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Goethe's Plant Morphology: The Seeds of Evolution

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It has long been debated whether the scientific writing of Johann Wolfgang von Goethe (1749-1832) provided the seeds for the theory of evolution. Scholars have argued both sides with equal passion. German biologist and philosopher, Ernst Haeckel (1834-1919) wrote, "Jean and Lamarck and Wolfgang Goethe stand at the head of all the great philosophers of nature who first established a theory of organic development, and who are the illustrious fellow workers of Darwin."[1] Taking the opposite stance was Chancellor of Berlin University, Emil du Bois Reymond (1818-1896). Du Bois was embarrassed by Goethe's forays into science. He wrote, "Beside the poet, the scientist Goethe fades into the background. Let us at long last put him to rest."[2] I argue that Goethe's scientific writings carry in them the seeds of the theory of evolution. Goethe's works on plant morphology reflects the conflicting ideas of his era on the discreteness and on the stability of species. Goethe's theory of plant morphology provides a link between the discontinuous view of nature, as exemplified in works of the Swedish botanist Carl Linnaeus (1707-1778), and the continuous view of nature, as exemplified in the work of the English naturalist Charles Darwin (1809-1882).

Although best known for his literary works, such as *Faust, Die Leiden des jungen Werther,* and *Wilhelm Meister*, Goethe was also deeply involved with the sciences. Some of his biographers lament that Goethe's literary productivity was impeded by all the time he spent pursuing his interests in comparative anatomy, metallurgy, meteorology, color theory and botany.[3] Goethe himself said that he valued his work as a scientist more than his poetic work.[4] He pursued a wide range of interests over the course of his 83 years of life. Until the very end of his life he was vitally interested in science. In his last letter, Goethe wrote about the debates on fixity of species taking place in the French Royal Academy of Science. Goethe's thoughts on science are both original but also reflect the spirit of the times.

Goethe is described sometimes as an Enlightenment and sometimes as a Romantic thinker, for indeed his life spans both of these periods. In many respects, Goethe's approach to science

[1] Goethe, Wolfgang Johann von. *Goethe's Botanical Writings*, translated by Bertha Mueller. Hawaii: University of Hawaii Press, 1952. 15.
[2] Magnus, Rudolf. *Goethe as a Scientist.* translated by Heinz Norden. Leipzig: Henry Schuman, 1947. xi.
[3] *Goethe's Botanical Writings*, 6.
[4] Magnus, 42.

reflects those typical of eighteenth century Europe. Goethe, as were most of his contemporaries, was swept up in geometrical spirit ushered in by the German mathematician Gottfried Wilhelm Leibnitz (1646-1716) who is credited with the dissemination of calculus.[5] Scientists of the eighteenth century embraced mathematical method, exact definition, and proof of propositions, and applied these rigorous methods of analysis to the development of systematic. The Enlightenment ushered in an era wherein people turned away from religion to explain the natural world, and sought explanation instead through the search for the laws of nature. These effects could be felt not just in the sciences but also in the daily lives of the eighteenth century Europeans. People were witnessing the rapid dissection and classification of the world around them. Since 1673 the measure of time had become more accurate through the invention of Christian Huygens' pendulum clock.

Goethe was also affected by the controversies surrounding the adoption of a more accurate and uniform system of measure, the decimal system. In *Faust* Goethe has the witches toy with alternate numbering systems not based on ten.[6] Even people's vernacular language was slated for improvement during the age of quantification. There were several proposals to make language more accurate and suitable for science by adopting universal languages either, as in the case of Linnaeus, by using Latin in a systematic way, or, as in the case of György Kalmár, by using calculus as a basis for an invented universal language. Goethe was also interested in the debates about accuracy in scientific language. On his journey to Italy from 1786-1788, Goethe wrote about the arbitrariness of nomenclature and played with the descriptive and labeling functions they fulfill.[7] Goethe is often described as an Enlightenment thinker who was fully immersed in the age of quantifications and, as we shall see, his work in the sciences reflects much of the geometrical spirit of that era.

Goethe's work in the sciences, however, also reflects the subsequent *Zeitgeist* or spirit of the times. Although he partook in the spirit of quantification of the Enlightenment, the following era of Romanticism equally influenced him. "Goethe's Faust spurns knowledge 'extorted with levers and screws', longing instead for a grasp of Nature's secret elements, her hidden active forces, the harmony of the whole of her parts."[8] Instead of the geometrical spirit, which strove to dissect, systematize and find the mechanisms of nature, the guiding spirit of the Romantic era became known in the German-speaking world as *Naturphilosophie* or natural philosophy. The Romantic scientists revolted against the analytical methods of their predecessors and sought to apply more synthetic methods; instead of looking for

[5] Leibnitz vies with English physicist Isaac Newton (1642-1727) for credit for the invention of calculus. It is Leibnitz' system of notation, however, that came into widespread use.

[6] "Desired Reconciliations: On Language as Experiment," MLN, Vol. 103, No. 5. Comparative Literature. (Dec., 1988) 1056-1071.

[7] "Italienische Reise" *Werke*, 11: 461.

[8] Andrew Cunningham and Nicholas Jardine in their Preface to *Romanticism and the Sciences*, xix.

fine differences Romantic scientists looked for similarities. The German biologist Gottfried Reinhold Treviranus (1776-1837) wrote that in the new science of life "the observations of the vital phenomena of animals and plants … receive their proper place and unite themselves into a whole…"[9] The French anatomist Etienne Geoffroy Saint-Hilaire (1772-1844) believed that nature made all living beings with one unique plan. Immanuel Kant (1723-1804) emphasized that scientists should examine the idea of a whole in its natural context. Kant's thought guided the German explorer and naturalist Alexander von Humboldt (1769-1859) to describe the vegetation of the new world in its native geography instead of merely bringing back plant specimens in order to classify their parts. Just as he had been intimately immersed in scientific developments of the Enlightenment, Goethe was involved with the scientific enterprises of Romantic thinkers, and is credited by some as one of the leading figures in the promotion of synthetic method.

At the heart of the difference between the Enlightenment and Romantic worldview lies the question of how much of the world is knowable to man. Many scientists of the Enlightenment believed that it was just a matter of time until every last word, mollusc, tuber, and compound was cataloged whereas many scientists of the Romantic era doubted that this feat could ever be achieved. Although there are many fascinating studies in encyclopedism and the backlash against the bean counters and aggregators, we will take as our example the field of botany. Goethe devoted many years to the study of plants and in his voluminous writings on the topic, we will see, portrayed the struggle to come to terms with perhaps the most pregnant question of his generation, namely the discontinuity or continuity of nature. Some botanists believed species to be discrete and stable, whereas others believed that species blended from one to the next with difficult-to-discern boundaries and that species also changed over time. Goethe's work on plant morphology reflects the conflicting ideas of his era. After a brief look at contemporary ideas on fixity of species held by prominent Enlightenment and Romantic natural scientists, we will place Goethe's botanical work in context by examining primarily the botanical systems and of Carl Linnaeus.

Goethe's contemporaries all came from a tradition of natural history that placed high value on accurately passing on information collected by ancient authorities, whether Biblical or Christianized knowledge of the ancient Greeks. Over the centuries ancient authority was passed down through manuscripts, which were repeatedly copied by hand. Such manual copying led to the perpetuation and accumulation of mistakes. Scientists of the Renaissance paved the way for Enlightenment science in that they began to look for answers in nature instead of in written documents. By turning to the natural world with a fresh eye, scientists found that neither the Bible nor the ancients had fully accounted for all of

[9] My translation from *Biologie, oder Philosophie der lebenden Naturfür Naturforscher und Aertzte,* 7-8.

nature. In the Renaissance science became the hobby and occupation of numerous upper class men. Much of the scientific work these people did had to be done in secret because new discoveries and interpretations could propose a threat to church order. One famous example of such a case is that of Galileo, who was tried for heresy because of his views. By the eighteenth century the belief in the absolute authority of the Bible and of the ancients had begun to wane, and it had become possible for men of varied classes to engage in science without the fear of punishment from the church. Those who found themselves with leisure time could engage in scientific experiments, or the building of cabinets of curiosities, or collecting specimens. With the accumulation of new data, Enlightenment scientists felt the need understand the laws behind nature's systems. This is the era into which Goethe was born and, like many of the men of his class, he took up the sciences. The leisure class often employed guides from the lower classes to show them the ropes. The lower classes typically lived in closer contact to nature and possessed folk-biological wisdom. Thus the interest in science spread through many levels of society to further undermine the absolute authority of religion and scholasticism.

Goethe encountered natural scientists of many persuasions, some of whose views were backward looking and some were forward looking. Opinions diverged about natural history diverged greatly in the eighteenth and nineteenth centuries. Today Darwin's theories of specialization, natural selection and evolution of species are accepted and are seemingly obvious, but in Goethe's era creationists and transmutationalists were on more equal footing. Enlightenment scientists who placed great store in the past, generally held views of natural history based on religion and Aristotelianism. There were those who believed in remnants of the ancient authorities and the creation story, others who were, with varying degrees of vociferousness, secular transmutationalists, and a whole range in between. Religion and fixity of species was being hotly debated in scientific circles. On the conservative end of the spectrum, Goethe was familiar with the great English botanist John Ray (1627-1705). Ray believed that in a single act of creation all species were designed in their perfect states. In 1686 in *Historia plantarm* Ray wrote, "the number of species in nature is certain and determined: *God rested on the sixth day, interrupting his great work* – that is the creation of new species."[10] Ray believed that species were defined by essences that stemmed from an exemplar or idea in the Divine Mind. However these "essences of things are wholly unknown to us. Since all our knowledge derives form sensation, we know nothing of the things that are outside us except through the power they have to affect our senses."[11] Ray believed that species were fixed and had essences but that individuals of a species varied in their

[10] Ray as quoted in Scott Atran. *Cognitive Foundations of Natural History*. Cambridge: Cambridge University Press, 1990: 162
[11] Ray as quoted in Atran: 163.

outward manifestations. These outward manifestations were all naturalists had at their disposal in making classificatory systems. Even after Ray's death, many scientists of Goethe's time embraced Ray's views concerning fixity of species.

The notion that organisms were created and then replicated copies of themselves – like nested Russian dolls – was quickly losing currency as the eighteenth century progressed. Three major discoveries called fixity of species into question: the fossil record, an increasing awareness of hybridization and European voyages of discovery. First, naturalists had at their disposal a growing number of fossils, some of which did not seem to represent any living species. The fossil record indicated that species change over time and even become extinct. Second, naturalists were becoming more and more aware of fertile hybrids; new species could emerge through experiments and in the wild through interbreeding between species. Third, previously unknown species were being discovered by Europeans in the Americas, Asia and in the Indies. These new specimens stretched the limits of Enlightenment systems. All new theories had to address the historical aspect of change, the stability and the diversity of species or, in other words, new theories of natural order had to account for the temporality and morphology of organisms. Thus began the questioning of the strictly analytical systems of the Enlightenment and the formulation of the more synthetic systems typical of the Romantic era.

Perhaps the least radical proposal put forth by one of Goethe's contemporaries was that of French naturalist Léopold-Chrétien-Frédéric-Dagobert (George) Cuvier (1769-1832), who is best known for his skill in comparative anatomy. He came to theorize that the creator began with basic forms. In the animal kingdom, for example, these forms could be divided into several contemporary branches, or *enbranchements* as he calls them. Animals could change in outward appearance within each branch. Due to functionally driven pressures to adapt to the environment, Cuvier believed there could be gradual transitions between organisms with the same basic plan. However, as he writes in 1805 in *Leçons d'anatomie comparée:*

> [T]hese smooth and invisible nuances are observed only so long as one remains within the same combination of principal organs, as long as the major provinces remain the same…but as soon as one passes to those which have other principal combinations, there is no more resemblance in anything, and one cannot mistake the interval or marked leap.[12]

For Cuvier distinct branches each began with typical principal organs. Over time, change could occur within these branches through modification of the principal organs but the branches always remained divisible by a "marked leap."

French naturalist Jean-Baptiste-Pierre-Antoine de Monet, Chevalier de Lamarck (1744-1829) represented a more radical adaptive and phylogenetic viewpoint. Lamarck is perhaps best

[12] Cuvier as quoted in Peter Stevens. *The development of biological systematics: Antoine-Laurent de Jussieu, nature, and the natural system.* New York: Columbia *University* Press, 1994: 70.

known for his notion that fossil records could be explained through the inheritance of acquired characteristic. Starting from the simplest of organisms, he believed one could trace a continuous development into the more complex. Although, analysis was for Lamarck a convenient way to identify and classify organisms and provided an artificial and arbitrary tool for naturalists, he nevertheless placed more store in the synthetic method to discover nature in its undivided entirety. In 1778 in *Flore françoise,* Lamarck wrote, "The order that is being discussed here, instead of being a confusing mass of names and ranks thrown together at random, will on the contrary form a whole subject to fixed rules, which, however, do not divide it, and do nothing except to determine the place which each species much occupy in the general series."[13] Lamarck differs from Cuvier in that he believed that all species could be traced to one common origin. His views were more radically transformational than Cuvier and they provided a basis for the work of other naturalists who wanted to extend the theories of spatio-temporal morphology.

French naturalist Étienne Geoffroy Saint-Hilaire (1772-1844) established the principle of "unity of composition". Geoffroy came to argue that all animals were fundamentally similar. He was a colleague of Lamarck and he expanded and defended Lamarck's evolutionary theories. Whereas Lamarck's views were materialistic in flavor, those of Geoffroy had a transcendental flavor. Like many naturalists in Germany, Geoffroy believed in the underlying unity of organismal design; Geoffroy believed that all animals are formed of the same elements, in the same number; and with the same connections. However these homologous parts differ in form and size, they must remain associated in the same invariable order. Geoffroy also believed in the possibility of the transmutation of species over time. Much like Goethe, as we will see, Geoffroy amassed evidence for his claims through research in comparative anatomy, paleontology, and embryology. It is telling that in the debates between Cuvier and Geoffroy, Goethe sides with the more radical transmutational theories of Geoffroy. Goethe's last writings, in fact, were in support of Geoffroy and his theories.

Uncertainty about the stability of species during the late eighteenth and in the nineteenth century caused philosophical debates. In the field of botany ideas about the fixity of species also rankled. From the Enlightenment to the Romantic period, the changes in botanical science mirrored the greater debates on species. Systems devised by botanists in the era of quantification came under fire once the fossil records, hybridization and new specimens tested their comprehensiveness. Botanists of the Romantic era devised more synthetic methods with which to classify the plant kingdom.

An analogy might be useful to better understand the task faced by botanists as they entered a world in which fixity of species was cast into doubt. To borrow an example from C.

[13] Lamarck as quoted in Stevens, 15.

Jeffrey in *An Introduction to Plant Taxonomy*, imagine being faced with a heap of coals and rocks to sort out. The result would probably consist of two piles, one of coal and one of rocks. But now, imagine being told to sort out a heap of coals alone. Most likely the result would be a progression of the biggest chunks down to the finest coal dust. Conceivable, each pile could even consist of one piece of coal.[14] Within Goethe's lifetime, the view of the plant kingdom as consisting of "coals and rocks" gave way to the view that the plant kingdom consists of only "coals."

Goethe carried around with him for several years bound into one slim volume Linnaeus' *Terminolgy, Fundamentals,* and Johann Gessner's *Dissertationes in explanation of Linnaean Elements.* These works accompanied him on the highways and byways around Weimar and on his Italian journey. What was Germany's most celebrated poet doing with these works on taxonomy? Goethe, as many others, were swept up by Linnean method. One typical portrait of Linnaeus depicts him seated outdoors surrounded by his attentive male and female students while giving a lecture. Linnaeus was known as a popular and beloved teacher at the University of Uppsala in Sweden. Some of his male students traveled to New Zealand, Japan, North and South America, China, Africa and Arabia to collect specimens for classification. Part of the reason Linnaeus attracted so many "disciples" as they were sometimes called, was because of his charm as a teacher. Since Linnaeus loathed travel, his students fanned out across the globe and sent specimens back to him. His personal popularity was only surpassed by the rapid popularization of his botanical systematics.

The predecessors of Linnaeus, such as Otto Brunfel (1448-1534) with *Herbarum vivae eicones,* Andreas Cesalpino (1519-1603) with *De plantis*, and John Ray with *Historia plantarum*, had already done much to systematize botany. Their systems relied on varied principles of organization but had in common the assumption that species were stable through space and time. Linnaeus shared this assumption. He wrote in *Fundamenta botanica* (1736) "We count today as many species as were created in the beginning."[15] Linnaeus imagined that the world began as an Eden or paradise containing all species and that it was just a matter of time until enough discoveries were made to complete the taxonomic record. As the son of a Lutheran minister, Linnaeus believed that God, in all his perfection, would not have left any gaps. He wrote in *Philosophia botanica* (1751), "The absence of things not yet discovered has acted as a cause of the deficiencies of the natural method; but the acquisition of knowledge of more things will make it perfect; for nature does not make leaps."[16] It therefore seemed to him that the world could be fully comprehended taxonomically. Because of the underlying assumption that species were

[14] Jeffrey, 8.

[15] Linnaeus as quoted by Gunnar Brober in "Broken Circle," in Tore Frängsmyr. Heilbron and Robin E. Rider. *The Quantifying Spirit in the 18th Century.* Berkely: University of California Press, 1990: 54.

[16] Linnaeus, 49.

discrete and stable, Linnaeus persisted in classifying all of the new specimens being sent to him by his pupils and other botanists. Linnaeus believed that he, or future botanists, would one day classify the entire plant kingdom.

To better understand the system Linnaeus proposed to achieve the classification of all plants, we might call to mind the heap of coals analogy once again. Linnaeus and his predecessors can be said to have approached plant taxonomy as if it were a mix of coals and rocks that could be easily sorted out. In his efforts to classify the plant kingdom in its entirety, Linnaeus became known for codifying "the rational principles of natural history by naming species of plants and animals according to their genus, arranging genera according to their family and ordering families by their class."[17] He developed a system of binomial nomenclature to make the language of botany universal. His system represents "perhaps the last and certainly one of the most successful attempts to articulate nature on the basis of a single relation, the relation of the part to the whole."[18] Linnaeus classified plants according to a sexual system. Instead of all the other variables one might choose, or instead of a more comprehensive system using several variables, Linnaeus chose the sexual organs of plants.

The fundamental features of the sexual system of classification are abstraction, numeration and artificiality. The Linnaean system is abstract in that it proceeded by setting aside as irrelevant all but a few select qualities of the plant. It is numerical in that it is "a basically simple but ingenious arithmetical system, whereby the genera are grouped into twenty-four classes according to the number of stamens (together with their relative lengths, their distinctness or fusion, their occurrence in the same flowers, or their apparent absence), while division into orders within each class is determined by number of pistils."[19] The artificiality of the Linnaean system lies in the privileging of sharply defined over the simultaneous consideration of multiple characteristics. These features made for a taxonomic system that was clear, logical, and easy to use; plants were either coals or they were rocks. The ease of quantification the Linnaean system provided appealed to Enlightenment thinkers such as Goethe.

Goethe began his botanical studies in Weimar where, as part of his official activities as Privy Councilor, he was drawn into forestry. At this time Goethe lived in the ducal Gartenhaus, given to him by the Duke of Saxe-Weimar surrounded by the forests of the duchy and the ducal gardens. Goethe was also named director of mines in Ilmenau and this took him on frequent trips to the country. During these years Goethe devoted much of his time to the sciences. In botany his early interests were in mosses, fungi, and algae and

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[17] Atran, 273.

[18] Larsen, James L. "Goethe and Linnaeus." *Journal of the History of Ideas*, Vol. 28, No. 4. (Oct.-Dec., 1967), pp. 590-596.

[19] John Lesch. "Systematics and the Geometrical Spirit" in in Tore Frängsmyr. Heilbron and Robin E. Rider. *The Quantifying Spirit in the 18th Century.* Berkely: University of California Press, 1990: 76.

later in the germination of seeds and flowering plants. As he was becoming involved with botany, Goethe began to read the works of Linnaeus:

> Under the circumstances I, too, was obliged more and more to seek illumination in matters botanical. Linné's Terminology, his Fundamentals upon which the structure was to rest, Johann Gessner's Dissertation in Explanation of Linnaean Elements all bound in a single slender volume, accompanied me on the highways and byways, and today that same volume reminds me of the active, happy days when those precious pages opened up a new world for me. Linné's Philosophy of Botany I studied daily, thus advancing farther and farther in ordered knowledge, attempting to acquire as far as possible all that might procure for me a more general view of this broad realm.[20]

Goethe became quite proficient at using the Linnaean system and continued to expand his knowledge as well as his circle of other enthusiastic botanists.

> During the 1780's Goethe befriended Friedrich Gottlieb Dietrich (1768-1850), who was a few years his junior. Dietrich was a descendant of the Ziegenhain family. They were known as authorities on local flora due to having supplied the apothecaries with medicinal plants and having maintained herbaria for generations. Although young, Dietrich was an expert in identifying plants in the region and knew all their names in the vernacular and in the Linnaean system of binomial nomenclature. Goethe took many botanizing walks with Dietrich and the two became so close that in 1785 Goethe invited Dietrich along for a visit to a spa in Karlsbad. Here they inspired other spa visitors to join in on plant collecting walks and afternoons at the spa were spent by many in deciphering the correct Linnaean classification of the plants they had collected. "The hotel guests all participated, especially those who themselves pursued this beautiful science. They found their minds stimulated in the most charming way by the sight of a handsome jerkin-clad country boy, running about, exhibiting great bundles of plants and designating them by names of Greek, Latin and barbaric origin."[21]

Like many others, Goethe helped to popularize the Linnaean system. Counting pistils and stamens proved to be not only easy for amateur botanists, but also provided relatively useful groupings. In making botany more scientific, it actually drew more people into the enterprise; amateur and professional botanists alike could contribute to the goal of classifying the entire plant kingdom. These attributes account for the quick spread of the Linnaean system and also for Goethe's initial enthusiasm, but Linnaeus also had his critics and rivals.

Critics of the Linnaean system faulted him for the artificiality and simplicity of his system. German philosophers Immanuel Kant addressed the incompatibility of artificial versus natural categories in systems of classification.[22] By not taking into consideration changes in time and space, the Linnaean system assumed species were fixed and that each group had a constant similar to an Aristotelian essence, a Platonic form or one of God's perfect creations. This perception of nature came to be hindrance as more data was accumulated that indicated that spatio-temporal changes were a significant factor in plant types.

Even at the height of his delight with the Linnaean system of botanizing on his trip to Karlsbad with Dietrich, Goethe was exposed to opponents of the Linnaean system:

> Our busy endeavors also had several opponents among the distinguished visitors.

[20] *Goethe's Botanical Writing*, 153.

[21] *Goethe's Botanical Writings,* 154.

[22] See Kant's *Critique of Judgment*.

> We repeatedly heard it said that this science of botany which we were so assiduously pursuing was by and large only a nomenclature, a system based on counting – and not very accurate counting at that; that it could satisfy neither reason not the imagination, and that it could achieve no satisfactory results. In spite of this objection we confidently pursued our way, which indeed promised to take us far enough into the science of plants.[23]

But these objections did plant a seed of doubt in Goethe's mind. In addition, Goethe had been reading Rousseau's *Botany*. Franco-Swiss philosopher Jean Jacques Rousseau (1712-1778) had also been a follower of the Linnaean system but slowly began to doubt it comprehensiveness. Rousseau wrote, "Yet I confess that the difficulties I encountered in my study of plants caused me to arrive at several methods whereby the study might be made easier and beneficial to others, by following the thread of a plant system by a method more progressive and less removed from the senses than the one pursued by […] Linné."[24] Goethe began to formulate his own doubts about the coherence of the Linnaean system:

> If I am to become consciously articulate about these circumstances, let the reader think of me as a born poet who is ordered to do justice to his subjects, always seeks to derive his expressions immediately from the objects themselves, each time anew. Imagine that such a man is now expected to commit to memory a ready-made terminology, a certain number and variety of words with which to classify any given form, and by a happy choice to give it a characteristic name. A procedure of that sort always seemed to me to result in a kind mosaic, in which one piece is placed next to another, in order to finally to produce out of a thousand individual pieces the semblance of a picture; and so in this sense I always found the demand to some extent repugnant.[25]

He was put off, as were an increasing number of naturalists by the scholastic nature of the Linnaean system. Goethe also complained that Linnaeus and his successors cared less for what *is* than for what *should be*. Like many other naturalists who were being practically overwhelmed with new materials from fossil records, from hybrids, from voyages of discovery, Goethe also began to question the ability of the Linnaean system to accurately portray nature. Linnaeus' presumption of the fixity of species and the artificiality of the system came to seem an impediment to understanding the natural world. Even as Goethe became dissatisfied with the Linnaean system, Goethe felt great reverence for Linnaeus, praising him for the "panoramic view" his system provided.

Overcome by restlessness, Goethe took these misgivings about botanical systematics with him on a trip to Italy. This journey proved to be a turning point in his studies of plants, but Goethe also wrote about cloud formations, meteorology, mineralogy, and conceived his ideas for several literary works, including *Die Römischen Eligien*. The Italian journey was to be a time of tremendous creativity for Goethe. He wrote, "The chief reason for my journey was to heal myself from the physical-moral illness... which made me useless… Here, however, another nature, a wider

[23] *Goethe's Botanical Writings*, 155.

[24] Rousseau as quoted in *Goethe's Botanical Writings*

[25] Goethe as quoted in Larson, 593.

field of art opened itself to me."[26] Goethe crossed the Alps at the Brenner Pass on the ninth of September 1786. From here he continued on to Verona and Venice. He remained in Venice for two weeks before moving on to Florence. His destination was Rome, the eternal city. Goethe reached Rome on the first of November 1786 and stayed there for four months. He moved on to Naples and then Palermo. He traveled to Messina then returned to Rome on the fourteenth of May and lived there for almost a year. On the eighteenth of June 1788 Goethe reluctantly returned to Weimar.

He returned convinced that botany could be approached in a different manner; "I felt that for myself there might exist another way, analogous to my own way of life in general."[27] During his trip to Italy, Goethe began to formulate a synthetic approach to botany. As he traveled further south he was struck by the luxuriance of the vegetation. Goethe tried to orient himself within this new variety of plant life. Having abandoned the counting of stamens and pistils as his primary means of classification, Goethe sought another means to orient himself. As he had so successfully done in his studies of osteology,[28] Goethe looked for homologies and the common threads that link all plants together. Goethe came upon the idea that the common part to all plants is the leaf. Admittedly the leaf can take many forms, yet it is the part of the plant that Goethe viewed as the essential characteristic that gave a plant its "plantness." Goethe's quote "All is leaf" is perhaps the most famous line from his botanical writings. What exactly did he mean by this?

To argue his case that all is leaf, Goethe assumed that other botanists and plant enthusiasts had observed some degree of similarity in plant parts. "Anyone who devotes the least attention to the growth of plants can easily note that certain of their external parts are often transformed, assuming, either completely or to some lesser degree, the form of neighboring parts."[29] From this point of consensus, Goethe began to make his case, piece by piece, that all parts of the plant are merely variations on one part. He made the case that the seed, when dissected, appears to be damp and tightly compact leaves. The first sprout out of the ground emerges with two cotyledons. These tiny oval-shaped pieces are not similar to the plants mature leaves, (but tend to look the same from plant to plant, as will later be important for the development of Goethe's theory.) Goethe made the case that the cotyledons are a form of leaf. Goethe argued that the petals of flowering plants are leaves of another color. Proceeding to the next plant part, Goethe desired to convince his readers that they should also view the stamen as a variation of the petal (which, of course, is a variation of the leaf).

[26] Goethe as quoted in Richards, Robert J. *The Romantic Conception of Life.* Chicago: The Chicago University Press, 2002.

[27] *Goethe's Botanical Writings*, 166.

[28] On 27 March 1784 Goethe discovered the intermaxillary bone in humans through comparing skulls of a variety of mammals. The lack of an intermaxillary bone had previously been thought to be one of the distinguishing characteristics between humans and other mammals.

[29] *Goethe's Botanical Writings*, 31.

> All this appears even more credible when we consider the close relationship of petals and staminal organs. If the kinship of all other parts to each other were equally obvious, so universally observed and settled beyond dispute, the present essay might be considered superfluous. [30]

Thus the argument was developed for all parts of the plant. Case by case he related all parts back to the leaf. Having made his case that "all is leaf", Goethe then asked, "What effect does a general element in its various modifications have upon one and the same form?"[31] Goethe expanded his theory from one in which all parts within a plant were related, to one in which all plants were related to one another. In other words, all parts of a plant are leaf, and all plants are variations of leaf.

With the thought that the leaf not only comprised all parts of an individual plant, but that the leaf was a unifying part among all plants, Goethe became convinced that there must exist an elemental leaf form. Goethe sought to find this actual physical plant from which all other plants were but permutations. He planned to search for it in Italy and drew sketches of what he thought he would find. He shared his ideas with others, including his friend and fellow poet, Friedrich Schiller (1759-1805). Schiller reacted with skepticism saying, "That is not an empiric experience, it is an idea."[32] Goethe was incensed. "Controlling myself, I replied. 'How splendid that I have ideas without knowing it, and can see them before my very eyes.'"[33]

Having always been a visual thinker, Goethe found it difficult to admit that his search for the actual plant with the primal leaf form might be in vain. Eventually, however, Goethe did just this; he developed a theory based on the notion that a primal leaf form did once exist, and that all plants now have this primal information encoded in them.[34] Goethe believed that this prototype would disclose all the possible types of plants there ever have been and will ever be. He called this plant prototype the "*Urpflanze.*" Goethe wrote in a letter to German poet Johann Gottfried Herder (1844-1803) in 1787, that with the Urpflanze "one will be able to invent plants without limit to conform, that is to say, plants even if they do not actually exist nevertheless might exist."[35] Goethe pictured a blueprint or *Bauplan* for "plantness" that would run like a common thread through all plants; no matter how they were transformed over time and space all plants would be recognizable as plants through an underlying code.[36] He writes that nature "pours her creations forth from the void, telling them neither whence they have come nor whither they are bound. Each must simply run its course."[37] Goethe called these limitless variations on a simple plan the metamorphosis of plants.

In 1790 Goethe published his theories on the transmutations of the leaf, and the metamorphosis of plants in a work entitled *Ein Versuch die*

[30] *Goethe's Botanical Writings*, 47.
[31] *Goethe's Botanical Writings*, 84.
[32] *Goethe's Botanical Writings*, 217.
[33] *Goethe's Botanical Writings*, 217.

[34] This line of thinking is similar to what we now term "genotype" and phenotype."
[35] *Goethe's Botanical Writings*, 14.
[36] Goethe's imagined "underlying code" which makes a plant a plant is something geneticists are studying today.
[37] *Goethe's Botanical Writings,* 243.

Metamorphose der Pflanzen zu Erklären, or *An Attempt to Explain the Metamorphosis of Plants.* Initially this work was largely ignored by the public. Nevertheless, Goethe continued to write about botany. He kept many notes for future works and completed a work on the spiral tendency of plant growth. Botany remained for Goethe a strong interest until his final days.

As the debate about fixity of species grew, Goethe became bolder in his support of unchecked metamorphoses of plants, animals, and of nature in general. He began to view systems, such as those of Linnaeus, as simply convenient tools to impose upon nature, but he believed these systems did not reflect nature. Goethe wrote, "Nature has no system; she has, she *is* life and its progress from an unknown center toward an unknowable goal."[38] In his later years, Goethe's thinking was that the evolution of nature was limitless. Unlike Darwin, Goethe did not identify a mechanism by which metamorphosis occurred; he simply stated that variations on basic primordial forms occurred due to environmental factors.

Public interest in Goethe's views on metamorphosis increased as the debate about fixity of species became one of general concern. There was a steady stream of devoted Goethe followers, who pointed out the importance of Goethe's ideas to the debate. As more support formed for the idea of evolution, Goethe seemed to many German scholars a leading thinker in this area. In a German translation of Erasmus Darwins's *Zoonomia*, the translator and commentator remarked in a footnote:

> It is noteworthy, that one of our best German poets Mr. Gehiemerath Göthe presented very similar ideas about the individuality of every single bud in Germany as here portrayed by our English singer of the "Botanic Garden." All the analogies presented here and from our Mr. Geimerath Göthe (about plant morphology) give these ideas the ring of truth.[39]

Even Erasmus Darwin's (1701-1802) controversial poem about evolution was given the stamp of respectability in Germany, because the beloved Goethe had previously written along the same lines.

Goethe was both a product of his times and an original thinker. He worked systematically as was typical of an Enlightenment thinker, and he synthesized his work into holistic theories of nature, as was typical of a Romantic thinker. Goethe approached nature with respect, awe and curiosity. Goethe wrote, "I feel I know you, nature and so I must grasp you."[40] In his attempts to grasp nature, Goethe's thoughts made their way into the general debate and influenced opinions. He advocated the thought that nature exists in a continuous stream, which could only be divided for artificial convenience. Goethe's theory of the metamorphosis of plants contained the seeds of evolutionary thought.

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[38] *Magnus,* .

[39] J. D. Brandis as quated in Günther Schmid. *Goethe und die Naturwissenschaft: Eine Bibliographie.* Halle: Emil Abderhalden, 1940. 244.

[40] From "Lied des Physiognomichen Zeichners" *Werke,* 16:128.

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