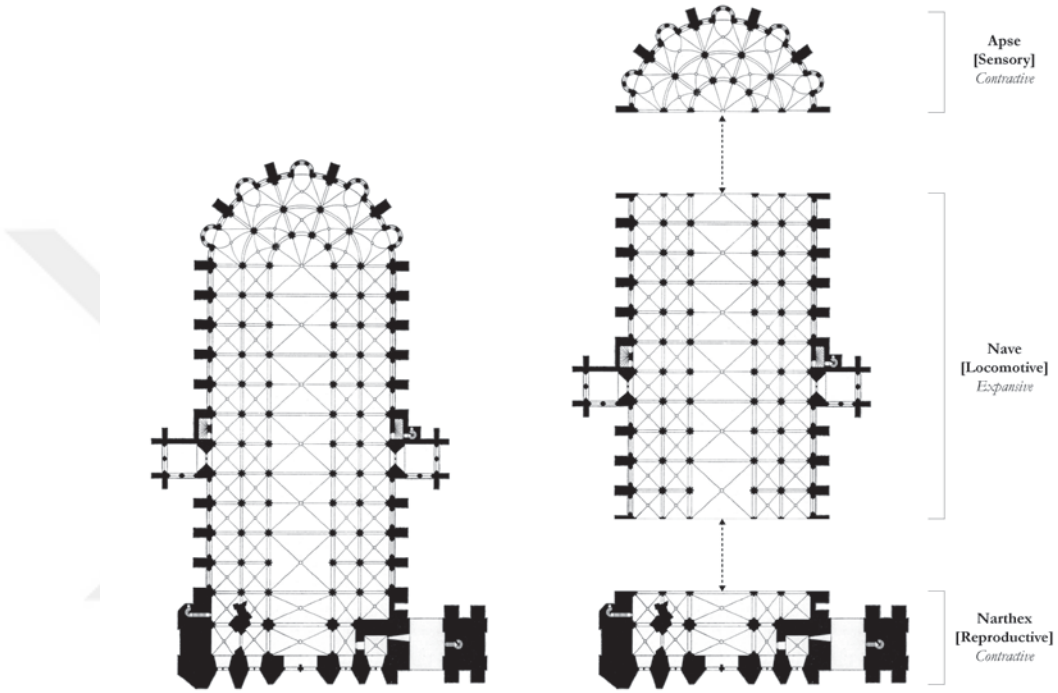

Figure 3.4.1.1 – Polarized parts of the Gothic body shown on plan of Bourges Cathedral.

While the Gothic plan shows a kinship to the animal body, in its morphological development it uses the contractive segmentation of the torso on both ends as a way to terminate planar growth. In this sense, the torso remains as a highly proliferative-expansive domain for formal development while the choir and narthex act mainly as appendages to the torso. Similar principle could be extended towards the transept that is homologous to the nave. Bony describes this principle due to the expansion of the transepts where “trefoil plans” or “the form of a two-tower façade, repeating the

treatment normally reserved for west façades" could emerge.[950] This also presents a polarity between the narthex and apse for their morphology; the former exhibiting mostly expansive tendencies in the vertical direction, while the latter often displays radial symmetry along the plan. This contrast also produces two overall directions for polarized growth that is also found in leaf morphology.[951]

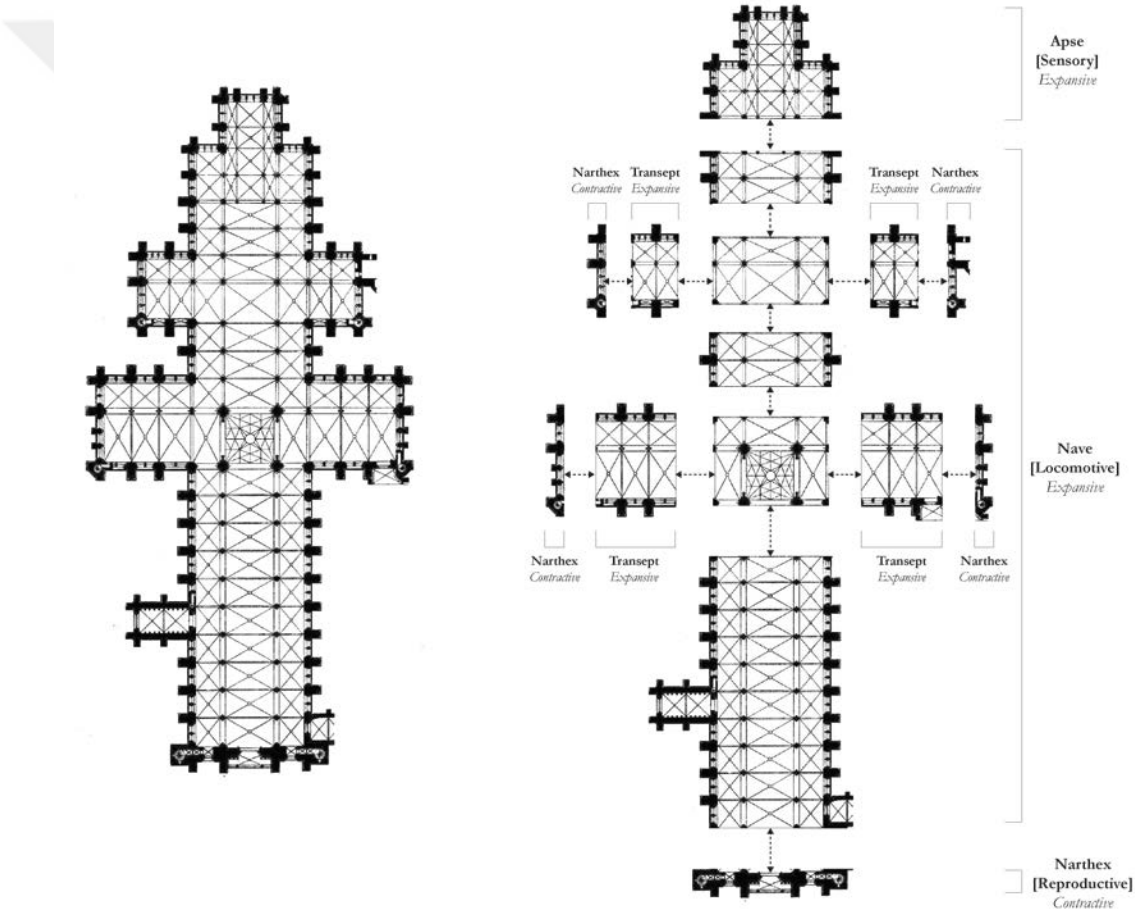

Figure 3.4.1.2 – Polarity breakdown of Salisbury Cathedral showing contractive apse and narthex, with expansive body-limbs.

[950] Bony, *French Gothic Architecture*, 135-6.
[951] Frankl, *Gothic Architecture*, 123. Frankl defines these tendencies as "gothic verticalism" that is found in the contractive plan of Amiens, and "gothic horizontalism" that is found in the expansive plan of Salisbury.

In Salisbury, the growth pattern looks more expansive with a double transept torso complemented with contractive apse that mimics the growth pattern of the nave. The overgrowth of the nave is also complemented with the single protruding spire located at the crossing. This expansive tendency of the nave and choir is balanced with the contractive narthex that remains small and less developed with contractive pinnacles and a flattened façade (Fig.3.4.1.2).

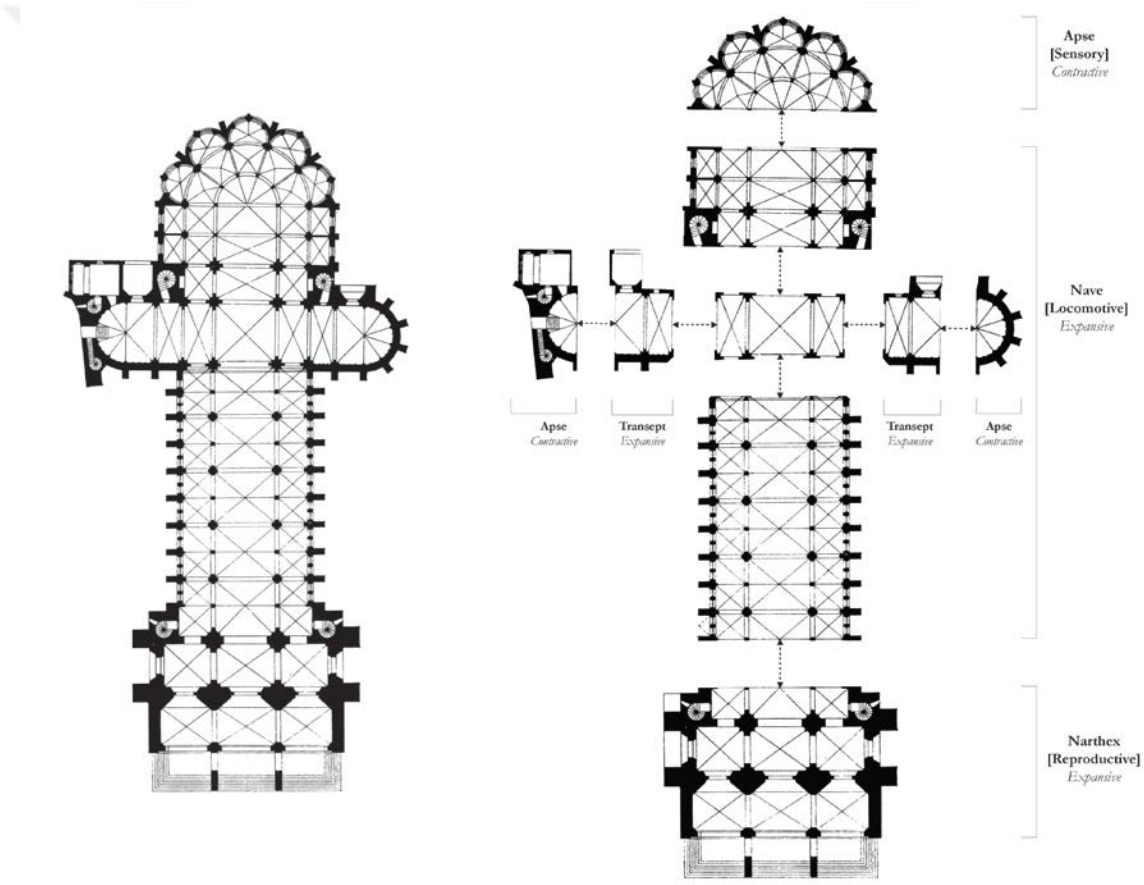

Figure 3.4.1.3 – Polarity breakdown of Noyon Cathedral showing contractive apse and narthex, with expansive body-limbs.

In contrast to Salisbury, in Noyon the growth patterns remain more contractive, with the cross body plan terminating in radially symmetric chapels along the distal ends

of the transepts, a trefoil plan that repeats the tendency of the choir (Fig.3.4.1.3). The plan shows a polarity between the expansive choir and contractive nave, while the twin towers that are placed at the narthex lack radial symmetry and exceed the height of the nave showcasing expansive axial tendencies. Such contrast between the two cathedrals could also be found between Laon and Notre-dame, where the former with four towers distributed among the narthex and transept showcases expansive tendencies and the latter shows a kinship to Bourges in its fully contractive plan with radial ambulatory space merging with the choir.[952]

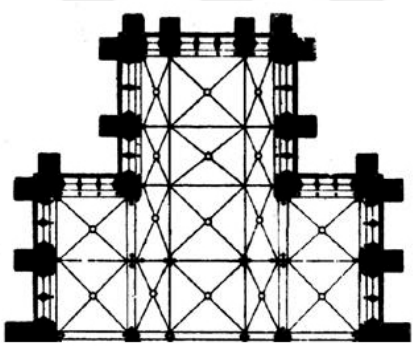

Figure 3.4.1.4 – The expansive apse of Salisbury Cathedral.

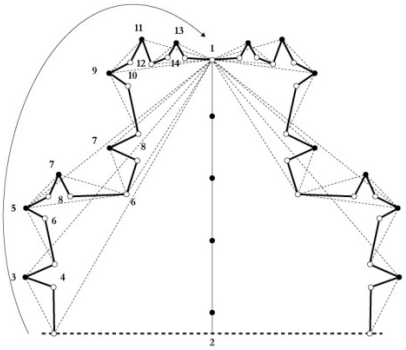

Figure 3.4.1.5 – Diagram of the linear form showing expansive development using using expansive points with odd numbers (black) and contractive points with even numbers (white) showing their order of generation.

[952] Bony, *French Gothic Architecture*, 201-2. Bony also draws on this comparison by relating Notre-dame to Bourges and Laon to Chartres, the former duo having contractive and the latter duo having expansive tendencies.

A more detailed look at the apses of both Salisbury and Noyon Cathedrals show growth in opposite directions. In Salisbury, the ambulatory showcases a repetition of the choir pattern with the movement radiating towards the expansive pole of the cathedral axis (Fig.3.4.1.4-5). In Noyon, the same movement appears in the opposite direction with the initial chapel radially multiplying towards the base (Fig.3.4.1.6-7). Here, contraction acts simply as a thickening of the orthogonal buttress located at the end of the choir that marks the transition from the rhythm of the choir. In this sense Noyon's apse shows a similarity to the formal development of a Ground Ivy leaf blade with expansive points distributed in a radial fashion. In contrast, Salisbury produces a more linear movement akin to palm leaves that produces a repetitive pattern of axially projecting columns.

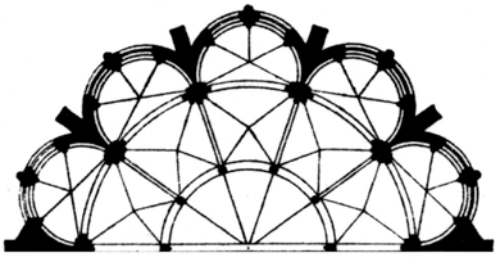

Figure 3.4.1.6 – The ambulatory of Noyon Cathedral.

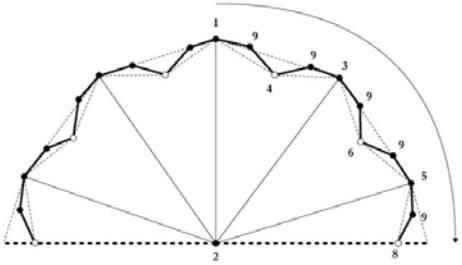

Figure 3.4.1.7 – Diagram of the radial form showing contractive development towards the base using expansive points with odd numbers (black) and contractive points with even numbers (white) showing their order of generation.

The radial movements that are observed in planar development also appear in the vertical development of the Gothic to articulate the distribution of buttresses and pinnacles. Among the two, buttresses mainly occupy the outlines produced after contraction while pinnacles emerge through expansion. Both elements act as stoppage to the geometric and structural development of the section, buttresses acquiring this role horizontally, and the pinnacles vertically.[953] This polarity is highly variable among the cathedrals and showcases different rhythms starting with the simpler triangular sections that are observed in Bourges and Chartres towards the more developed examples of Beauvais (Fig. 3.4.1.8). Thus, the Gothic as a polarized development of the *Urhütte* presents two main streams of formal development. The first one occurs on the coronal plane or plan that organizes the segmentation and repetition of huts with radial and linear tendencies. The second one turns the development towards the transverse plane along the section of each hut redistributing spiraling tendencies towards the vertical apex of each hut.

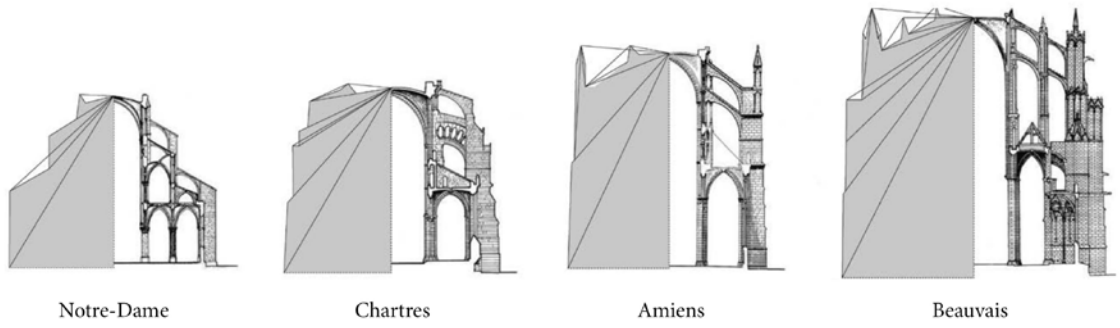

Figure 3.4.1.8 – Diagrams of Gothic cathedral sections showing polarized development following contractive buttresses and expansive pinnacles.

[953] Frankl, *Gothic Architecture*, 87. Frankl defines the exposed and "continuous flow" along the buttress system "a bridge or channel of forces" that redirects the weight of the vault towards the ground. He considers the buttresses as a primarily structural and ornamental system that combines the interior to the exterior as a whole. Bony considers a contrast between pinnacles and buttresses where "vertical perforations are in conflict with the long sloping curve of their arches." He views pinnacles as "shooting upward with a sort of inner vitality" contrasting the radial voussoirs.

3.4.2 Metamorphosis of Urhütte

Apart from vast historical interest, Gothic geometry has always attracted architects to devise digital tools for the study of its systemic and generative capacity. Recent studies have either focused on procedural modeling of Gothic cathedrals, digital models of Gothic vaults or mesh subdivision strategies that are capable of generating their complex geometry.[954] Apart from certain computational approaches, the Gothic presents an inherently digital systemic that is capable of producing continuity as well as discontinuity. In *The Sympathy of Things*, Spuybroek considers the rib as a highly variable and configurational element of the Gothic system that appears as a combination of "the elementary and discrete state of things we find in Greek ontology with the flexibility and continuity of Baroque ontology."[955] Considering its ontological status, he states that the "Gothic was already digital (and expressionist) in the twelfth and thirteenth centuries" and can accommodate digital investigations towards the study of its geometric complexity.[956] While this new theoretical and algorithmic view offers a foundation for the study of Gothic morphology, this chapter will present an alternative and novel approach looking at recursive procedural modeling derived from Goethe's concept of metamorphosis. As a digital modeling technique, this approach shows kinship to shape grammars in its sequential articulation of formal information; however, it differs from it with its simplicity of polarity rules, notions of symmetry and bi-polar arrangement of

[954] An example of parametric Gothic tracery could be found in Sven Havemann and Dieter W. Fellner, "Generative parametric design of Gothic window tracery," in *VAST'04 Proceedings of the 5th International conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage* (2004): 193-201. For an example of the procedural modeling strategies and its application for the Gothic vault study see Chevrier, C., Maillard, Y., Perrin, J.P., "A method for the 3D modelling of historic monuments: the case of a gothic abbey," in *International Archives of Photogrammetry, Remote Sensing and Spatial Information Science*, 38 (5/W1), (2009). For an algorithmic mesh subdivision approach to generate complex geometric shapes see Michael Hansmeyer and Benjamin Dillenburger, "Mesh Grammars," in *Open Systems: Proceedings of the 18th International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2013)*, eds. R. Stouffs, P. Janssen, S. Roudavski, B. Tunçer, (2013): 821–829. An overview of the concepts for procedural and generative modeling with focuses on rose windows and Gothic massing see Ulrich Krispel, Christoph Schinko and Torsten Ullrich, "A Survey of Algorithmic Shapes," *in* Remote Sensing 7(10), (September 2015): 12763-12792 .
[955] Spuybroek, *The Sympathy of Things*, 65.
[956] Ibid.

sequences and morphogenetic phases.[957] In this sense, polarity offers a non-formalist, recursive and parametric notion of formal development that is highly abstract, generative and geometric. As a generative technique, polarity does not require shapes, but focuses entirely on abstract geometric information embedded in form that could be represented by points, lines and triangular meshes.

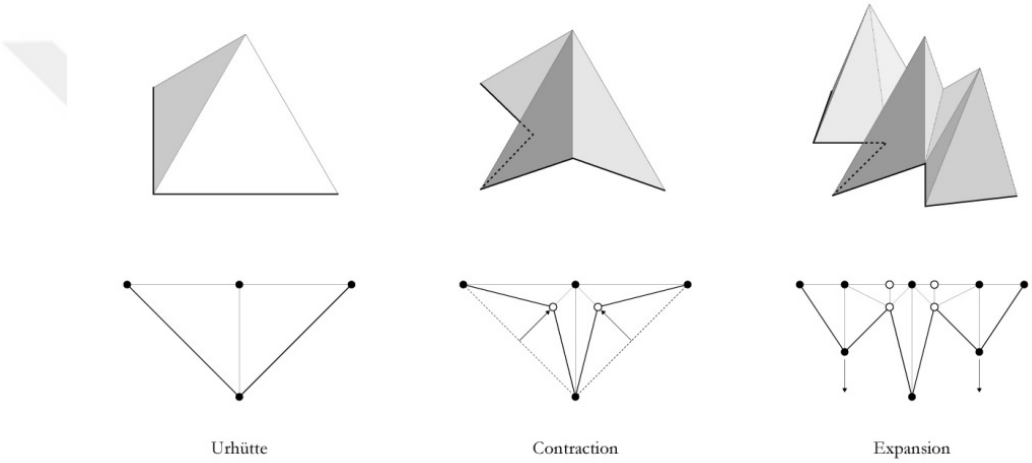

Figure 3.4.2.1 – Polarity rules for planar development of *Urhütte*. The isometric view of half-pyramid is shown on top with its corresponding planimetric views located below each frame. The initial pyramidal geometry breaks on the ground plane by adding expansive and contractive points similar to the leaf sequences. Expansive points are black while contractive points are shown as white dots. Each expansive triangle produces new apices at different heights.

The application of polarity rules towards three-dimensional formal studies requires an extension of the two-dimensional model described through leaf morphogenesis in Chapter 2.4. This approach considers the simple pyramidal topology of the *Urhütte* as an archetype for formal development that is capable of undergoing metamorphosis in planar and vertical directions to generate various architectural

[957] An introductory overview of shape grammars could be found in George Stiny, "Introduction to shape and shape grammars," in *Environment and Planning B*, Vol. 7 (1980): 343-351. Stiny defines shapes through a set of boundary lines that through the application of basic rules can produce similar or new shapes that emerge out of the intersection, overlap or subdivision of lines. Shape grammars requires topological shapes to reproduce itself.

morphologies. Among the two, planar development shows a similarity to the leaf sequencing with its articulation on the coronal-ground plane of the hut (Fig.3.4.2.1). During contraction, the initial pyramidal form breaks into symmetrical triangles by collapsing each polygonal edge towards the center of gravity that aligns with the apex of the pyramid. During expansion, each triangle edge is capable of establishing a new local symmetry with the creation of a new apex along the vertical planes. When this occurs, the triangle located in between the two apices acts as a bridge to topologically reconnect divided segments while in later development it subdivides through contraction producing its own local axis of symmetry.

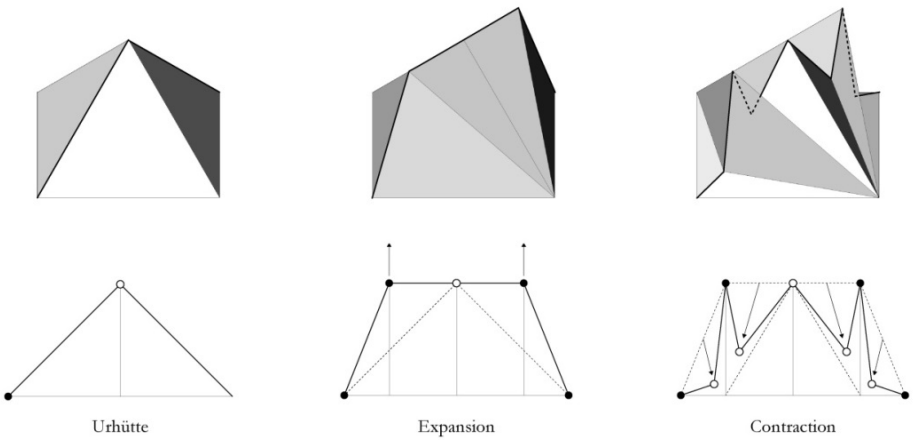

Figure 3.4.2.2 – Polarity rules for vertical development of Urhütte. The initial pyramidal geometry breaks on the vertical plane by adding expansive and contractive points similar to the leaf sequences. Expansive points are black while contractive points are shown as white dots.

After the completion of planar development, each resulting triangle located along the symmetry axis undergoes a vertical development that replicates the metamorphic sequence along the sagittal and transverse planes of the *Urhütte* (Fig.3.4.2.2). What differs in this process is the production of the vertical symmetry axis that aligns with

expansive points. During contraction, each triangle breaks in two by pulling the expanded outline towards locally established centers. During this process, expansion tends to produce more pointy forms such as pinnacles, gables, sculptures; whereas, contraction produces elements that connect these spikes such as buttresses, roofs or walls. In this sense, the vertical development that primarily occurs on the transverse plane also mimics leaf morphogenesis in its redistribution of symmetrically related triangles.

3.4.3 Polarity and Gothic Metamorphosis

The planar and vertical development of the *Urhütte* could be better visualized by looking at geometric principles and metamorphic sequences governing the three segmented parts of a Gothic cathedral, the contractive apse and expansive nave and spires. This approach will consider all the main segments of a cathedral as metamorphic multiplications of the *Urhütte*. Prior to developing a notion for the ontogenetic development of a cathedral, each of these segments will be first studied through their own embryogenesis. In apses, planar development predominates the vertical that usually produces radial symmetry occurring in plan (Fig.3.4.3.1). Among the four examples that are chosen, Notre-dame apse shows the most contractive development occurring along plan that does not produce distinctive chapels (Fig.3.4.3.2). In contrast, Chartres shows more distinctive development in plan with the asymmetrical repetition of radial chapels (Fig.3.4.3.3). This is also found in Soissons and Amiens. In the former, the same rhythm produces a more uniform five-fold repetition, whereas in the latter the axial chapel is more expansive compared to the radially repeated ones. In all examples each distinctive radial symmetry axis is lifted upwards during expansion where the production of buttresses and roofs follow a similar development to the nave (Fig.3.4.3.4-5).

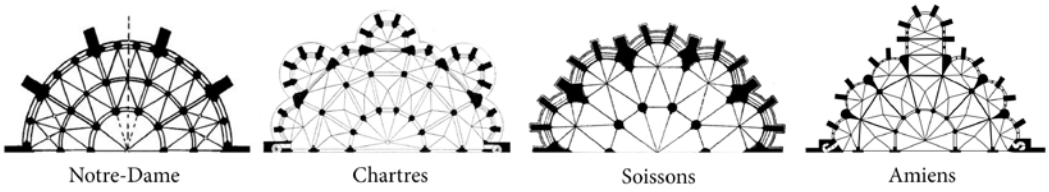

Figure 3.4.3.1 – Apses of the selected Gothic Cathedrals.

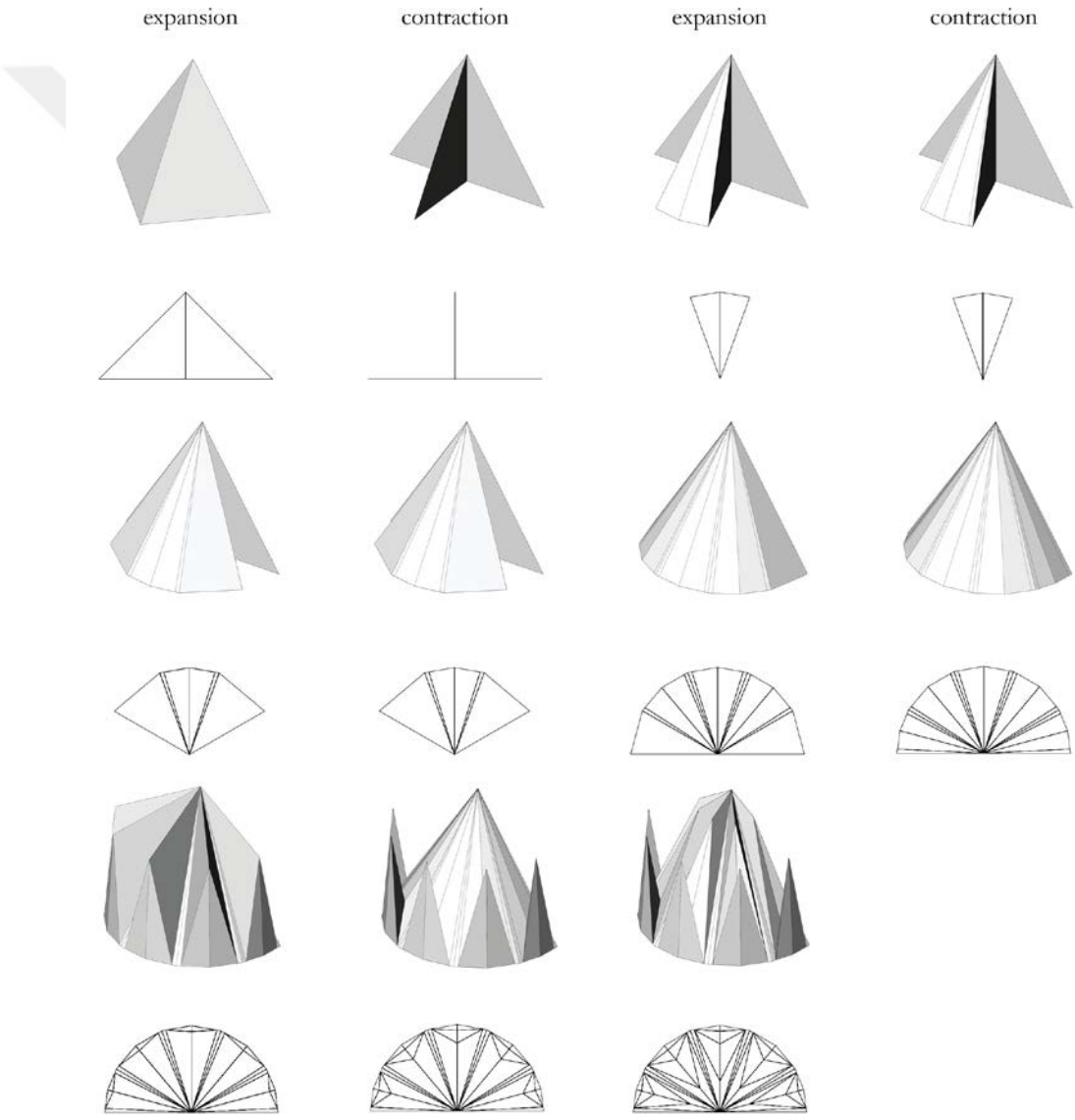

Figure 3.4.3.2 – Metamorphosis of the apse of Notre-Dame Cathedral.

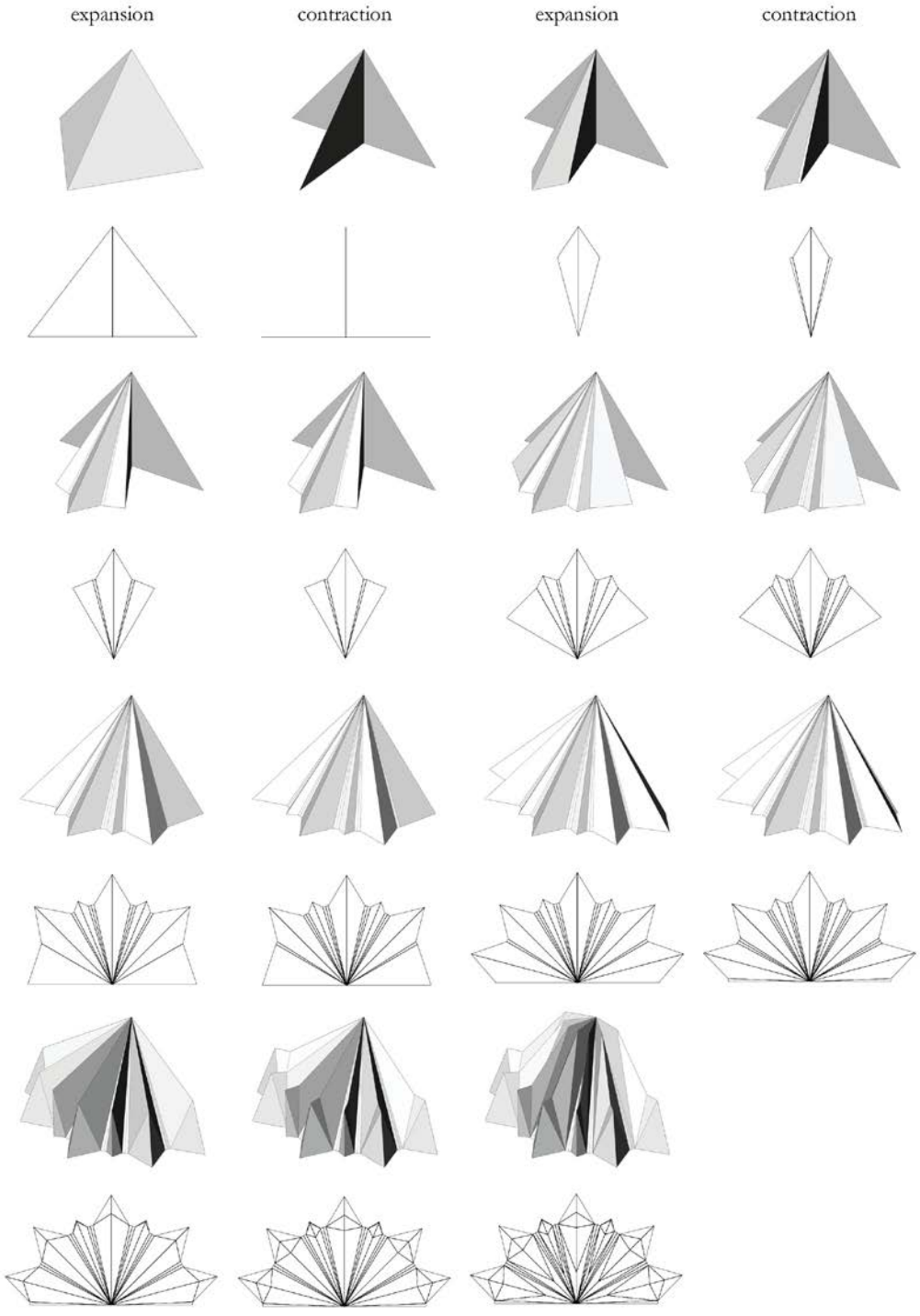

Figure 3.4.3.3 – Metamorphosis of the apse of Chartres Cathedral.

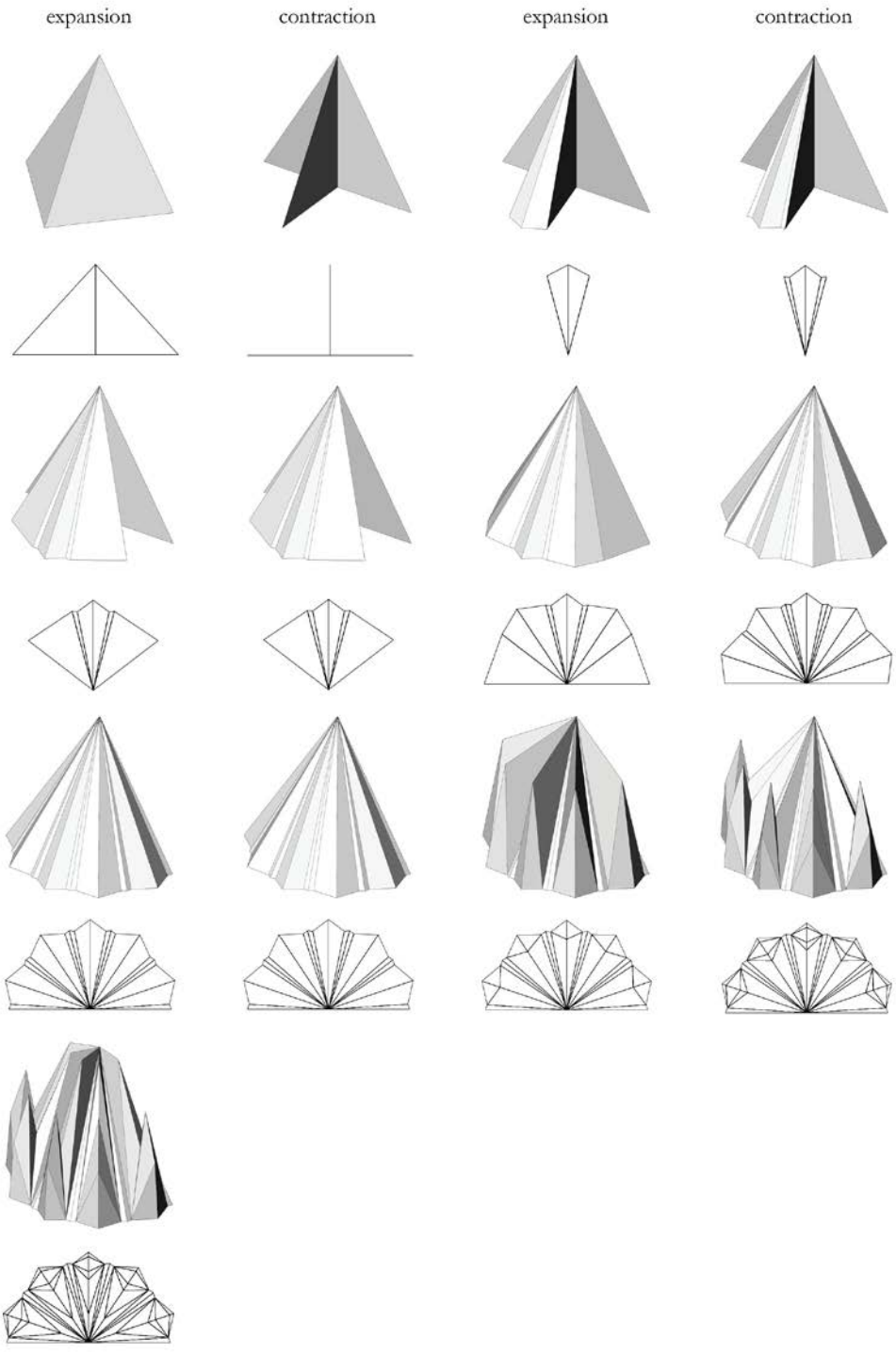

Figure 3.4.3.4 – Metamorphosis of the apse of Soissons Cathedral.

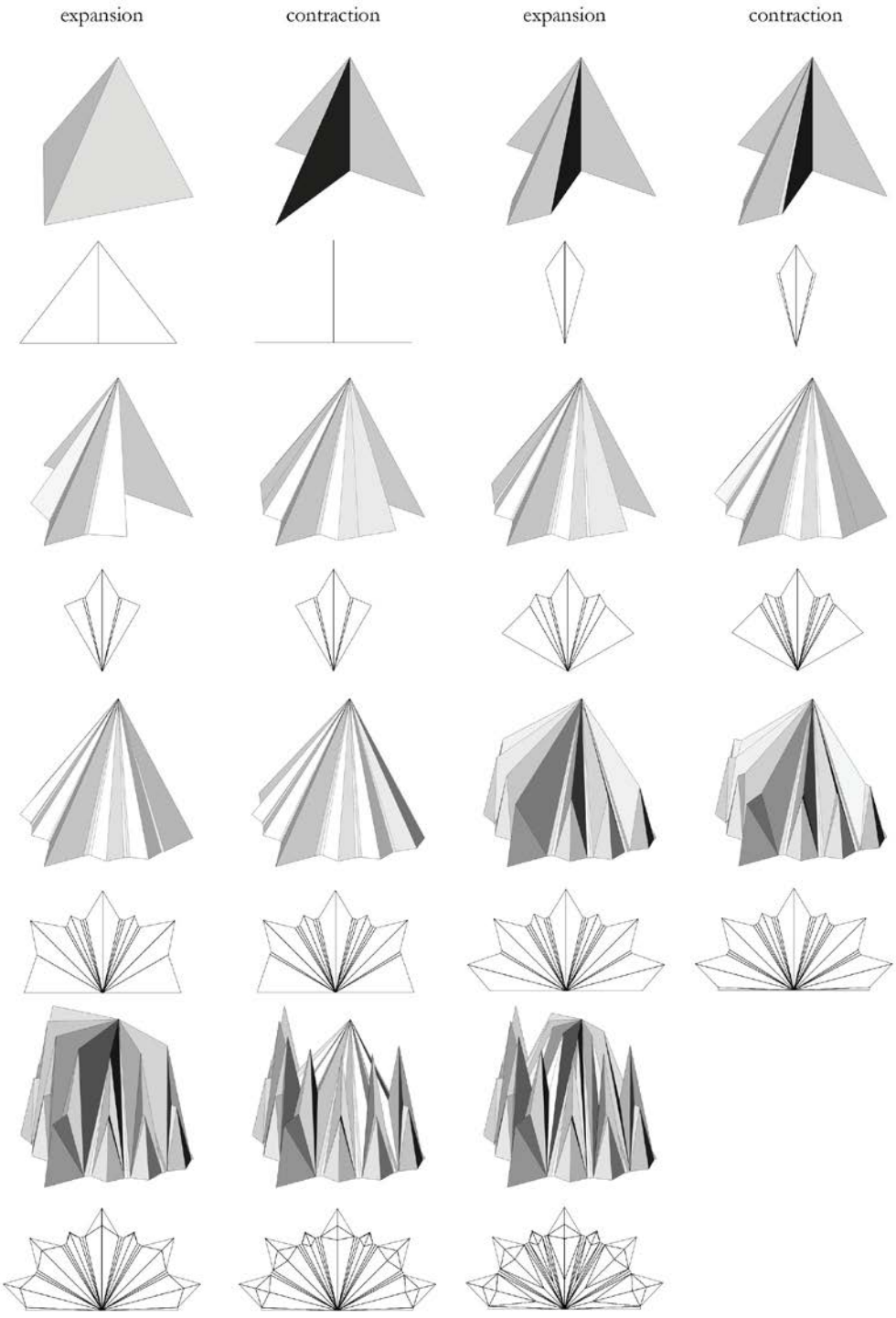

Figure 3.4.3.5 – Metamorphosis of the apse of Amiens Cathedral.

The overall morphology of the spires show that polarity is mostly established along the vertical direction with transverse and sagittal planes showing polarized distribution of contractive level divisions and expansive pinnacles or buttresses (Fig.3.4.3.6). In Noyon, the quadruple pinnacles emerge due to the contraction on the transverse plane with the pyramidal roof segmenting along corners (Fig.3.4.3.7). In the south tower of Chartres the development is similar; however, the expansive division segments the octagonal roof with the tower, where the roof appears as a singular large pinnacle (Fig.3.4.3.8).

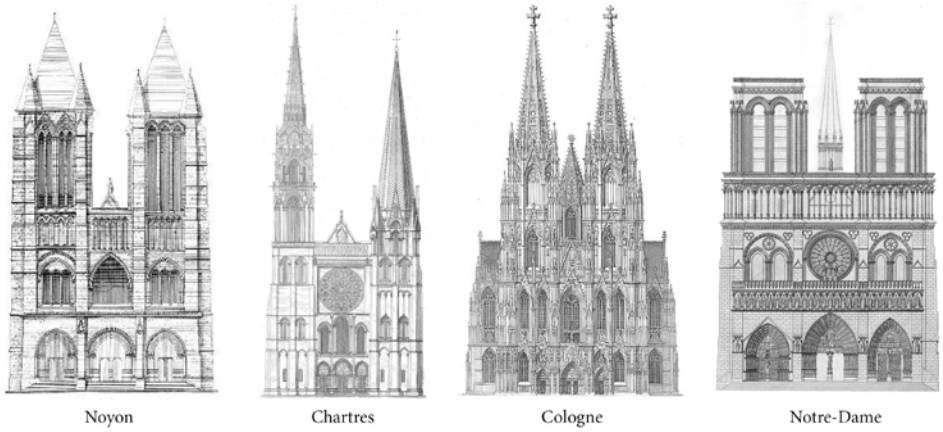

Figure 3.4.3.6 – Elevation of the narthex of the selected Gothic cathedrals.

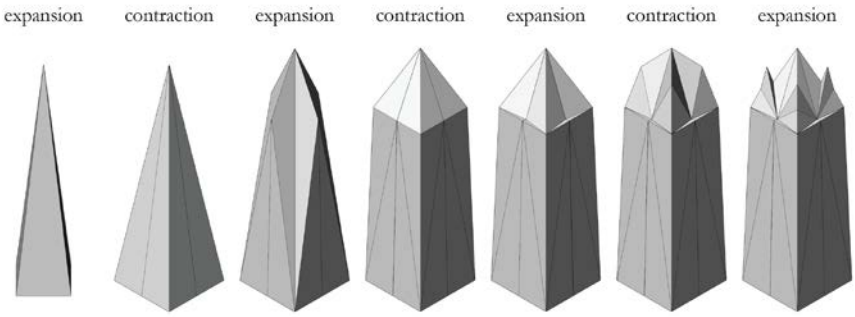

Figure 3.4.3.7 – Metamorphosis of the spire of Noyon Cathedral.

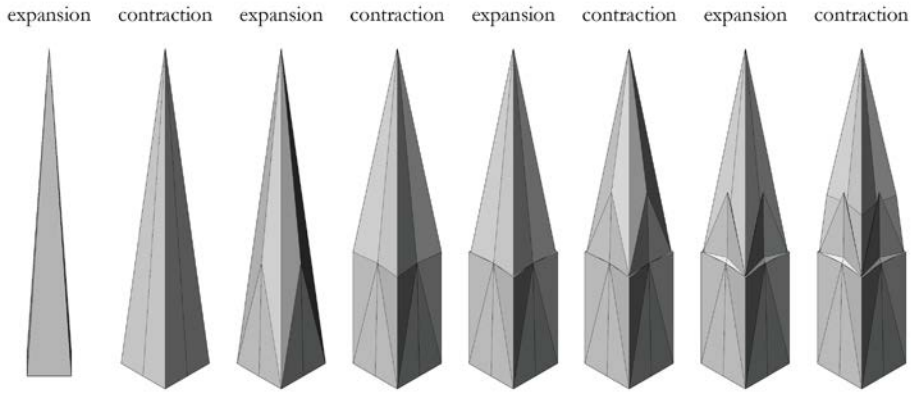

Figure 3.4.3.8 – Metamorphosis of Chartres Cathedral south tower.

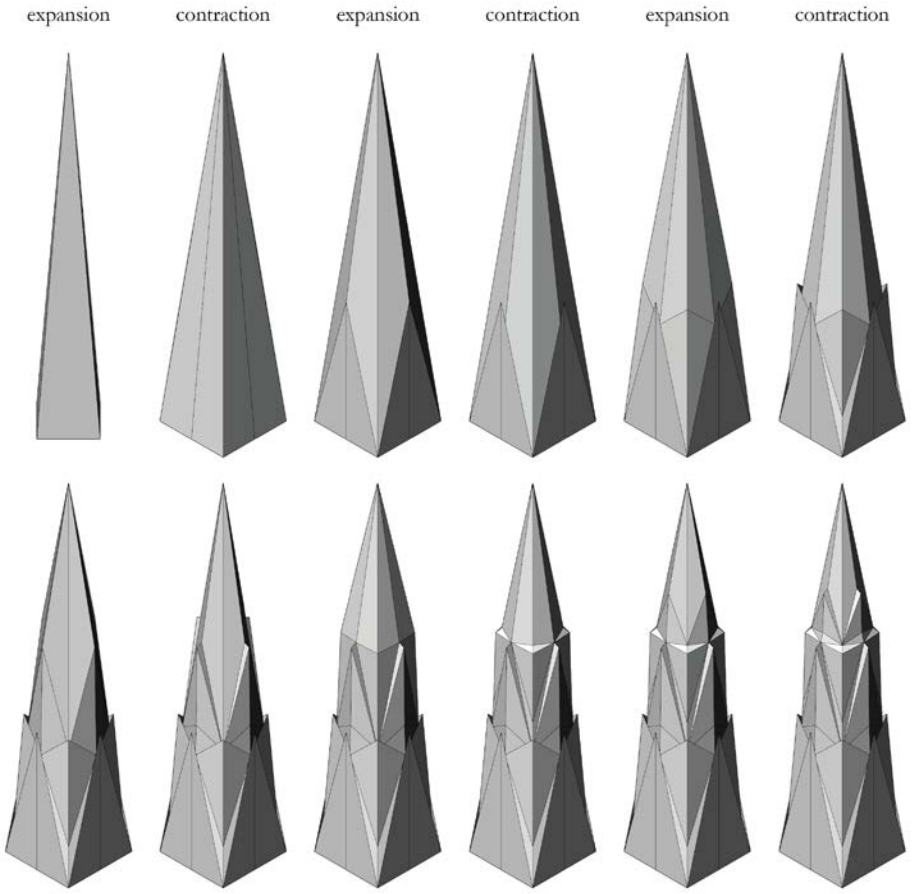

Figure 3.4.3.9 – Metamorphosis of Cologne Cathedral spire showing alternating distribution of pinnacles.

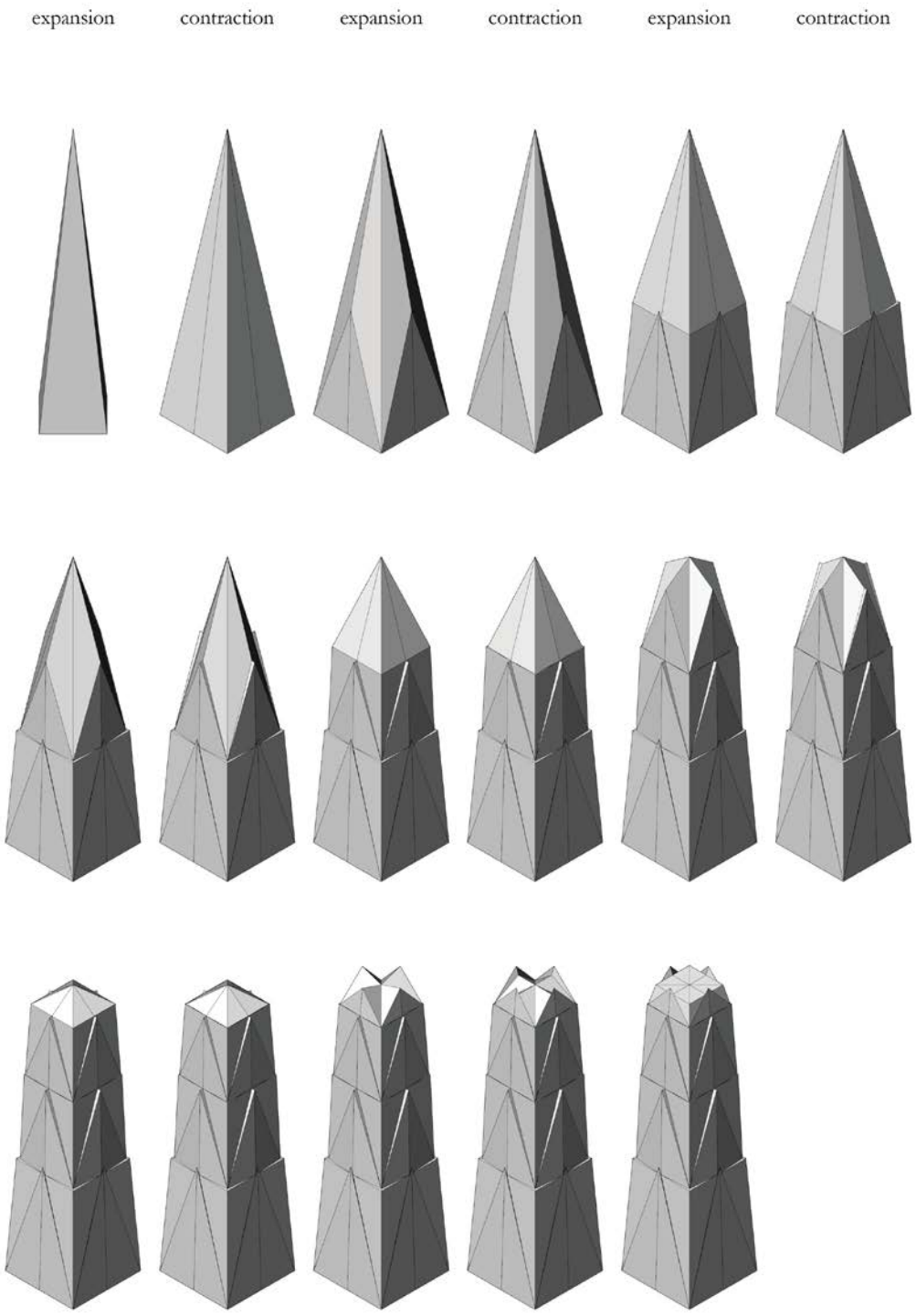

Figure 3.4.3.10 – Metamorphosis of Notre-Dame Cathedral spire showing contractive development.

In Cologne, the vertical development alternates between sagittal and transverse planes where the pinnacles are distributed in a zigzagging fashion reminiscent of the spiraling tendency observed in plants (Fig.3.4.3.9). Although the twin symmetrical spires are fully merged with the narthex, they show highly proliferative and expansive development. In contrast, in Notre-dame the towers appear more contractive due to the lack of polarization along the segmented stacking of levels (Fig.3.4.3.10). In this example, the tower terminates with no distinctive roof or pinnacle, instead a contractive surface appears, flattening the top of the tower.

Another configurational aspect of the Gothic system is its variability on the coronal plane with different body-limb organizations and ratios articulating overall massing development. Although most cathedrals utilize either a single axial or cross body plan, examples such as Salisbury, Cantenbury and Bourges display exceptions to this rule and showcase the vegetal variability of the torso.[958] Among these, Salisbury displays a double transept with the first one forming a single spire at the crossing marking the intersection of the body plan. In Cantenbury the torso is doubled with the new cathedral expanding from the older plan to produce a conjoined body plan. Compared to the highly expansive character of the Gothic, in Bourges the contractive torso fails to develop any orthogonal transepts that can produce a distinctive crossing. The pavilions located on both sides of the nave resonate as contractive transepts that do not produce an effect on the massing and in that sense remain as parts of the torso. These morphological

[958] Bony, *French Gothic Architecture,* 120-124. Bony considers this dual division among the Gothic as a contrast between three schools of Gothic that define morphological tendencies for the torso. Among these "Sens formula" presents a single nave with no distinguishable transepts as the contractive body plan. The other two schools of Paris and Northern Trade Routes showcase the most variable examples of the Gothic with double or multiple transepts as the more expansive examples.

tendencies could be visualized using two examples showcasing a torso without limbs and a torso with single transept wings (Fig.3.4.3.11-12).

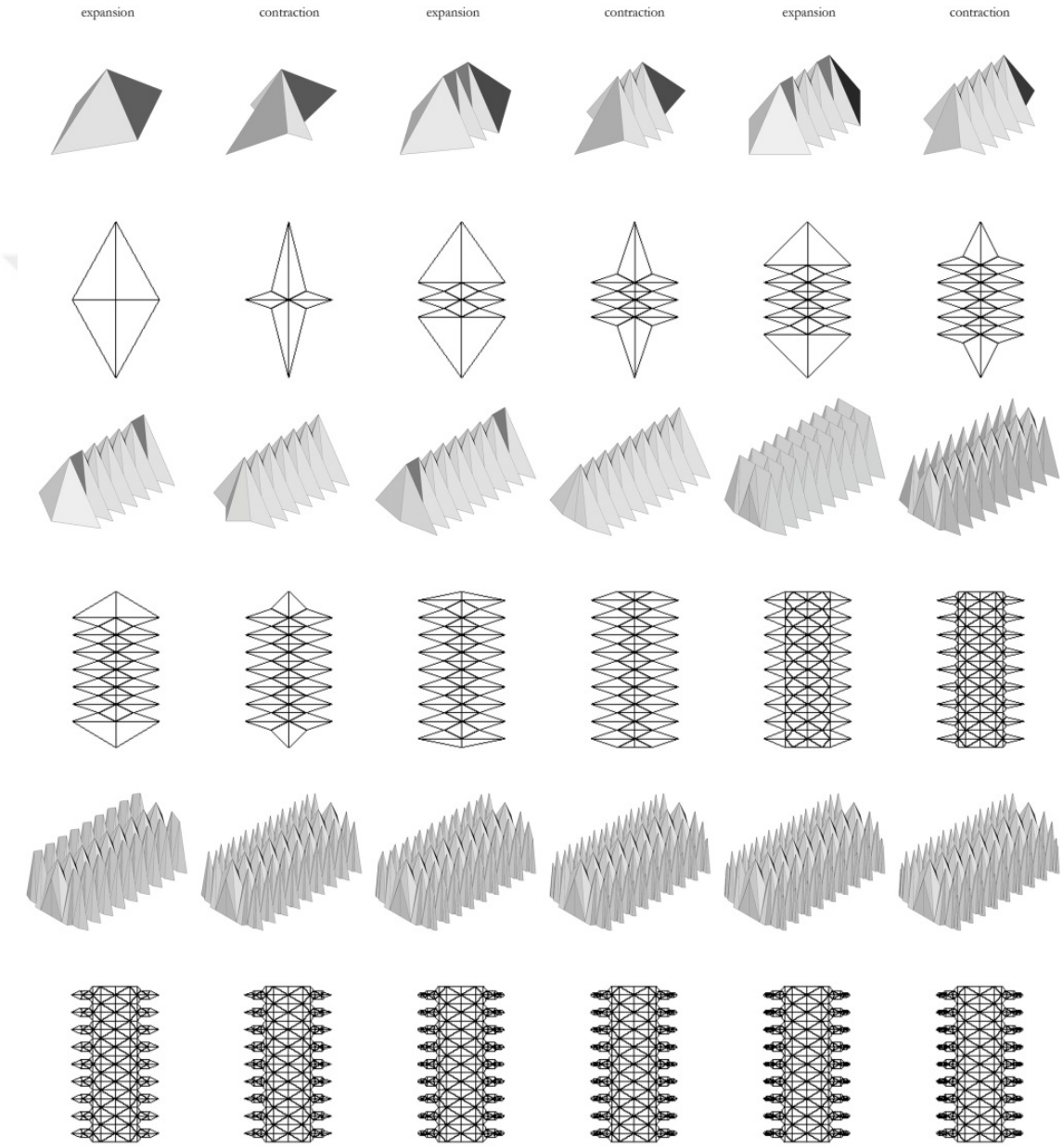

Figure 3.4.3.11 – Metamorphosis of a contractive body plan with no distinctive limb formation.

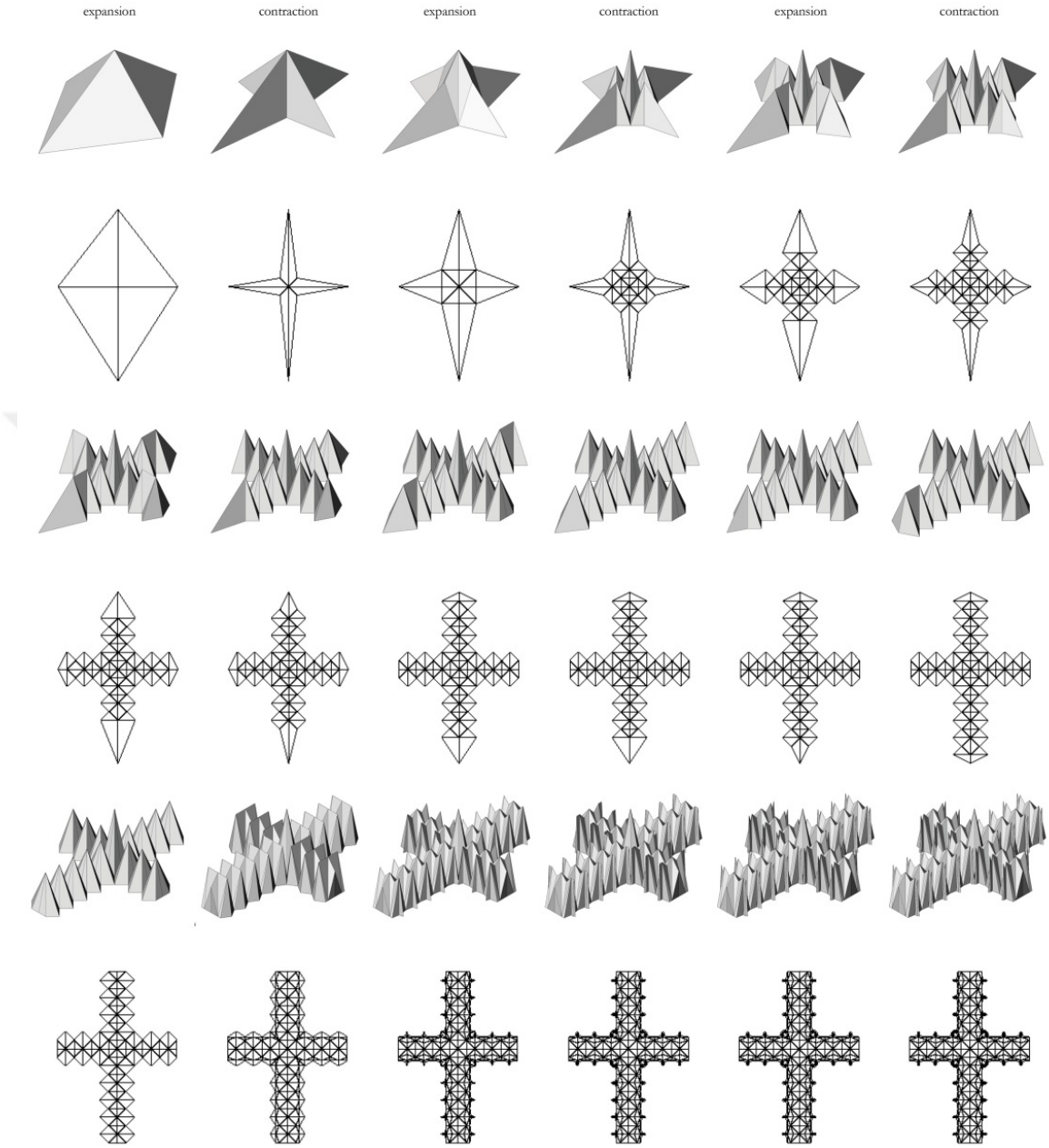

Figure 3.4.3.12 – Metamorphosis of an expansive body plan with two limbs attached at a crossing forming a local spire.

In the body without limbs, the metamorphosis of the *Urhütte* takes place in a symmetrical fashion by recursively subdividing the torso into repetitive nave segments (Fig.3.4.3.11). During contraction, the symmetrical development moves towards both

poles of the torso where growth is terminated by either a contractive narthex producing spires or a contractive choir forming an ambulatory. During expansion, each nave segment undergoes individual development that changes the direction of growth from the coronal plane towards the transverse. In these sequences a polarity between contractive buttresses and expansive aisles emerge that can produce various rhythms on the transverse plane.

In the cross body plan, the metamorphic sequence follows a similar progression comparable to the singular torso; however, the main difference occurs on the initial formation of limbs that multiply the development of the torso towards different orthogonal directions by reproducing huts through division (Fig.3.4.3.12). These often show modularity due to the quadrilateral formation of the crossing where the huts of the torso and limbs align diagonally. The addition of lateral wings allows the body to produce new local structures at distal ends of each limb. An expansive spire could protrude from the crossing while limbs could also produce contractive or expansive structures. In the former, the body resembles the Noyon cathedral with three contractive ends and a singular expansive termination reserved for the main entrance to the nave. In the expansive case, the limbs could undergo a termination that is similar to narthex attached to nave, where additional towers could be added to the massing, as can be found in the examples of Laon and Tournai. Among the two, Tournai presents a hybrid termination with radial chapels superseding the narthex at the distal ends of the transept. The two body plans show that the torso of the Gothic is highly variable and expansive; but it still requires polarization to produce contractive structures at the growing tips of the torso to terminate its metamorphic development on the coronal plane.

A more detailed look at an individual section of the nave shows polarized relationships among the structural members of the Gothic cathedral, particularly in the sequencing of flying buttresses, pinnacles and vaults (Fig.3.4.4.13). Bony considers "the idea of opposing a quadrant arch to the thrust of the vault for maximum economy in buttressing was the principle out of which the flying buttress was born" and views the Gothic structural system as an improvement to the Romanesque triangular buttresses showing more diverse rhythms.[959] Comparative studies of Gothic sections show that each cathedral produces different polarities due to horizontal and vertical expansion of the overall massing. Among these, Chartres Cathedral shows a more expansive version of the Bourgess with its broken section geometry that deviates from the triangular Romanesque churches (Fig.3.4.4.14).

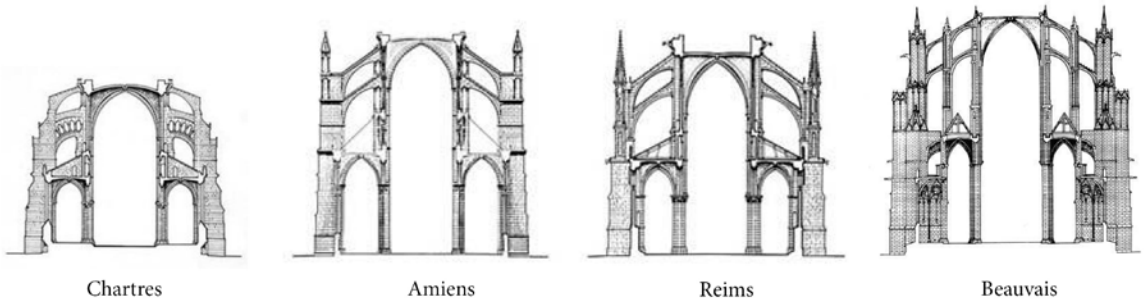

Figure 3.4.3.13 – Nave sections of the selected Gothic cathedrals.

[959] Ibid., 41. Bony mentions that the vertical expansion of the buttresses was a structural necessity due to the diagonal angle of the roof that tended to break curving arches. As the buttresses could "no longer remain hidden under the roofs of the aisles" they started vertically expanding and producing pinnacles, and flying buttresses as structural members.

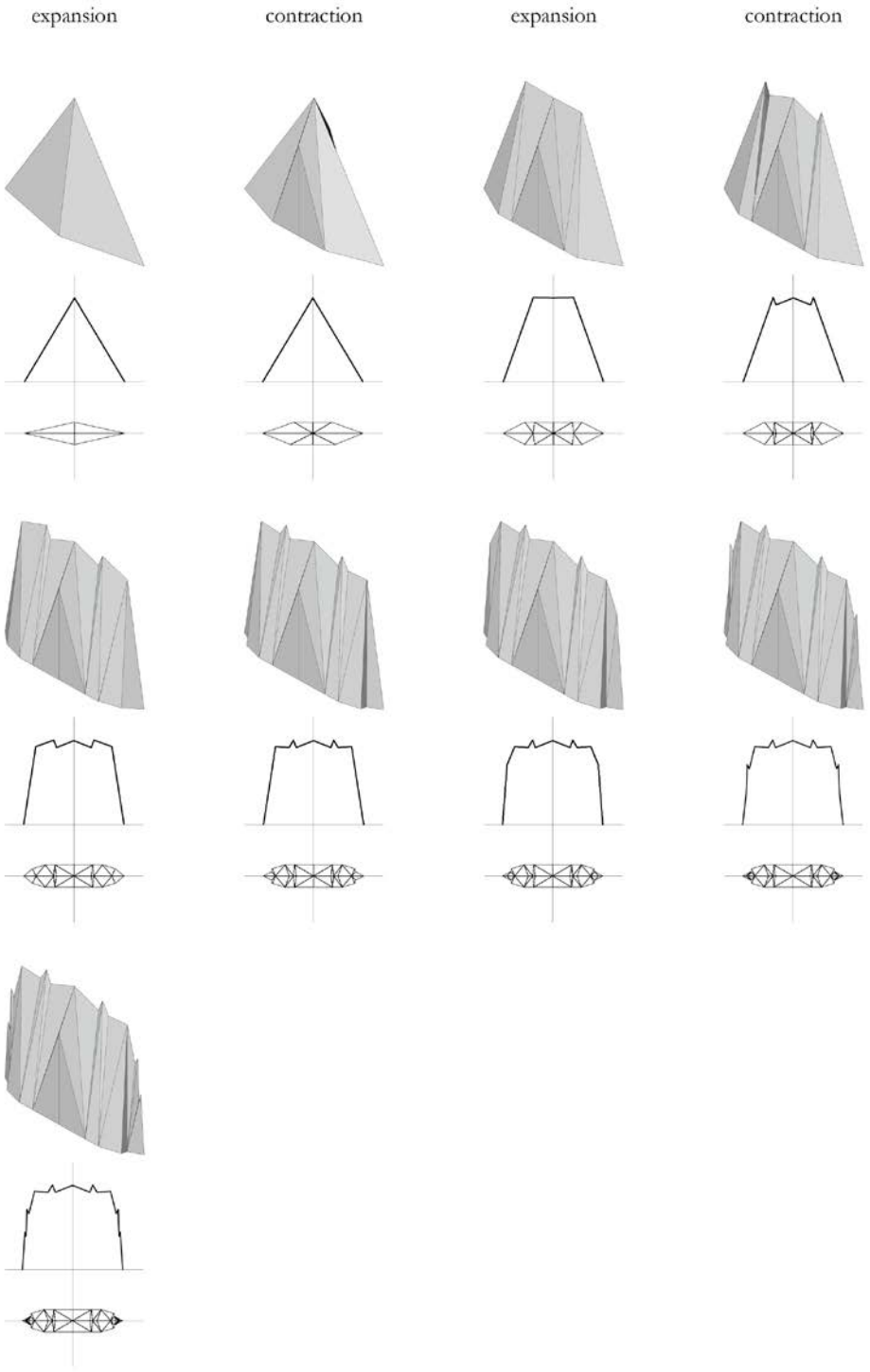

Figure 3.4.3.14 – Metamorphosis of the nave of Chartres Cathedral.

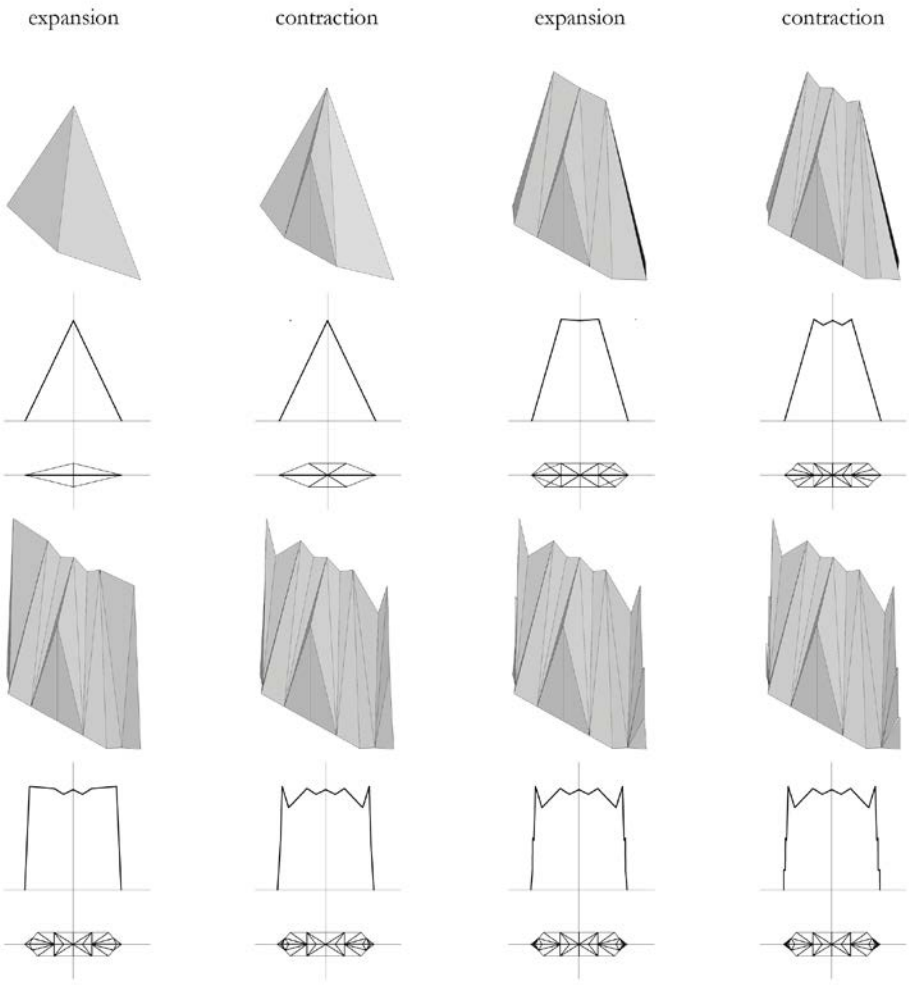

Figure 3.4.3.15 – Metamorphosis of the nave of Amiens Cathedral.

In Amiens and Reims the pinnacles located at the top of the buttresses show the expansion of the outline of the section as a continuation of the polarized development of the Gothic section (Fig.3.4.3.15-16). Both Cathedrals are similar in terms of their complexity in the transverse plane that distributes contractive buttresses with expansive pinnacles.

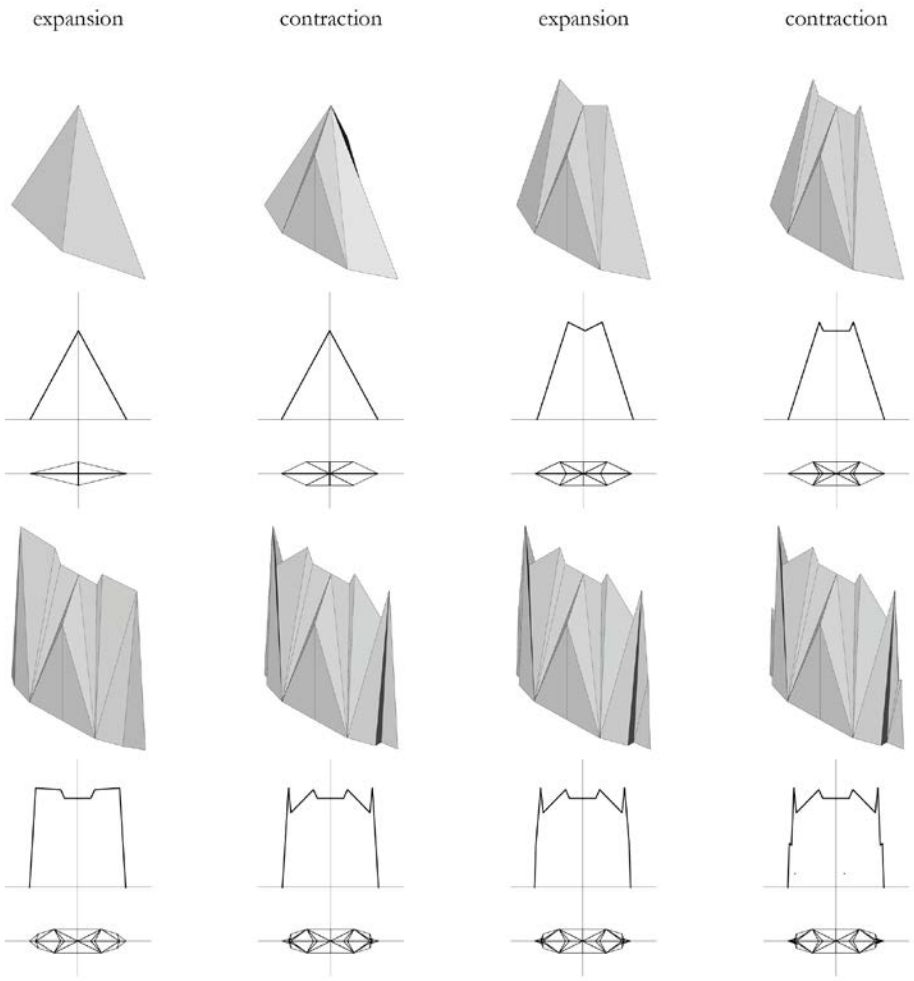

Figure 3.4.3.16 – Metamorphosis of the nave of Reims Cathedral.

In Beauvais this rhythm is amplified with a further addition of triple pinnacle lines that show the sequential relation of the buttresses that transfer the loads of the central nave towards the ground (Fig.3.4.3.17). These Gothic sections show that the higher the nave is built, the wider or heavier the section becomes, thus justifying the placement of pinnacles and additional lateral buttresses in the section to balance the polarized development of the geometry and mass.

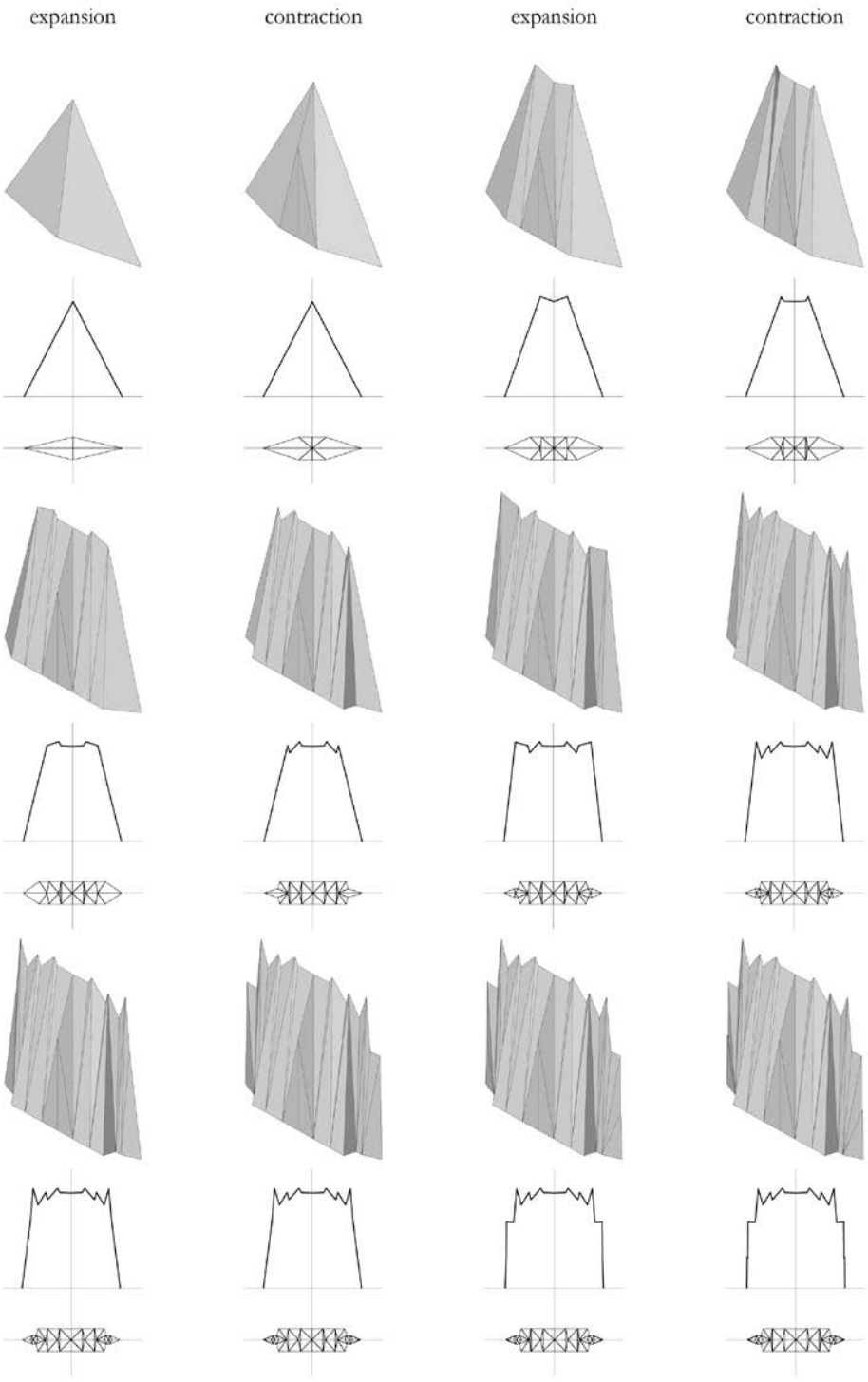

Figure 3.4.3.17 – Metamorphosis of the nave of Beauvais Cathedral.

3.4.4 Polar-Parametric Gothic Cathedrals

The generative and diagrammatic notion of the *Urhütte* could be further extended by looking at the ontogenetic development of two cathedrals that show polarized tendencies. This approach consolidates the multiple metamorphic developments of the three Gothic parts to produce a cumulative Cathedral body. The main discussion in this chapter will be developed by using Laon and Noyon Cathedrals as polarized morphologies. In Laon, the highly expansive quadruple torso produces no distinctive apses along the ends of the limbs; instead, the contractive narthex is reproduced at the ends of transepts that produce asymmetrical spires, one showing contractive termination with no distinctive roof, whereas the other one becomes highly expansive with octagonal radial distribution of pinnacles (Fig.3.4.4.1-3). This tendency also transmits to the apse development, where the expansive pole of the torso is terminated with a highly contractive narthex that produces two small pinnacles. In this sense, Laon shows similarities to Salisbury with the latter producing two transepts with contractive spires. However, in Laon the vertical development produces multiple spires in addition to the single spire located at the crossing that protrudes from the torso directly. This identifies with Laugier's typological picture for the Gothic where the cross body plan is capable of producing nine total spires, two on the ends of body axis and limbs and a single spire located at the crossing.[960]

[960] A depiction could be found in Eugene Viollet-le-Duc, "Bird's-Eye View of an Ideal Cathedral," In *Dictionnaire Raisonne* De L'architecture Francaise Du Xie Au Xvie Siecle, Vol.2 (Paris: F. De Nobele, 1967, Orig. 1854). Viollet-le-Duc's typological cathedral remains primarily expansive and fails to consider contraction as an alternative option for the transept development. See also Fingensten, "Topographical And Anatomical Aspects Of The Gothic Cathedral." Fingensten also discusses the asymmetrical distribution of elements of viollet-le-duc's ideal cathedral with a single choir and triad of narthexes with twin spires.

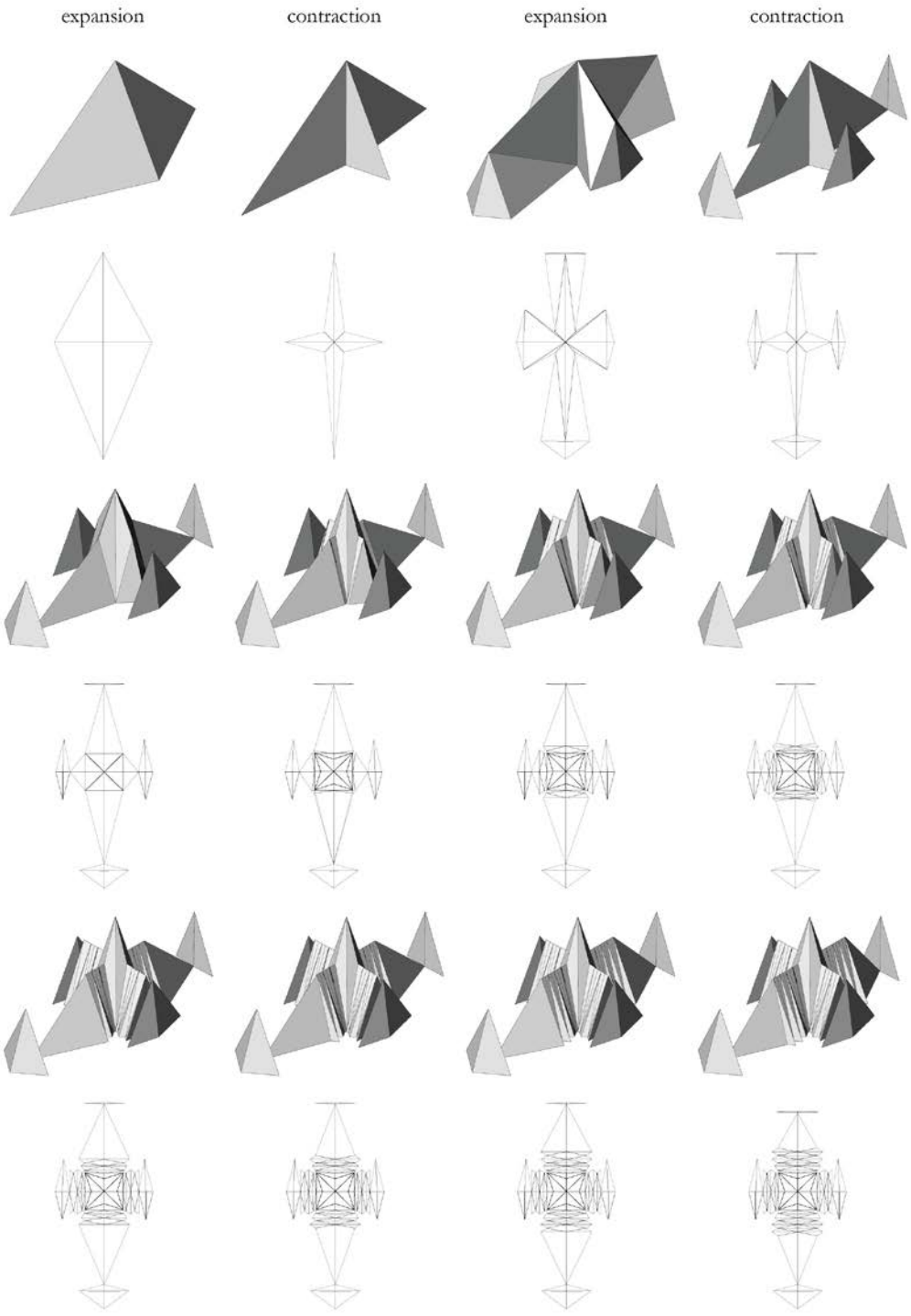

Figure 3.4.4.1 – Metamorphosis of Laon Cathedral, part 1.

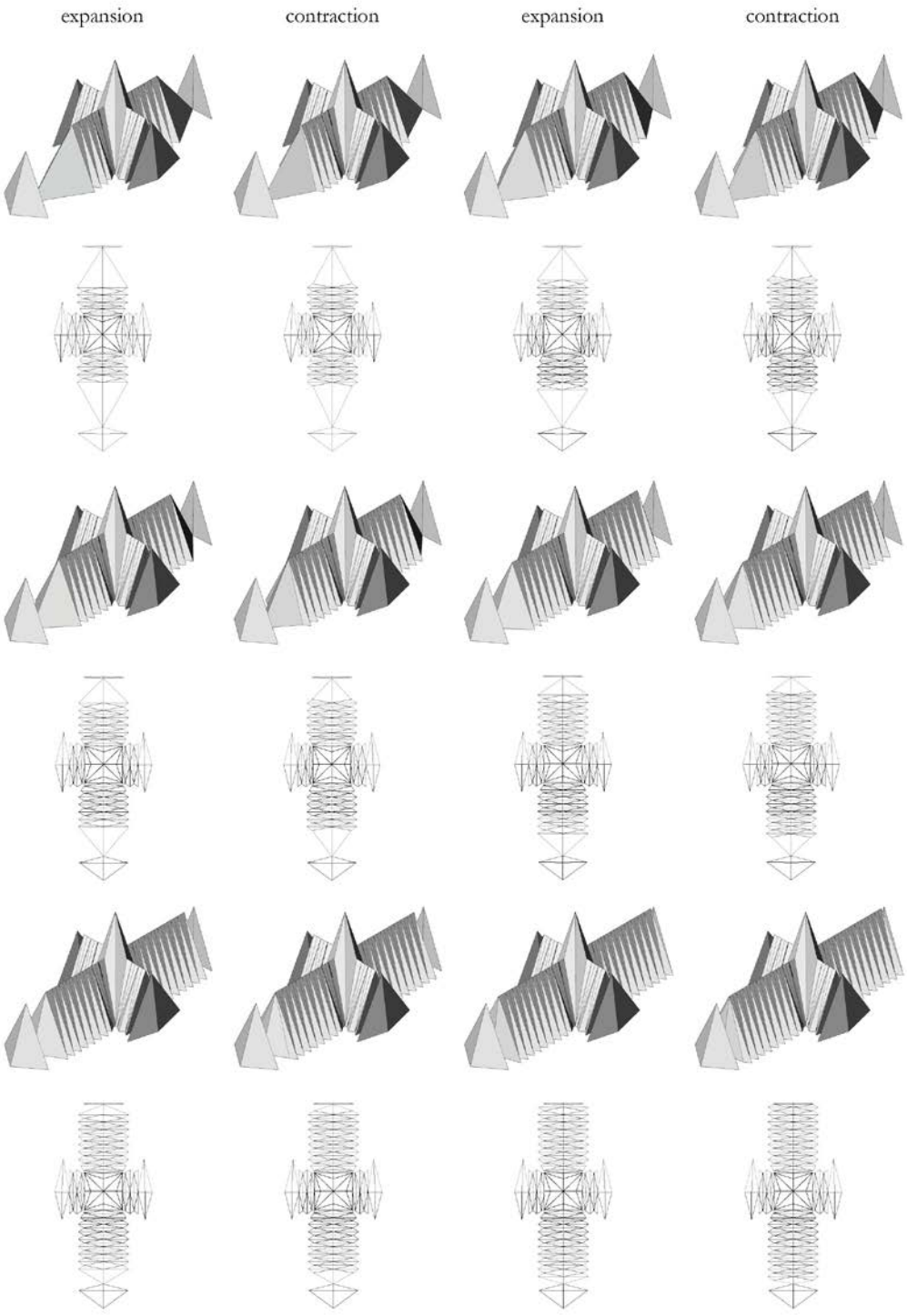

Figure 3.4.4.2 – Metamorphosis of Laon Cathedral, part 2.

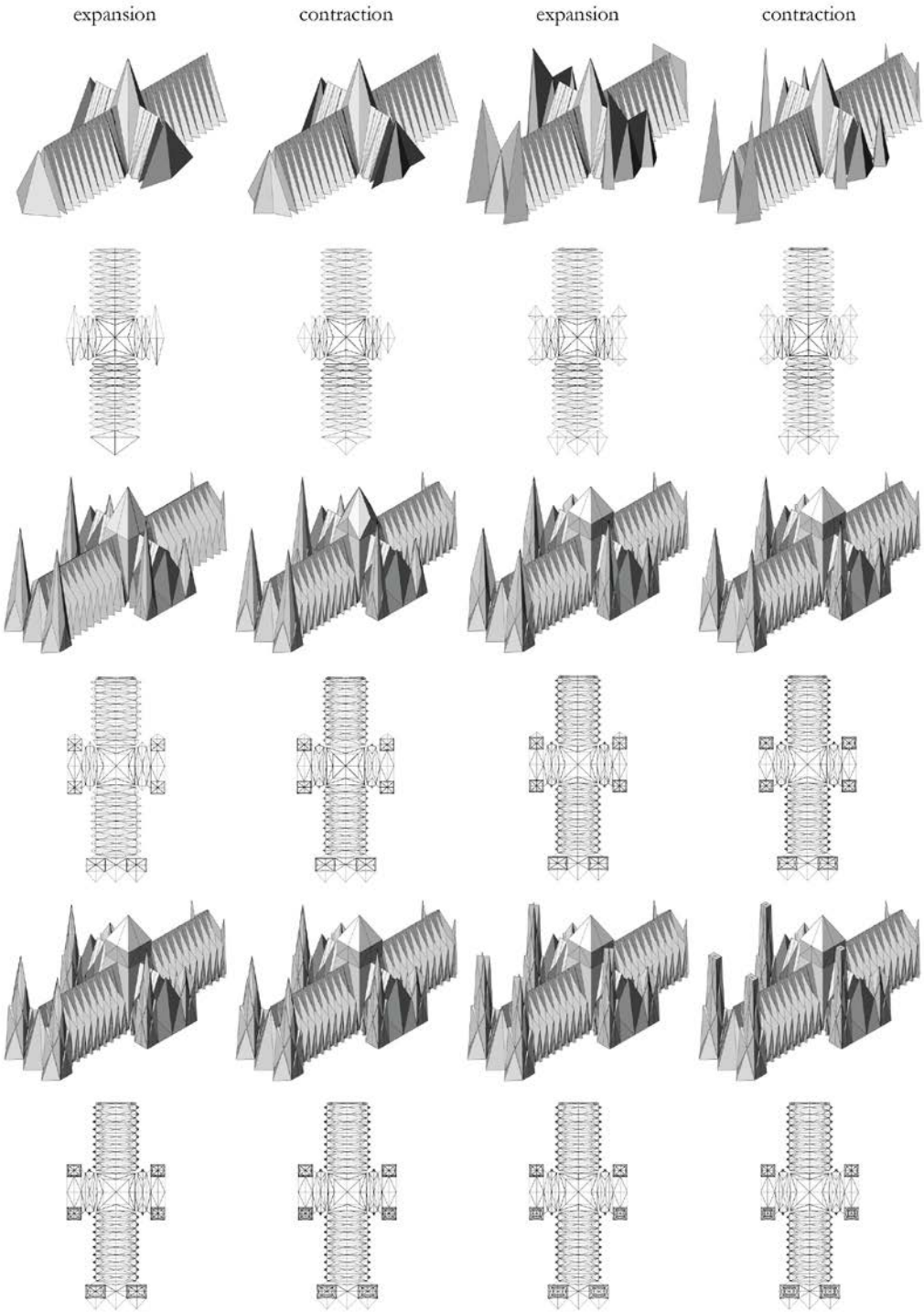

Figure 3.4.4.3 – Metamorphosis of Laon Cathedral, part 3.

Compared to Laon cathedral, in Noyon the ontogenetic development remains mostly contractive with the cross body plan terminating with radial apses on three ends and a highly expansive narthex at the contractive pole of the torso (Fig.3.4.4.4-6). This cathedral shows contractive tendencies in its morphology due to the underdevelopment of its transepts and crossing with no distinctive spire. Along the coronal plane, polarization occurs mainly in the development of the narthex to show a primarily expanded plan; however, in its vertical development, it remains mostly contractive with the twin spires terminating into four pyramidal pinnacles on corners. Comparing the morphology of Laon and Noyon shows that the former produces a lean torso; whereas, Noyon shows more of a swollen body particularly towards the expansive pole where the choir and transepts outgrow into each other. This shows that expansive tendencies in plan often yield to further vegetative growth where the body remains lean and highly proliferative. With contraction the torso often joins with the appendages through anastomosis, where additional local structures could be attached at the distal ends of the limbs. In vertical development, expansion yields reproduction of towers as a redistribution of the excess material, whereas contraction produces smooth appendages that often fail to produce polarization. When both tendencies are manifest in the production of spires, an asymmetry occurs where the towers take on different roles as morphological development redistributes the gravity of the narthex trying to balance expansive-lighter spires with contractive-heavy ones.[961]

[961] Frankl, *Gothic Architecture*, 127. Frank also draws on such polarity and compensation between the masses of the two spires that are built at different times: "for great care was taken to balance the mass of the two towers, the lighter mass of the new compensating for its greater height, which certainly bears a better relationship to the height of the façade than the southern tower, built, as we recall, for a recessed west front."

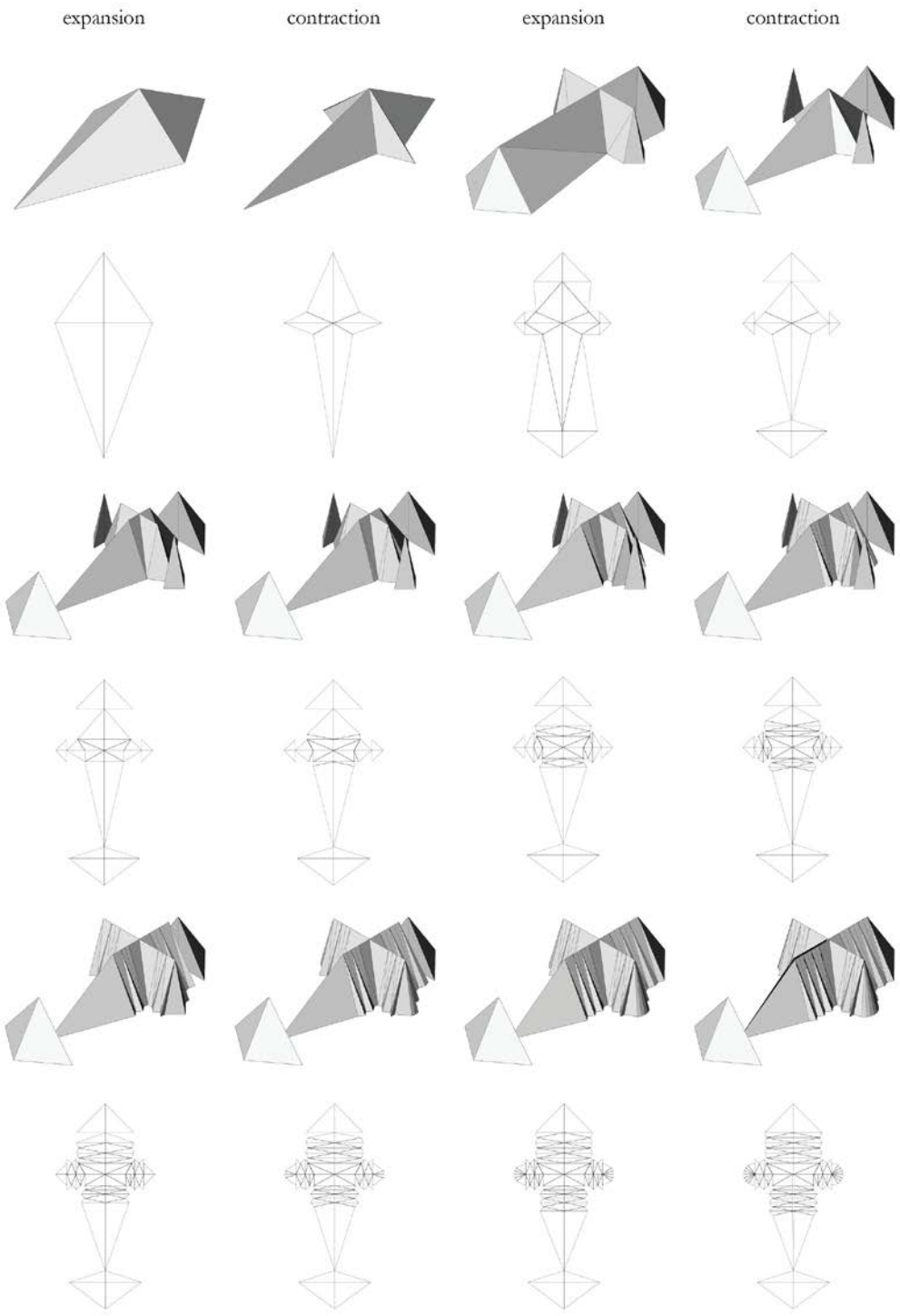

Figure 3.4.4.4 – Metamorphosis of Noyon Cathedral, part 1.

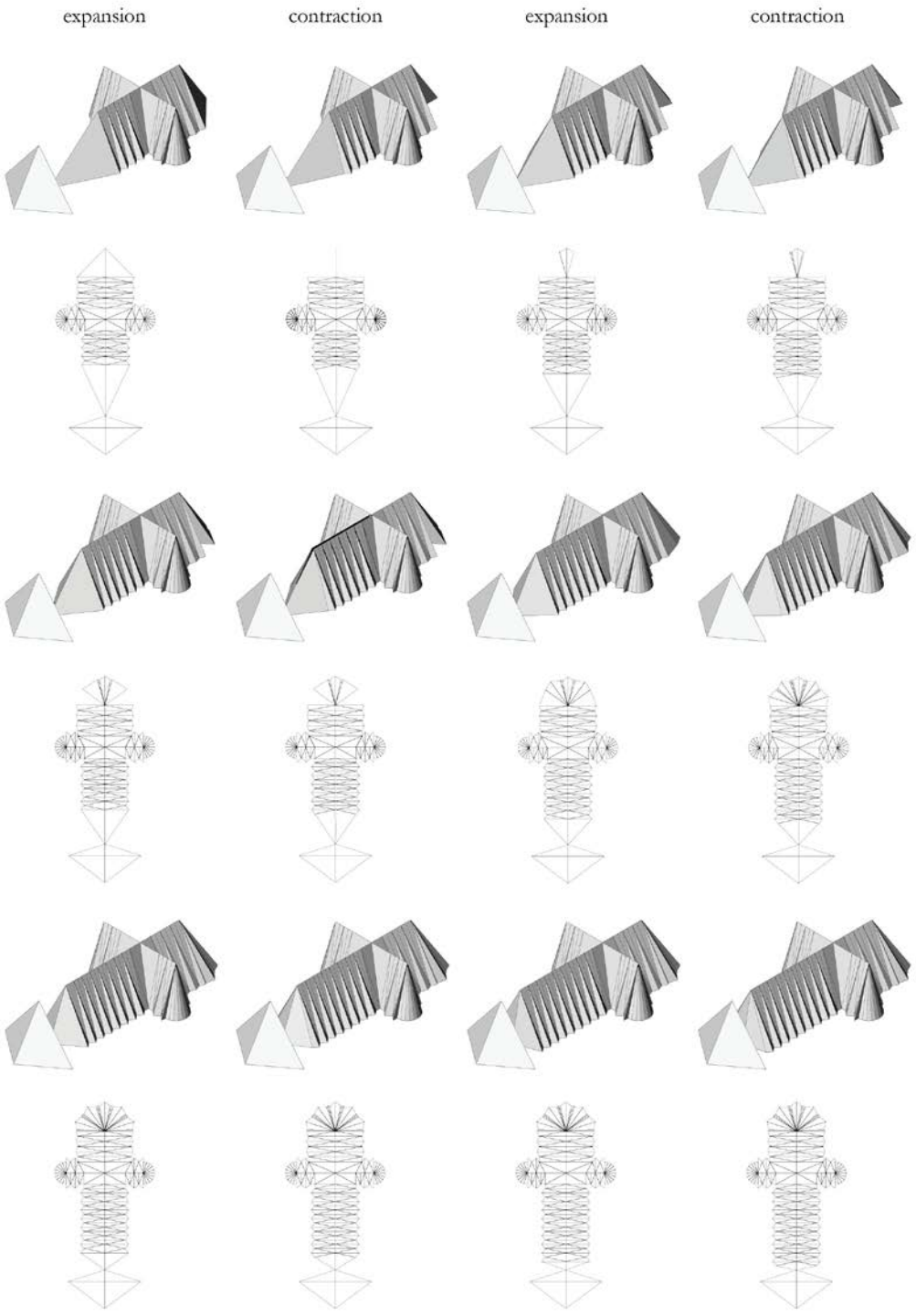

Figure 3.4.4.5 – Metamorphosis of Noyon Cathedral, part 2.

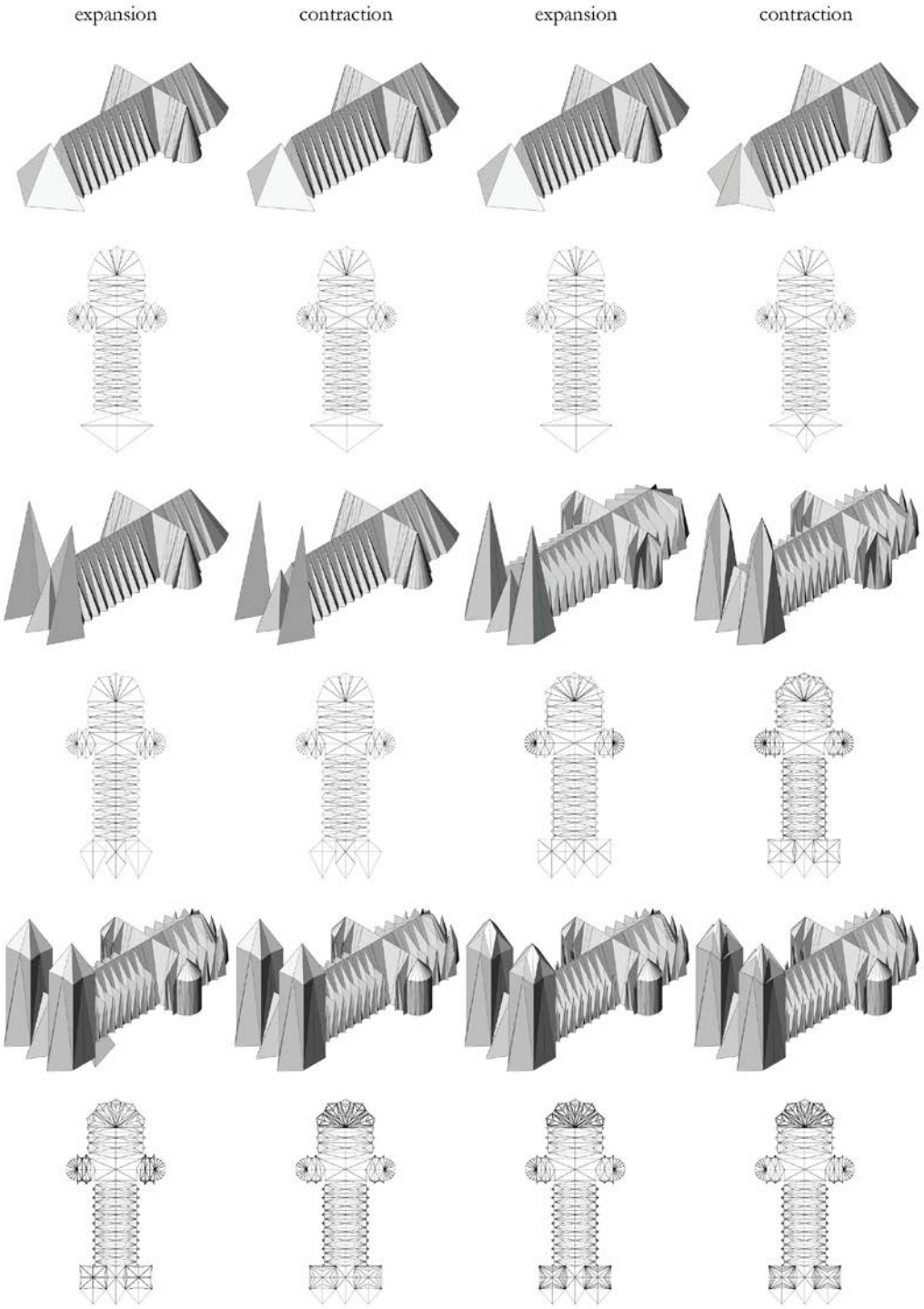

Figure 3.4.4.6 – Metamorphosis of Noyon Cathedral, part 3.

The vegetal capacity of the Gothic anatomy could be further expanded towards looking at the formation of mutant cathedrals where polarity could be used to generate structures that do not exist under natural conditions, yet can still showcase possible morphological outcomes. This Gothic teratology study shows properties akin to assemblages where a proliferative torso with multiple limbs, or appendages with different polarization could be produced. These variations are shown in the in figures 3.4.5.7-10. Among these, mutant cathedral #1 displays a quadruple organization of the torso that is terminated with three expansive wings that produce asymmetrical towers and a single contractive apse that establishes a body axis. The expansion of the narthex is compensated with the contraction of the naves that generate a rather lean massing.

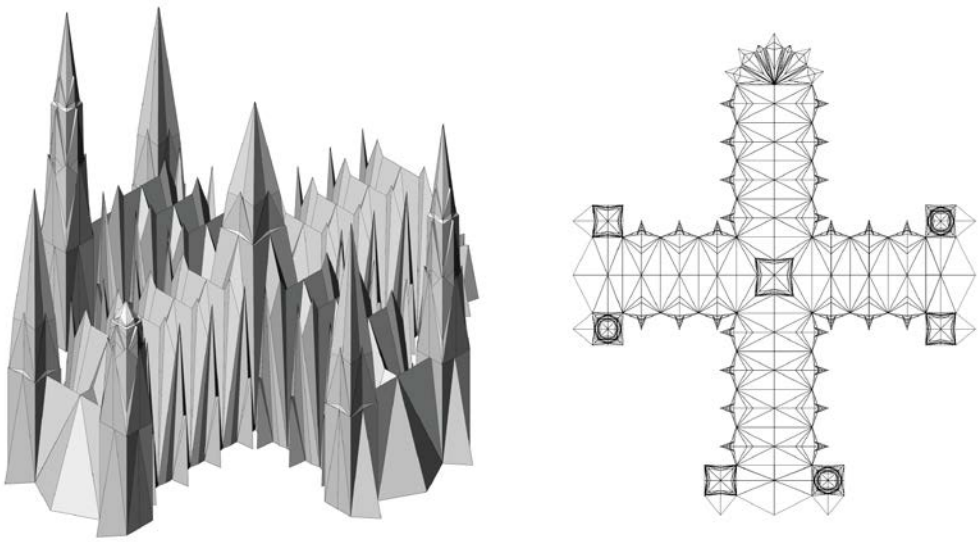

Figure 3.4.4.7 – Mutant Cathedral #1 with expensive tendencies showing no distinctive apse formation.

While cathedrals often terminate the torso with an expansive narthex and contractive apse along the ends of the torso, lack of polarization could also produce symmetrical systems where a torso with two contractive appendages and local spires

could be considered. This is shown in the mutant cathedral case #2, where the lack of polarization causes the torso to alternate between narthex and nave producing local spires along the sides of the body. The highly expansive torso is compensated with the contractive apse and narthex to close the body at both proximal ends.

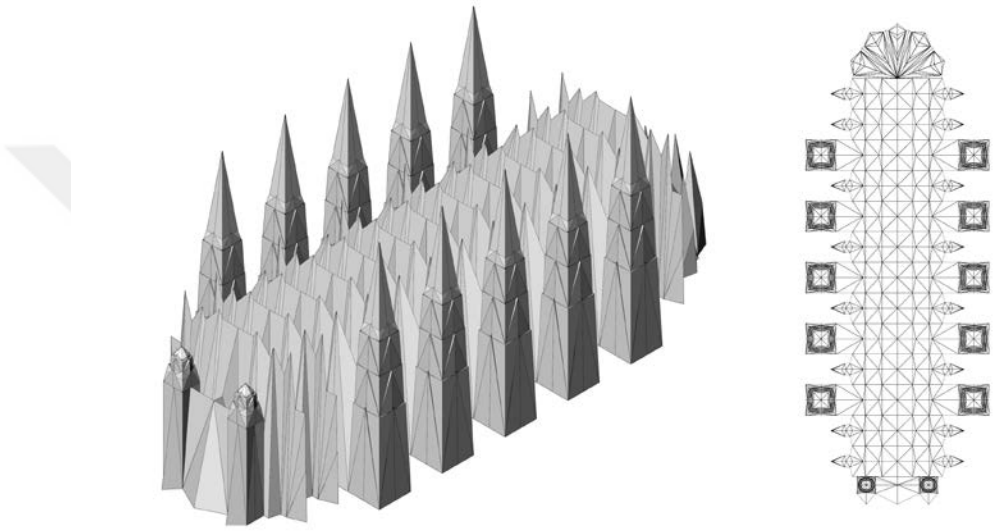

Figure 3.4.4.8 – Mutant Cathedral #2 with double apse showing and a torso made up of multiple narthexes.

Expansive tendencies in the torso could also yield asymmetrical limb formation that could be visualized in the mutant cases #3-4. In the former, the vegetative torso produces a ring of bays on the destral side that remains more contractive with apses located at distal ends. The opposite side repeats the termination of the main torso with an expansive narthex producing two towers. While the contractive pole shows a polarity towards the expansive side that produces three local spires at each crossing along the torso, the swelling of the bays towards the choir is compensated with the contraction of the nave and production of spires. In the last example, the expansive destral and the contractive sinistral transepts are contrasted with the production of apses and towers.

With the expansion of the transept the main body axis produces more of a tree structure with the local appendages terminating towards apses. While this contractive side still produces spires at each crossing, these remain contractive compared to the other half of the cathedral that shows more expansive tendencies in its vertical development.

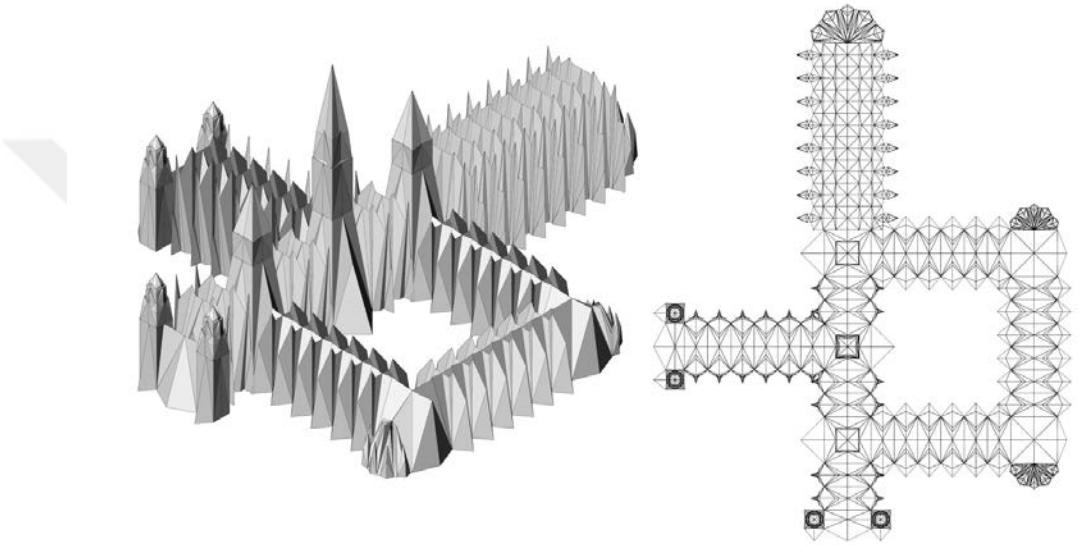

Figure 3.4.4.9 – Mutant Cathedral #3 with asymmetrical limb formation resulting in a contractive ring with apses, and an expansive wing with contracted spires.

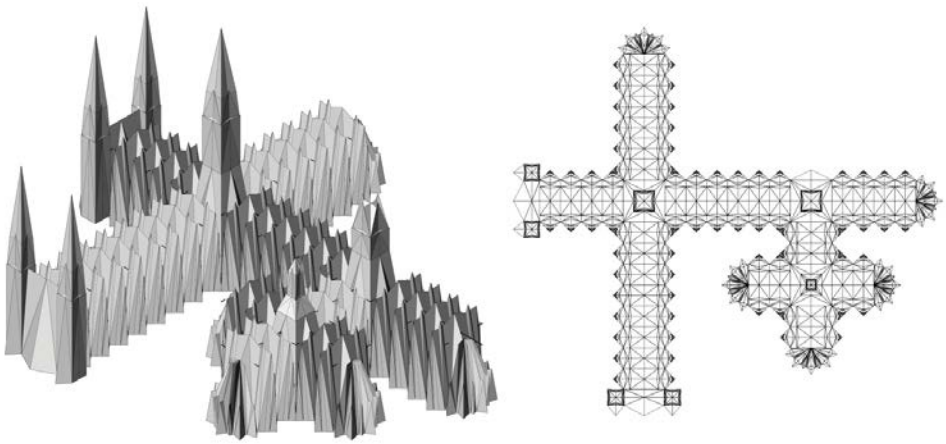

Figure 3.4.4.10 – Mutant Cathedral #4 with asymmetrical limb formation resulting in a expansive wing with multiple apses, and an expansive wing with contracted spires.

3.5 Conclusion: Goethean Morphology and Ecology of Design

Among most of his romantic works and scientific studies Goethe always uses landscape as a metaphor for organic development that is applicable to animals, plants and architecture.[962] This ecological view of the environment is deeply connected with the science of morphology where external factors could develop polarized effects on formal expressions of organisms. An example of this could be found in *Elective Affinities*, where character routes, views and architectural projects show morphological relationships to the polarized structure of the landscape.[963] While the landscape offers potential developmental models for morphology, it also presents ideas on ecology, evolution and variation and how polarity could offer new views for each category.[964] Prior to looking at how polarity could offer a two-fold ecological system, two different views on form and environment will be discussed through Darwinian and Lamarckian concepts of evolution and variation. These aspects will be extended towards architecture under the science of morphology that offers rules for development and environmental influences that can produce variation on body-limb relations. These case studies shown under four different categories will be used to discuss characteristics of a Goethean ecology of design while relating them to expansive and contractive environmental conditions.

One of the first cumulative theories on the ecological influence of evolution is presented in *Origin of Species* by Charles Darwin, who considers the progressive evolution and variation of species to be effected primarily by the law of natural selection

[962] For a discussion of the Goethe's aesthetic interest in landscape and systematic engagement with picturesque see McCormick, "Young Goethe in the Landscape."
[963] Goethe, *Elective Affinities*. These aspects are mainly developed in the first part of the thesis discussing the type of structures and their relationship to the moss hut.
[964] Waddington, *The Evolution of an Evolutionist*, 258. Conrad Waddington discusses the landscape as a model of morphogenetic development. This "epigenetic landscape" is structured via "chreodes" that are engraved into the topography of a valley to guide development of individual species during their movement from a high to low altitude.

that tries to establish fixed expressions and behaviors among species.[965] To study variation of species, Darwin considers "the ancient progenitor, the archetype as it may be called, of all mammals" to be extended towards comparative studies among species due to "the plain signification of the homologous construction of the limbs throughout the whole class."[966] This homology between parts of an organism and members of classes is applied towards understanding animal and plant structures, where "the bones of the skull are homologous with-that is correspond in number and in relative connexion with – the elemental parts of a certain number of vertebrae."[967] Similarly, all organs of the flower "sepals, petals, stamens and pistils" are composed of "metamorphosed leaves, arranged in a spire."[968] To discuss variation among these homologous structures, Darwin considers a natural selection to offer a law of compensation that is not attributed to internal structuring of morphologies, but towards external utility of their features that aid their survival. Although he considers a common universal law for how "some of the cases of compensation" should occur among the variation of species, these variations become stabilized because "natural selection is continually trying to economize in every part of the organization."[969]

> Natural selection acts solely through the preservation of variations in some way advantageous, which consequently endure. But as from the high geometrical powers of increase of all organic beings, each area is already fully stocked with inhabitants, it follows that as each selected and favored form increases in number,

[965] Darwin, *The Origin of Species.*
[966] Ibid., 435.
[967] Ibid., 436
[968] Ibid.
[969] Ibid., 147.

so will the less favored forms decrease and become rare. Rarity, as geology tells us, is the precursor to extinction.[970]

To exemplify the dynamics of natural selection, Darwin considers the morphology of the mole showing no eye development "probably due to gradual reduction from disuse" from mainly living underground.[971] He describes a polarity between the sensory organs of the animal as eye contracts other appendages of the head are expanded: "natural selection will often have effected other changes, such as an increase in the length of the antennae or palpi, as a compensation for blindness."[972] However, he considers the effects of external factors on morphological expression to be "extremely small in the case of animals, but perhaps rather more in that of plants but aided perhaps by natural selection."[973] While Darwin proposes polar tendencies for the law of compensation, his view on how morphological variations are expressed relies outside in organic form that relates adaptation to natural selection so that unfit organisms are destined for extinction.

In *Evolution in Four Dimensions*, Eva Jablonka and Marion J. Lamb look for alternative theories of evolution to offer a new synthesis influenced by Lamarckian dynamics of inheritance of traits.[974] For the variation of species, they consider a more teleological dimension where traits are firstly "*targeted*, in the sense that it preferentially affects functions or activities that can make organisms better adapted to the environment; and secondly "constructed, in the sense that, whatever their origin, which variants are

[970] Ibid., 109. Richard Dawkins, *The Extended Phenotype: The Long Reach of the Gene* (New York : Oxford University Press, 1990), 210. Dawkins extends this law of compensation towards the polarized activity of the genes. He discusses this aspect by looking at the snail shells: "Genes for too-thin shells therefore endanger their germ-line copies, which are thus not favored by natural selection. Shells that are too thick presumably protect their snails superlatively, but the extra cost of making a thick shell detracts from the snail's success in some other way."
[971] Ibid., 137.
[972] Ibid., 138.
[973] Ibid., 132.
[974] Eva Jablonka and Marion J. Lamb, *Evolution In Four Dimensions: Genetic, Epigenetic, Behavioral and Symbolic Variation in the History Of Lif*e, illustrations by Anna Zeligowski (Cambridge ; London : MIT Press, 2014).

interited and what final form the assume depend on various 'filtering' and 'editing' process that occur before and during transition."[975] This combination of internal direction and refinement is defined as "soft inheritance" following Ernst Mayr, "when the hereditary material (or process) is not constant from generation to generation but can be modified by the effects of the environment or the organism's activities-it qualifies as Lamarckian inheritance."[976] Jablonka and Lamb discuss the role of DNA methylation as a potential candidate for gene modification and inheritance occurring in organic bodies. Although not much is known on how this process occurs, it tends to question the central dogma of biology in how DNA, RNA and protein synthesis work as other ways of replicating information could potentially be discovered among cells. While DNA methylation acts primarily as a defense mechanism for cells to detect foreign DNA that could cause harm, it could also "have been recruited for the regulation of normal gene expression and cell memory."[977] As a result, they consider a morphological and genetic link between how variations and traits could be passed between species and generations. While being critical of the gene-centered view of neo-Darwinian theory of evolution, "as molecular biology uncovers more and more about epigenetic and genetic inheritance, and as behavioral studies show how much information is passed on to other by non-genetic means," they state that Darwinian theory must be reevaluated and "efforts must be made to incorporate multiple inheritance systems and educated guesses they produce."[978]

Compared to Darwinian natural selection and Lamarckian inheritance, in his morphological writings Goethe develops an intrinsic law of compensation where a "limit is set to nature's structural range" driven by polarized relationships established in animal

[975] Ibid., 319.
[976] Ibid., 229.
[977] Ibid., 330.
[978] Ibid., 344.

bodies.[979] Goethe compares giraffe with mole, where the former shows expansive appendages and a contracted torso compared to the opposite relationship found in the latter with a more contracted torso lacking segmentation of the head and formation of eyes. He relates this phenomenon to the allocation of nourishment in the body for polarized development of its parts to establish an overall budget metaphor for animal morphologies.

> These are the bounds of animal nature; within these bounds the formative force seems to act in the most wonderful, almost capricious way, but is never able to break out of the circle or leap over it. The formative impulse is given hegemony over a limited but well-supplied kingdom. Governing principles have been laid down for the realm where this impulse will distribute its riches, but to a certain extent it is free to give to each what it will. If it wants to let one have more, it may do so, but not without taking from another. Thus nature can never fall into depth, much less go bankrupt.[980]

While Goethe considers the direct influence of the environment for the evolution of species, he doesn't consider this to be an extrinsic function of adaptation, but an intrinsic driving force of the archetype. Similar to how polarity structures the budget along the body, he considers the environment to pose polarized influences through the bloating and drying effects of water and air (Fig.3.5.1). For the former, he mentions marine mammals that show "a marked bloating effect on bodies" however, due to the "laws of the archetype, this swelling of the body must be followed by a contraction of the

[979] Goethe, *Scientific Studies*, 120.
[980] Ibid., 121.

extremities or auxiliary organs."[981] In contrast, "the air, by absorbing water, has a drying effect" and becomes more suitable for lighter and lean animals, particularly birds.[982] Goethe mentions that the amount of material that is not used for the body is utilized towards clothing them with expansive auxiliary organs that could also be clothed with fur and feathers. He also discusses hybrid cases, such as stork and sandpiper that show contracted hind limbs adapted for swimming and expanded forelimbs that are fit for flight.

Figure 3.5.1 – Polarity between body and limbs depending on the environmental conditions.

Compared to Darwin's reductionist and Lamark's deterministic views on evolution, Goethe considers a more indirect engagement between species and the

[981] Ibid., 122.
[982] Ibid.

environment where the latter does not impose a teleological trajectory but instead influences certain morphological expressions. In "Toward a General Comparative Theory," Goethe extends the interrelationship of species and environment towards one of polarization, where the environment shows more direct influence on the appearance of animals, but their internal structure remains conditioned by polar relationships of the archetype.[983]

> An initial and very general observation on the outer effect of what works from within and the inner effect of what works from without would therefore be as follows: the structure in its final form is, as it were, the inner nucleus molded in various ways by the characteristics of the outer element. It is precisely thus that the animal retains its viability in the outer world: it is shaped from without as well as from within. And this is all the more natural because the outer element can shape the external form more easily than the internal form. We can see this most clearly in the various species of seal, where the exterior has grown quite fishlike even though the skeleton still retains all the features of a quadruped.[984]

Although species and environment are in polarized relationships, this does not impose any deterministic outcomes for morphology; but instead, form as a mediator of internal and external space constantly offers a balance of forces and developmental traits.[985] Tantillo considers the law of compensation as an open-ended trajectory for evolution where "nature is free to allocate the resources within limitations of the

[983] Ibid., 55.
[984] Ibid.
[985] Craig Holdrege, "Seeing the Animal Whole," in *Goethe's way of Science: a phenomenology of nature*, ed.David Seamon and Arthur Zajonc *(*Albany, NY: State University of New York Press, 1998): 213 – 232. Holdrege considers animals to reveal the environments they live in with their morphologies. He compares the horse and lion limbs to state that in the former : :the fewer bones mean fewer joints; the fewer the joints, the fewer the muscles. The flexibility the horse thereby loses in the leg is compensated for the stability and strength it gains through its bone structure."

budget."[986] The evolution of the sloth from the ancient Megatherium shows that evolution is also polarized with double trajectories as in these species "striving is not necessarily a positive progression."[987] This shows that expansion is progressive, whereas contraction is essentially retrogressive, however, both trajectories satisfy the needs of an animal for survival as its form is adapted to the conditions of its environment.

In *The Evolution of Designs,* Philip Steadman revisits the historical development of biology and studies the influence of scientific approaches towards the theoretical development of architecture in the nineteenth and twentieth century.[988] In considering an organic link between architecture and biology, Steadman compares Darwin's "elective" and Lamark's "instructive" theories of evolution, stating that in the former "environment chooses appropriate changes in organisms from the range offered by variation and considers cultural development more along the latter characteristics" whereas in Lamarckism "the environment is imagined to be able to exercise a direct effect on organisms."[989] Speculating on the applicability of biological analogies towards design, he considers the scientific approaches to project "functional determinist" approaches towards art and architecture that often tend towards failure.[990] In terms of defining a fitness value for architecture, he criticizes both the anthropocentric approaches as relying on "a concept of intended purpose" or aesthetic judgment, and scientific approaches that try to exclude the designer to define a causal relationship between form and function in

[986] Tantillo, *The Will to Create*, 115.
[987] Ibid., 123. Tantillo compares two-toed and three-toed sloths as evolved versions of the Megatherium. The retrogressive evolution is contractive in the animal where the large bone structure is replaced with mobility of limbs and contraction of the head. Richards, *The Romantic Conception of Life*, 484. On the law of compensation Richards develops similar remarks and relates the retrogression of sloth to the lack of nutrition for development: "if food supplies had been reduced, there would have been a comparalbe reduction in the size of the primitive animal; and a slower moving creature would have allowed for an expansion of the limbs, thus producing the awkward modern sloth."
[988] Philip Steadman, *The Evolution Of Designs: Biological Analogy In Architecture And The Applied Arts* (London : Routledge, 2008).
[989] Ibid., 180.
[990] Ibid., 183.

an "automatic, deterministic" manner.[991] This dichotomy between artistic creativity and structural engineering becomes the scope of Steadman's investigation to seek an alternative approach due to the contingent "interaction between form and function" on top of the reciprocal influence between form and environment.[992] He reviews the historical approaches towards defining function or fitness in design as leading to abstraction where "the biological analogy was conducive to a belief in functional determinism in design; it removed the designer, it encouraged an exclusive attention to utilitarian functions, and it suggested that designed objects were the product of selection exercised by their 'functional environments'."[993] But he states that "both processes, the creation of scientific hypotheses and of architectural form, demand invention and are *not* logically deductive ones, nor are they capable of being mechanised."[994] Yet, he still considers that both fields could be combined under "same theoretical and analytical tools" that can bring "potential application of some ideas from the theory of systems, coming from biology, to the sciences of the artificial."[995] Steadman finds such unification in Goethe's morphology that demands a similar extension towards architecture.[996]

Goethe's consideration for a polar ecology is analogous to Humboldt's biogeography where the altitude and climate show direct influences on the morphological expressions of species.[997] However, Goethe is more interested in the effects of polarity

[991] Ibid., 183.
[992] Ibid., 191.
[993] Ibid., 198.
[994] Ibid., 199.
[995] Ibid., 234.
[996] Ibid., 235-6. Towards the end of the book Steadman quotes from W. R. Lethaby who advocates for such extension towards creating an architectural morphology based on unified laws: "Some day we shall get a morphology of the art by some architectural Linnaeus or Darwin, who will start from the simple cell and relate it to the most complex structure." William R. Lethaby, *Architecture* (London, 1911; 3rd edn, Oxford, 1955), 2.
[997] Richards, *The Tragic Sense of Life*, 21.

towards development where he contrasts aridity with moisture and hot with cold weathers that through their mixtures produce novel species.[998]

> We will find the effect of climate, altitude, heat and cold, together with that of water and common air, to be quite powerful in the formation of the mammal as well. Heat and moisture have a bloating effect and produce apparently inexplicable monsters, even within the limits of the archetype; heat and dryness produce the most perfect and fully formed creatures, no matter how they may differ from man in nature and form–the lion and tiger, for example. Thus only a hot climate is able to impart a semblance of man to imperfect organisms, as happens in the ape and parrot.[999]

The influence of altitude and climate could also be extended towards architectural bodies where the polarization of parts and whole show expansive and contractive tendencies. Humidity often results in more vertical development and expansive plans as can be found in Northern Gothic, whereas in southern styles horizontality is more expressed, as can be seen in Baroque palaces and Palladian Villas.[1000] This also causes certain expansive-bloating and contractive-lean effects on massing of cathedrals. For instance, Notre-dame and Bourges develop a highly expanded torso, whereas Salisbury and Laon show more contractive torsos and expansive limbs. In this sense, Bony's comparison of Northern and Parisian Cathedrals could be extended towards a more

[998] Goethe, *Goethe's Botanical Writings*, 136. Goethe also makes similar remarks for plant morphology by contrasting leaf and root (stem). The former develops primarily in light and aridity, whereas the stem needs moisture and darkness.
[999] Goethe, *Scientific Studies*, 122.
[1000] Bony, *French Gothic Architecture*, 133-134. Bony describes a symmetry for the axial development of northern plans that "point in the four directions of the compass." The transepts mimic either the development of the choir or the nave, where "the triple repetition of the choir pattern or trefoil plan."

morpho-ecological comparison among other styles of architecture (Fig.3.5.2).[1001]

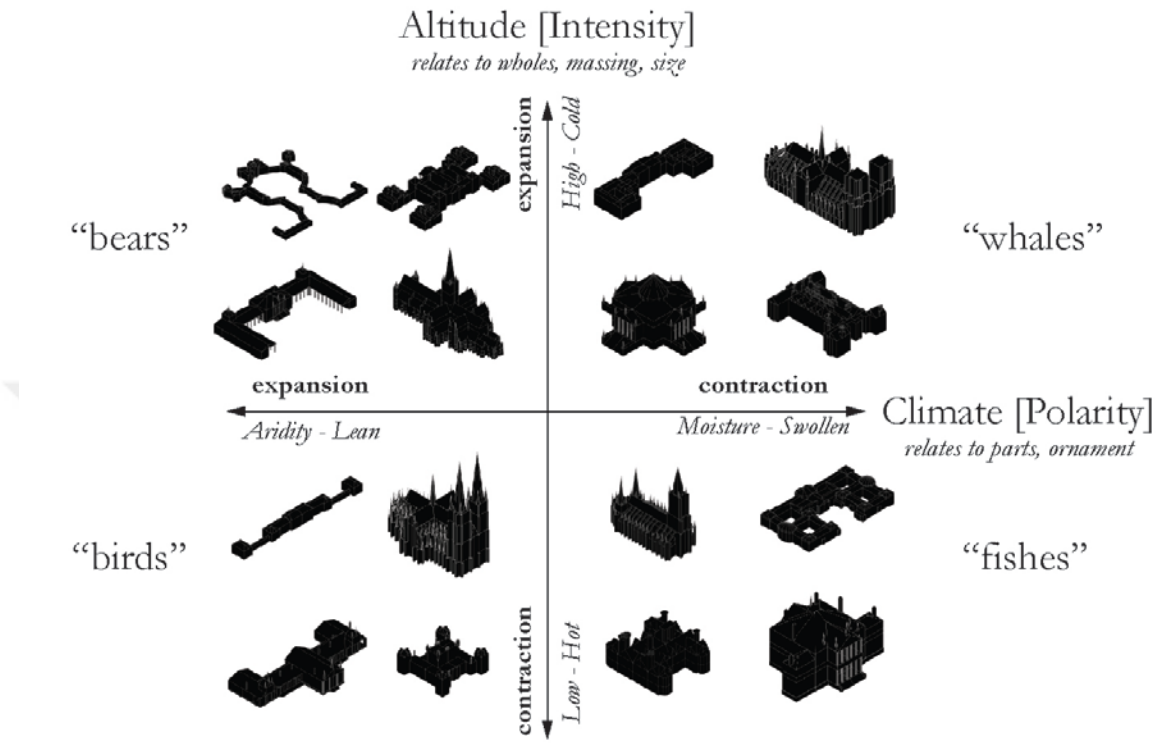

Figure 3.5.1 – Polarized ecology of Architectural Morphologies showing four categories based on the interrelationship of altitude and climate associated with animals to signify their morphological body-limb ratios and placement in the quadruple matrix.

When applied towards architecture, Goethe's concept of polarization as a mediator between internal structural development and external adaptation or activity of species, could offer morpho-ecological comparisons among various precedents examined in this thesis. In architecture, massing is often directly influenced by altitude and placement within urban or rural areas. While an increase in altitude often results in contraction; in the ground plan, as in most Palladian Villas and English Manor houses, or

[1001] Ibid., 131.

placement within a densely packed urban context as in Notre-Dame Cathedral.[1002] In contrast, English Gothic Cathedrals such as Salisbury and Lincoln show similar expansive development akin to Baroque palaces due to their placement in open landscapes and lower altitudes. Similarly, altitude affects the overall size of buildings by either contracting their size or expanding their surface area or volume. With their similar morphological developments in horizontal and vertical directions, Baroque Palaces could be considered as expanded Palladian Villas, and English Manor houses could be viewed as contracted Gothic Cathedrals. This contrast resembles the polarization between the summer house and manor house in *Elective Affinities*, with the former acquiring traits akin to Palladian Villas or English manor houses, and the latter appears as a Baroque Palace. In this way, Goethean morphology, as a polarized model of ecology, offers a cumulative view of the architectural landscape where all buildings are both internally and externally adapted to their environment by distributing their resources towards their form.

[1002] Spuybroek, *The Sympathy of Things*, 63.

APPENDIX A. PSEUDO CODE FOR EMBRYOGENESIS ALGORITHM

Step 1: Initialize Polarity Parameters, Axis Poles (A, B) from a Gravity Center (O).

Step 2: Send Axis Points (A, B) to embryogenetic growth function (EGF) with Expansion Switch as True.

Embryogenetic Growth Function (EGF)

Inputs: Point A, Point B, Origin Point O, Polarity Switches

While Total number of growth cycle count (C) is greater than zero
- **If** Contractive Growth
  - **If** Thresholds Are Satisfied For Contraction
    - **If** Switch is Expansion
      - Find new point (P) along axis using Expansion (A, B)
      - Contractive-Expansion Parameters: Polarity, Intensity, Rotation
    - **Else**
      - Find new point (P) along axis using Contraction (A, B)
      - Contractive-Contraction Parameters: Polarity, Intensity, Origin Point
    - Send New Axis #1 (P, A) back To Step 3, Adjust Switches, Adjust Parameters, Increment C
    - Send New Axis #2 (P, B) back To Step 3, Adjust Switches, Adjust Parameters, Increment C
  - **Else**
    - Send Axis (A, B) back To Step 3, Increment C
- **Else If** Expansive Growth
  - **If** Thresholds Are Satisfied For Expansion
    - **If** Switch is Expansion
      - Find new point (P) along axis using Expansion (A, B)
      - Expansive-Expansion Parameters: Polarity, Intensity, Rotation
    - **Else**
      - Find new point (P) along axis using Contraction (A, B)
      - Expansive-Contraction Parameters: Polarity, Intensity, Origin Point
    - Send New Axis #1 (P, A) Back To Step 3, Adjust Switches, Adjust Parameters, Increment C
    - Send New Axis #2 (P, B) Back To Step 3, Adjust Switches, Adjust Parameters, Increment C
  - **Else**
    - Send Axis (A, B) back To Step 3, Increment C
- **Else**
  - Visualize Axis Line (A, B)

Expansion Function

Inputs: Point A, Point B, Polarity P, Intensity I, Rotation R

Step 1: Evaluate a new point (NP) along axis (A, B) using P

Step 2: Define axis vector (V) from point B To A

Step 3: Rotate axis vector (V) from A towards B using R

Step 4: Amplify Axis Vector (V) Using I

Step 5: Displace NP using scaled and rotated V

Step 6: Return NP

Contraction Function

Inputs: Origin point O, Point A, Point B, Polarity P, Intensity I, Rotation R

Step 1: Evaluate a new point (NP) along axis (A, B) using P

Step 2: Define axis vector (V) from N P towards O

Step 3: Rotate axis vector (V) from A towards B using R

Step 4: Amplify axis vector (V) using I

Step 5: Displace NP using scaled and rotated V

Step 6: Return NP

APPENDIX B. PSEUDO CODE FOR ONTOGENESIS ALGORITHM

Step 1: Initialize polarity parameters for ontogenesis.

Step 2: Define number of leaves in the sequences.

Step 3: Start EGF for each leaf in the sequence using Ontogenetic Growth Function (OGF).

Ontogenetic Growth Function (OGF)

For Each leaf axis (A, B)

Interpolate embryogenesis parameters (polarity, intensity, rotation and threshold) using starting, middle and end values for each parameter

Send leaf axis (A, B) to EGF with interpolated parameters

Visualize leaf

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