Classical Music in the Anthropocene

by Nathan Currier

Editor's Note:

Currier picks up his argument from the previous issue and advocates for an ecomusicology that is more "ecological" than "ecocritical." The ideas presented here are rich and will surely provoke discussion, not only regarding the cited authors and the topics of interest to ecomusicology and climate communication, but also to more traditional musicological inquiry. For example, what connections are there between Currier's Gaian Variations *(2004) and Libby Larsen's* Missa Gaia: Mass for the Earth *(1992), as well as Paul Winter's* Missa Gaia / Earth Mass *(1982)? Do their changing engagements with Gaia reflect the arrival of the anthropocene? The* Ecomusicology Newsletter *welcomes responses to this thoughtful and thought-provoking contribution.*

--Aaron S. Allen

The opening of one paper by leading climate scientist James Hansen put it bluntly: "Climate change is likely to be the predominant scientific, economic, political and moral issue of the 21st century" (Hansen, 2011). Hansen will eventually be right, whether through intense adaptive activity or inordinate suffering. But now? Back in 2005, prominent climate activist Bill McKibben wrote an Earth Day article looking at climate and the arts: "Oddly, though we know about it," he said, "we don't *know* about it. It hasn't registered in our gut; it isn't part of our culture. Where are the books? The poems? The plays? The goddamn operas?"

The arts are unquestionably vital to all human cultures, and it should not be controversial to suggest that something as monumental as Hansen describes will drastically impact every aspect of culture, including all arts. Nine years after McKibben's article, there is new talk of "cli-fi," the genre of climate fiction, and yet I hope such a development only reveals the problematic relation between McKibben's observations and Hansen's: now there *is* a new climate "genre," and yet the climate crisis feels little closer to the collective gut. The problems lie elsewhere, but time is running out.

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His compositions have been heard at prestigious venues, from Avery Fisher Hall at Lincoln Center to the Philharmonie in Berlin, and he is a winner of many prizes and awards, such as the Rome Prize, Guggenheim, American Academy of Arts & Letters' Academy Award, National Endowment for the Arts, Fulbright, NYFA, Fromm, Ives, Barlow, and ASCAP awards and prizes.

The topic of Currier's largest musical work is Gaia theory, which views the Earth as a single self-regulating entity. His massive oratorio Gaian Variations *was premiered at Avery Fisher Hall by the Brooklyn Philharmonic for Earth Day 2004. Currier has more recently become involved with Gaia theory itself, co-authoring with NASA scientist Paul D. Lowman (the first geologist to join NASA, and later a founder of comparative planetology) a chapter of the book* Chimeras and Consciousness *(MIT Press, 2011). When NASA celebrated the 50th year of its exobiology program, a passage from their chapter "Life's Tectonics" (concerning the role of life and water on tectonics here on earth) was read in the opening keynote address.*

Currier is also active in climate science. He has been a member of Al Gore's Climate Project since 2007 and became Senior Climate Advisor and methane specialist for Public Policy Virginia. He has spoken at Columbia University, New York University, and UNICEF Headquarters at the United Nations, among many others, and has presented to about 1,000 people on climate change. Since last year he has been writing about climate issues for Huffington Post, and recently served as a panelist for a segment of Gore's "24 Hours of Reality" which live-streamed to a viewership of 8.5 million.

Thus far, there has really only been one *cultural object* offered to help the mind conceptualize the Earth and its climate – Gaia, the idea of James Lovelock and Lynn Margulis. The scientific community has been uncomfortable with the name, especially here in the United States, but the name itself is not necessary, and nowadays there are a wide variety of higher education degree programs in "Earth Systems Science," if one prefers to call it that. But one needs some kind of organizing principle of thought to begin conceptualizing planetary-scale processes. Needless to say, most cannot pursue such degree programs, and part of the wisdom in Nobel laureate William Golding naming Lovelock's idea "Gaia" was that it packed so much into one little word, reaching the gut.

Gaia's importance in understanding climate can best be expressed in Hansen's saying simply, in the same paper quoted previously, that "feedbacks are the core of the climate problem." Lovelock was initially going to call his idea the "Earth feedback hypothesis," and it was the first use of feedbacks applied to the global scale, which Lovelock saw as the core of planetary self-regulation. It is no longer controversial to suggest that a direct inspiration of Earth Systems Science is found in Lovelock's work. To go back to McKibben, whatever name you want to use for it, you cannot know the climate unless you *know* "G---." The climate scientists don't need help conceptualizing complex global processes, but everyone else does, and the scientific community has not offered any other mental tools to help. That is our problem.

Precisely a year before McKibben's article, for Earth Day 2004, a large musical work about Gaia theory, *Gaian Variations*, was premiered at Avery Fisher Hall. The *New York Times* music critic began his review referring to its texts as "mostly pseudoscientific." Fortunately, few agree with his view now, and the score of the work will soon be on display at the prestigious London Museum of Science. But composers mostly want their works performed, and the premiere was also, notoriously, cut off mid-stream for "overtime" when the orchestra had barely performed two hours of its three hour contract – perhaps as good a metaphor as any for what might now await us.

I composed *Gaian Variations*. Its origins go back to 1991, when I was part of an installation project called *The Earth is Dying*, the music for which became the "theme" of the oratorio, when I began composing it in 1997. This month marks the tenth anniversary of its controversial premiere, and the intervening decade has seen many things: the addition of 5% to atmospheric CO_2, the incredible loss of about 50% – within a single decade – in the annual minimum summer arctic sea ice volume (see Polar Science Center; for discussion see McKie, 2012), and on the other side of the ledger, the positive development of a new field of musical study – ecomusicology. What follows is my contribution to the vivacious debates surrounding ecomusicology, in the hope that I might provide some small positive contribution towards our infinitely larger problem.

I agree with Aaron Allen (2011) that the field is currently best considered as "ecocriticism + musicology," and not "ecology + musicology." A key point of this essay is to argue for the profound need to add that *other* ecomusicology, far more science-based, that would constitute "ecology + musicology." The current ecocritical musicology should of course continue on in parallel, but the special value of what I am suggesting stems from the particular and peculiar place of music among the arts. At least since the time of Phythagoras, music has been associated, perhaps more than any other art, with what might be called the "enchantments of science." C.P. Snow's oft-cited divide between the sciences and humanities, as will be explored in this essay, is complex and has grown from, among other things, unfortunate developments in the nature of the scientific enterprise itself. As it has before, however, classical music and its education might play a powerful role in healing such rifts that grew within twentieth-century culture.

A science-based ecomusicology, on the other hand, is likely to be unsuccessful without something akin to Gaia theory. There is little question that, in the recent history of science, Lovelock played a key role by having initiated something that brought the Earth and life sciences closer together, but what is less often observed is how, with its deep well of cultural resonance, Gaia could similarly help bring all these sciences closer together with the rest of culture, helping resolve the "Two Cultures" dilemma. Indeed, Allen, in his own discussion of Snow's essay, looks out at our looming climate crisis and worries about the future of education. Observing a curriculum that Paul Erlich recommended for creating environmentally literate citizens, Allen wonders if this might just

reinforce the "Two Cultures" problem in a new way – by mostly eliminating the humanities (Allen, 2012). Degrees in Earth Systems Science, or Erlich's environmental curriculum, are indeed vastly time-consuming undertakings, but Margulis became interested in her later years with the idea of creating a Gaia curriculum (see "Gaia by Any Other Name" in Schneider et al., 2004), and in fact Gaia curricula of various levels of complexity could be easily conjoined with and constructed within a humanities framework.

The development of ecomusicology is unquestionably a positive step. Since the field is currently bound to ecocriticism, discussing its current state demands a close scrutiny of ecocriticism. Ecocriticism is an outgrowth or expression of environmentalism. Laurence Buell has defined ecocriticism as being "conducted in a spirit of commitment to environmentalist praxis," and in 1994 the WLA (Western Literature Association) made the definition of ecocriticism its conference theme – and with no fewer than sixteen position papers providing definitions of ecocriticism, not one of them questioned the field's underlying link with environmentalism. The contribution of Cheryll Glotfelty, who subsequently became one of the most influential figures in the field, stated, "Most ecocritical work shares a common motivation: the troubling awareness that we have reached the age of environmental limits.....This awareness sparks a sincere desire to contribute to environmental restoration." The current Wikipedia entry is more blunt: "All ecocritics share an environmentalist motivation of some sort."

The reason that this is so vital to this essay is as follows: this environmentalism, what I will call "traditional environmentalism" – i.e., what has been known by that name since the 1960s, Rachel Carson, etc. – is, I believe, now entering a crisis in a way that has been rarely articulated but that is of great import. While I see myself as an environmentalist, and am understood to be one, traditional environmentalism appears to me to have an inherent – and not incidental – difficulty in grappling with the climate crisis. For example, it might initially seem surprising to contemplate, but the environmental movement has had most of its large-scale achievements come at the price of *exacerbating* warming: control of sulfur pollution and acid rain (see IPCC, 2007, Chapter 2.4); nitrogen oxide controls and the development of the catalytic converter (see Environmental Protection Agency, 2012, page ES-10, and Environmental Protection Agency, 1998; for discussion, see Wald, 1998); and probably even the fixing of the ozone hole (see IPCC, 2001, Chapter 6.4, and IPCC/TEAP, 2005) all *increase* radiative forcing (a perturbation in the planet's energy balance which leads to an increase or decrease in the mean surface temperature). Further, this political movement has been galvanized around emotional positions such as a vehement opposition to nuclear power – an opposition that, if successful, could render climate catastrophe virtually inevitable (see Hansen et al., 2013). The same is true of geoengineering, which will be discussed in an unusual – but highly "ecocritical" – fashion in the final part of this essay. Taken all together, these points might make one wonder if traditional environmentalism, while it both recognizes the climate problem and wants to ameliorate it, could in the end become almost as large an impediment to resolving it as climate change denialism.

Here again, the absence of Gaia theory seems paramount. Lovelock was certainly central to the birth of traditional environmentalism – his electron capture detector made the ambient readings of chlorinated pesticides that gave *Silent Spring* its authority and urgency – but Lovelock has been complaining about its problems since, and with climate policy long floundering, perhaps we are starting to see some of the immense implications of his arguments. It is a great tragedy that Carson died so young. It was only the year after her death when Lovelock first conceived his "Earth feedback" idea, and given her brilliant and inquisitive mind, and her ability to communicate with the wider public, our history might have been different had she lived another decade. Indeed, the very opening sentences of *Silent Spring* (after the initial fable), express an outdated notion that died soon after they were published:

> The history of life on Earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the Earth's vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight.

This is almost the antithesis of the Gaian view. Lynn Margulis sometimes used to define Gaia by stating simply: all life forms modify their

environment, and the sum of those modifications is Gaia. While oxygen was recognized as being of biological origin when Carson wrote this, it was not yet known that most other atmospheric constituents were also biogenic (all the primary constituents except the noble gases). Lovelock, from the beginning of his idea of planetary feedbacks, became one of the first to consider the biological origins of many of the trace gases, and it was this that led Lynn Margulis to seek out his advice, beginning their long collaboration on Gaia theory. Indeed, such biological gas exchange is of primary importance to his idea, since the essence of Gaia theory is that our planet self-regulates through feedback mechanisms in many of which biological activity plays a key role. Over geological time these are of immense impact – perhaps even the mountains we see around us could not have been created without the activities of organisms (see Lowman, Currier, 2011).

Thus, environmentalism might need its own internal revolution now, and this paper points toward a different kind of environmentalism, and in turn toward a different kind of ecomusicology – that is, to a more science-based, Gaian musicology.

Thus, environmentalism might need its own internal revolution now, and this paper points toward a different kind of environmentalism, and in turn toward a different kind of ecomusicology – that is, to a more science-based, Gaian musicology. In expanding upon Allen's saying that the current ecocritical musicology is *not* ecology + musicology, it is worth noting that ecocriticism already has its own internal problems concerning the place of ecology within *it*. Among the sixteen WLA papers defining ecocriticism, the one that focused on this most directly was from Stephanie Sarver (University of California, Davis). She noted, "As literary scholars, our work may be informed by environmentalist concerns, but we ultimately study texts, not organisms," and added that, "this work is better described as a form of environmentalism than the practice of ecology" (Sarver, 1994) – something which seems to have remained true over the intervening decades.

Sarver also mentions something, germane to this essay, that appeared in one form or another in at least a quarter of those early position papers, and that was the need for ecocriticism to "introduce environmental matters into more main-stream literary discussions." Since the mid-90s, that suggestion has been fulfilled, but in ecomusicology the same does not yet seem equally true. For those who don't see much value in applying their new ideas to the old standard repertory of Western European music, it might be good to remember that it was Thoreau who said, regarding the study of the classics in literature, "We might as well omit to study Nature because she is old." And one might also say: just as in the political sphere it is commonly noted that the climate crisis originated within the history of the developed West, and therefore Western culture should lead in solving it, so too might it be equally necessary within the cultural sphere to go back inside the Western European tradition in order to more fully understand what has happened and where we must turn. Indeed, in the current paper this is assumed to be the case, and the author generally sees Western science and Western culture to be inextricably intertwined, and both utterly and equally vital to navigating the shoals of the current predicament.

Some in ecomusicology reject the very notion that humanity is now facing a vast and looming predicament, attempting to deconstruct this notion as merely being one "subjective framing," that of "alarmist, dystopian, apocalypse" (Rehding, 2011). In fact, the newest United Nations report from the Intergovernmental Panel on Climate Change (notable in many scientific circles for its conservatism) has raised the level of certainty around its core findings (greater than 95%), and suggests that continuing on our current trajectory (represented by new RCPs – or "representative concentration pathways" of greenhouse gases) could lead to a planet largely uninhabitable for our current civilization sometime after the current century: we currently are closest to the concentration pathway RCP 8.5, which stands for "8.5 watts per square meter," which should translate into a warming at least five times greater than current, and there are also, in its fine print, ECPs, or "extended concentration pathways," for describing climate beyond 2100, where RCP8.5 leads eventually to an even more

drastic warming, one that would almost unequivocally devastate society (IPCC, 2013).

A curious and highly significant feature of our historical moment has been the rapid ascendancy of popular music among cultural "elites," particularly here in the U.S. Some have attributed this to our late-stage capitalism and its commercialist pressures (see Halle, 2013, 2014; Ross, 2013). Whatever the cause, its effect remains to be well elaborated. How does classical music of the common practice period, compared to all the other music listened to on the planet – be it popular, non-Western, avant-guard, minimal, indigenous – distinguish itself from the rest, if it all? I might say, in the following regard above all: classical music provides a seemingly unique sense of an irreversible arrow of time, of a non-repetitive one-way narrative thrust forward, of a development, an unfolding, downward towards some resolution and finality in time. This is of particular interest because of its curious relevance to the current human predicament: such a sense of time accords not only with the exigencies of crisis, but also with the laws of thermodynamics. At the same time that physicist Ludwig Boltzmann, frustrated by critics of his work on thermodynamics, moved towards philosophy to better refute those critics and place his work into a wider theory, music theorist Heinrich Schenker worked on his theory to elaborate the forward-moving unfolding of classical music. The music that I will examine first appeared at the same time as well (Schenker had become primarily a theorist by 1900; Boltzmann decided to become a philosopher in 1901; Mahler's Third Symphony was first performed in full in 1902). Boltzmann's work quickly became fundamental to ecology. Lotka saw "available energy," what Boltzmann was formulating through stochastic derivations, as the primary thing being fought over in Darwinian competition, and thus the primary unifier of physics and biology. Thus, if ecomusicology is going to be ecology + musicology, we need to start there.

Much recent ecology is based on such work. For example, the work of the brothers Odum, Howard and Eugene, often referred to as ecosystem ecology, is based on the thermodynamic principals of energy flows through ecological systems (see Schneider and Sagan, 2005). It is hard to envisage a good contemporary musical parallel, however, flourishing under a pop-music led ideology (I do agree that popular music represents an important and vital facet of musical expression, however). One way of viewing the underlying crisis of the Anthropocene might be to see a strong dissonance between the thermodynamics of the whole biosphere and human aspiration. To quote a memorable *New York Times* music section title (from a 1991 profile of the pop-inspired neo-minimalist David Lang) "Pop Goes the Music – Classical, Too" (Schwarz, 1991). This was both cute and has since largely come true, but now we seem equally headed towards "Pop Goes the Civilization." Classical music might have closer ties to the roots of our current dilemma, but it is also far more likely to prove relevant to its resolution.

Therefore, in this essay I will start by going back to the founding of traditional historical musicology in classical music, to try to show that ecomusicology – when understood as ecological musicology – was actually an underlying view already existent at the summation of the common practice period, subsequently buried in the history of the 20th century. The excavation of this earlier ecomusicology is of vast importance to the paper, and I will anchor my whole argument in one small segment of classical music's past. The institution of classical music is by nature highly conservative, given the art's intense performative demands. While the predominant programming philosophy of the modern period was led by complementarity, this should now be as defunct as modernism itself, and thus, if classical music serves some higher purpose, that purpose should run both through its past and present equally, continuously renewed and ever-evolving. It is interesting to note that the small segment of the repertory discussed here, primarily, music of Gustav Mahler, has been perhaps the most singularly ascendant part of the whole core classical music repertory during the last half century, and so one might be led to ask whether, while an unconscious reflex of the world musical community, the material presented here nevertheless was somehow at work in this striking fact. I will then explore more generally how rethinking ecomusicology as ecological musicology could bring the whole field closer to musicology's center, closer to the core of contemporary thought, and closer to a role in untying the Gordian knot that will unquestionably create an existential stranglehold on this century: the climate crisis.

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Ecomusicology in the late common practice period

Our word musicology (in German, Musikwissenschaft – literally, music science) stems from the period when the study of music history became a professional pursuit, as it did for Spitta, whose biography of Bach appeared in 1873. The word ecology comes from the same time, the term being coined by German scientist Ernst Haeckel in 1866, in his book *Generelle Morphologie der Organismen*, a response to Darwin's *On the Origin of Species* (1859). Haeckel first read Darwin's work after returning from travels in Italy inspired by Goethe's famous Italian journey. One of Haeckel's mentors, shortly before committing suicide, had written a work about single-celled marine organisms called radiolaria. In carrying forth Goethe's spirit of combining art and science, and inspired by this mentor, Haeckel made a series of superbly wrought etchings of radiolaria while observing those around Messina, uncovering a trove of never-before seen species, in his final days before leaving the country (Richards, 2005). He sent a copy to Darwin, who called them, "the most magnificent works which I have ever seen," and Haeckel began to suspect that he could in fact use these very organisms to help prove Darwin's theory. When he introduced what he called 'ecology' he was trying, with his *General Morphology*, to combine Darwin's theory with Goethe's form of Natural Philosophy (Goethe had initiated the discipline of morphology). At the same time, he added in his own knowledge of embryology, and what he termed 'ontology,' in order to create his personal version of what quickly was dubbed Darwinismus – the German form of Darwinism (Celenza, 2010). Musicology and ecology, thus, appear at the same time, towards the end of what is often called the common practice period or tonal period in Western music history, which spans roughly from Bach through Mahler.

Gustav Mahler is seen not only as the end of the common practice period, but also as a kind of summation of it, and it is of considerable interest to look back at Mahler, therefore, and examine how his work relates to the beginnings of ecology. It is not enough to show that, from his First Symphony's opening – "Nature waking up after a long winter," as he titled it in one of the programs he supplied – through *Das Lied von der Erde* (*The Song of the Earth*), Mahler was continuously concerned with expressing nature through music. For our present purposes, what matters is not his sympathy for nature, but for science.

One of Mahler's closest personal friends, from the age of twenty until the end of his life, was the poet Sigfried Lipiner (McGrath 1974). Lipiner had been a student of natural science, became known as a vocal proponent of Haeckel's work, and wrote a dissertation in which Goethe's *Faust* was analyzed as an expression of Haeckelian philosophy. Lipiner's writing was appreciated by Wagner, and Wagner was himself a fan of Haeckel's work. After Wagner's death, the Wagner Academic Society frequently entertained guests with meetings held on scientific topics, which is where Mahler was likely first introduced to such material. Mahler became known rather early in his career as a 'philosophical composer,' deeply invested in Nature. Natural Philosophy – although this was the period of its decline, and its replacement by the term 'natural science' – was a term still appreciated by Haeckel and others through the late 19th century, and Mahler's personal library included the works of Darwin, Lamarck, Goethe and, of course, Haeckel (Celenza, 2010).

Important to understanding the relationship between early ecology and music – and Haeckel's place in the history of science and culture in late 19th century Germany – is the fact that Haeckel was also an artist. Even today, many students first learn the beauty of the microscopic world from his finely wrought depictions of the radiolaria. His most famous collection of drawings was called *Kunstformen der Natur* – the *Art forms of Nature* (1899-1904). It is worth noting that nothing was known of the pre-Cambrian until the 20th century, and so these radiolaria, single-celled eukaryotes (i.e., cells with nuclei) dating back to the early Cambrian, were seen as the origins of life itself. And in Haeckel's drawings, they also became works of art. It should be easy to see why Haeckel had immense cultural influence.

Another important aspect of Haeckel and his work is that he contextualized evolutionary theory within a philosophical framework, which he called Monism (the name had first been used by Christian von Wolff a century earlier, to denote systems of thought which avoid Cartesian dualism). This placing of Darwin and evolution within a broader worldview was vitally important to the reception of evolution among artists in Germany. As Anna Harwell Celenza demonstrates in *Darwinian Visions: Beethoven Reception in Mahler's Vienna*, part of this uniquely German reception to Darwin started right away with the first German translation of *On the Origin of Species*. Made by Heinrich Georg Bronn, it

appeared only a few months after Darwin's initial publication in English. Bronn, who first coined the term Darwinismus, made it explicit that his version was far from being a mere translation. Another disciple of Goethe, Bronn had written a work dealing with fossils as a succession of extinct species half a decade earlier. Darwin was apparently fascinated to see part of it, translated into English, just months before the *Origin* appeared (Richards, 2005). So, as Bronn prepared his German version of the *Origin,* Darwin and Bronn communicated in looking for the right equivalents of keywords. Several variants of "natural selection" were discussed. Bronn himself came up with natürliche Züchtung, literally, natural breeding, which in the second German translation appeared as natürliche Züchtwahl, or natural breeding choice (Celenza, 2010). This might make sense when discussing sexual selection, but hardly makes sense in the broader meaning of natural selection. Yet precisely this helped accelerate the acceptance of Darwinism in Germany. Haeckel then combined this version of evolutionary theory with the pantheism of Goethe (a powerful element through Spinoza's influence), and in this way, Haeckel created a philosophy suggesting a development towards something, towards self-realization, somewhat like the embryo's self-fulfillment in the mature organism. A centralizing role, moreover – and this harmonized well with other German philosophers like Schopenhauer and Nietzsche – was given to art.

Mahler's Third Symphony was so steeped in this worldview that it could be called a "Monist Symphony." Mahler initially called the work *My Happy Science*, but later removed the title. It was not *The Happy Science*, as in Nietzsche (although it is *also* a reference to Nietszche's work by that name), but *My Happy Science* (Floros, 2003). Mahler's happy science, in other words, in opposition to Nietzsche, was his personal response to Haeckel's Monism and Darwinian evolution: the structure of the whole symphony, as he explained to friends, was designed to depict evolution, and to show a multi-tiered view of Nature, going from the raw stuff of 'still uncrystallized inorganic matter' in the opening movement, through the plants and animals, then to humans, and finally to the spiritual world in the last movements. One of Lipiner's poems has been noted as a likely inspiration for the program. The poem, which begins with the origins of the world as a sleeping cloud, in fact closely mirrors Haeckel: in a speech a few years before Mahler started writing the Symphony, Haeckel, discussing the ether that scientists assumed filled the void of space, mentioned the idea of dust grains in the ether, "As the Kant-Laplace nebular hypothesis has it, the rotating heavenly bodies separate themselves out from that vibrating primeval cloud" (Haeckel, 1892). For Mahler, whose inspirations were strongly rooted in Beethoven's Ninth and its nebula-like beginning, Lipiner's poem must have seemed resonant. Mahler's final tier might today seem almost irreconcilable with a scientific program, but this is largely because of the absence of worldviews today like Haeckel's. The last movement depicts love as ultimate redemption, but closer in spirit to Hildegard than Wagner (the main theme recalls Beethoven's Quartet op. 135, and conjures its world of relinquishment), and for Mahler *this* is the happy science, the sense of some self-realization consonant with the physical world. This Symphony and the Fourth, deeply interrelated in their creation (the last movement of the Fourth was going to be the Third's last movement), were the last works for which Mahler expressed extra-musical programs, so one can only speculate whether the Third's evolutionary metaphor became inherent in his creation of large-scale structures. Given the increasingly organic-sounding results of Mahler's writing in sonata forms, it would not be hard to imagine that this initially explicit use of a Darwinian (*and* teleological) metaphor later became ingrown, fundamental to his vision of musical gesture creating narrative meaning.

Celenza's article details how the spell of evolutionary science and Haeckel's philosophy began to permeate Viennese culture around this time, with parallel developments in the works of Mahler and Klimt. It was clearly something broader than the two individual artists' inspirations: as she says, speaking of the visual arts and the influence of Haeckel's *Kunstformen der Natur*,

> the effect of these wondrous, exotic images, the organic patterns of concentric circles and undulating radiolarian, must have influenced Klimt and his colleagues during the Secession's early years. Even the unusual appearance of the famous Secession building, with its geometric symmetry and leafy golden orb, carried traces of Haeckelian inspiration.

It was in this Secession Building that something worthy of note took place in 1902: the unveiling of the Beethoven monument by Max Klinger was accompanied by an exhibition widely seen as having great importance at the time, as well as subsequently. It has been described as the final late Romantic view backward towards Beethoven. Klimt's famous *Beethoven Frieze* was not just utterly unlike Klinger's sanctifying monument to the composer. Nor was it

notable primarily for giving an evolutionary viewpoint such a broad showcase in contemporary art (Klimt had already begun to do this earlier). Rather, it was clearly extending a Haeckelian view *backwards* to Beethoven, claiming him as part of its vision, while it also suggested an 'evolution' from Beethoven to Mahler. Indeed, most notable to critics in Klimt's work was not only the giant Darwinian gorilla looming from our deep past, but how it construed its central knight's features to look like Mahler, something taken up in many nasty comments in the conservative press, saying the Secession had turned "Beethoven into a Jew" (Celenza, 2010).

Thus, we see how Mahler was not just consciously steeped in an ecological and evolutionary view (initially, Darwin had been strongly focused on competitive relationships, and his last book, on the impacts of earthworms, represented a point of departure in the direction of more fully ecological thinking; see Schneider et al., 2004, Chapter 14), but that Mahler's stance was in fact then seen as a direct development from Beethoven. When one considers Beethoven's own emphasis on development and the creation of more organic musical structures, as well as his own philosophical grounding in Goethe's pantheism by his later years, this should not be too surprising. The explosion of sonata forms in Beethoven – rightly pluralized by Charles Rosen – was at one with this view. After all, crudely put, Beethoven not only expanded the sonata form greatly, but allowed the sense of development to permeate the whole structure, from the exposition to extended codas in the recapitulation. Haeckel's 'ontogeny recapitulates phylogeny' conception of biological development became known as the recapitulation theory. A composer whose music exploited a revolutionary, naturalistic, even improvisatory technique that emphasizes forward-moving exploration and development of musical motives and their often altered or further-developed recapitulations, clearly belongs within this worldview. And as Solomon made clear in *Late Beethoven,* Beethoven's late works expressed his own unique spiritual view, influenced by pantheism almost as much as was Haeckel's Monism. Thus, in the early 20th century, Beethoven could also be seen as a Haeckelian composer.

Celenza's *Darwinian Visions* does not aim to distinguish for the reader between today's neo-Darwinism and Darwin's actual work, nor contextualize such distinctions within the current state of science. Nor does she strive to show that there was a specifically *ecological* worldview in Mahler. With the addition of these, one might then show that the famous Klinger-Beethoven exhibit amounted to something like an act of ecomusicology.

Ecomusicology should rest near the core of musicology because by the time that musicology proper came into existence in the late common practice period, it was already a major feature of the conscious thinking of classical music's most famous creative figure, shared by some of his colleagues, and was understood, with some justification, as a thread that they could draw backward as far as Beethoven.

The 'Two Cultures' and the industrialization of science

The current problem of science and culture might be the opposite of what C.P. Snow believed when he wrote his oft-cited *Two Cultures* essay in 1959. Its full title was *The Two Cultures and the Scientific Revolution*. Most people, in using the phrase 'scientific revolution' mean those changes that took place centuries ago, but Snow meant something quite different, and far more recent: as he put it, "for myself, I should put it much further on, not earlier than thirty to forty years ago." Forty years prior to 1959 was 1919 – the exact year of Haeckel's death. After this revolution, there were no more Haeckels, no extensions of the ecomusicology I have just described.

What was this second scientific revolution, following the first one of the 18th century? What Snow had in mind was the full application of the scientific method to *industry*. But what never seems to have occurred to him is that, in the mixing of these two, there might be a powerful impact going in the other direction – namely, the industrialization of science. And there can be little question that this also took place. Like a giant assembly line of thought, scientists more and more took to their little corner of the conveyor belt of 'idea space,' as the scientific endeavor grew exponentially in the period between the wars. Things went apace and there was certainly a lot of progress, assuming underlying assumptions were correct, but the last vestiges of Natural Philosophy disappeared in that revolution.

"This polarization is sheer loss to us all," Snow wrote, of the trenchant divide between the sciences and humanities. I certainly agree: it not only eliminated the Haeckels, but made it nearly impossible to have a culture where great science and art met and commingled to the degree they had during the period of Goethe's influence. And yet one might say that the explosion of information in all scientific disciplines over the last 150 years means that having some basic philosophical framework

becomes even *more* important: no one can hope to 'understand science,' in any sense of complete knowledge, so the *framework* of one's conceptions becomes even more vital.

For the recent 50th anniversary of Snow's essay, cited as being one of the most influential since WWII, articles were published discussing such things as the Cold War drive behind Snow's rationale (*New York Times* – see Dizikes, 2009), general progress in science education since (*Scientific American* – see Krauss, 2009), and outgrowths to Snow's essay such as John Brockman's "Third Culture." There was no discussion at all, even with 50 years' hindsight, that Snow's scientific revolution itself might have had its drawbacks, but Brockman's original book, *The Third Culture: Beyond the Scientific Revolution* (1995), had a chapter in it by Lynn Margulis, called *Gaia is a Tough Bitch*, written with impassioned ferocity, which, in essence, made just this point.

While perhaps an even greater scientist, Lynn Margulis might be considered the Haeckel of our time. Haeckel reclassified the divisions of life, giving the names for the Protists and the Monera. In our time, first under the influence of Margulis' work, and later collaborating with her directly, Robert Whittaker created the modern Five Kingdom division of life (still the most common classification of organisms), adopting Haeckel's names – the Monera and the Protists – in adding the two Kingdoms of pre-Cambrian life to the plants and animals that had long defined life for biologists, and further making fungi a third Kingdom of Phanerozoic life (earlier, fungi had been considered as belonging with plants, based on lifestyle characteristics). Max Tayler (see Tayler, 2003), in laying out the recent history of evolutionary biology, notes Margulis' central role:

> During the latter part of the 20th century, several important 'paradigm shifts' occurred in our view of cell evolution. Perhaps the most obvious of these, because it was so hotly contested, was the symbiotic origin of mitochondria and chloroplasts. It was an old idea, with roots in the late 19th century, whose successful revival was championed by Margulis (1970).

Taylor also recognizes how Margulis' work seems to revive something from Haeckel, who had taken a similarly 'bottom-up' view, starting from the microscopic world:

> As Whittaker & Margulis (1978) noted, many early classifications were essentially 'top-down' views of the living world, tracing plants and animals downward into plant-like and animal-like 'lower organisms'. The German evolutionist, embryologist, microscopist, philosopher, artist and long-jump champion of Jena University, Ernst Haeckel, who was the strongest 19th century advocate of the distinctness of unicellular organisms, had a 'bottom-up' view, looking at the diversity of the living world from the earliest cells.

There are, of course, vast differences between the modern Five Kingdom division and Haeckel's three Kingdom tree from a century earlier (not least, Haeckel gave the name Monera to a *phylum* of the Kingdom Protists, not to a Kingdom of its own, and it was a somewhat confused phylum, at that – a lot has transpired in biology since Haeckel's *General Morphology*!). But, most importantly, Haeckel was perhaps the first person who considered the importance of the microbial world on a par with the visible world of plants and animals, something that Margulis championed more than anyone else in our time, and a key to her worldview. Near the end of her life, Margulis was in the third set of winners of the Darwin-Wallace award, given only once every fifty years, the first set of which went to Haeckel and Wallace himself (along with some others, and it has now become an annual award).

Margulis, like some anachronism from Haeckel and late 19th century Natural Philosophy, used to bemoan that modern scientists didn't feel that they should have a philosophy. No one doubts today the vast implications of Margulis' scientific work and the endosymbiotic theory: three of the four hypothesized mergers in Margulis' 'serial endosymbiotic theory' (SET), her life's work, have been substantiated by evidence, and two are generally accepted and now found in all biology textbooks. In Brockman's *Third Culture*, authors made comments on the other authors' essays: Niles Eldredge wrote that Margulis' "notion of the symbiotic origin of the eukaryotic cell was probably the grandest idea in modern biology," and Richard Dawkins wrote that, "This is one of the great achievements of twentieth-century evolutionary biology, and I greatly admire her for it" (Brockman, 1995). Yet the scientific establishment openly scorned this same work when Margulis first tried to publish it, not long after Snow's essay. We must ask ourselves how the 'industrial-scientific complex' which grew during the period Snow wrote about – from the beginnings of peer review to the emergence of so-called 'consensus science' – could not only lead itself astray scientifically, but also how it impeded scientifically-grounded philosophy, and how it alienated the humanities from science altogether. Were all these things related?

In one passage, Snow's essay mentions the German scientific educational system in the mid-19th century, and how it was superior to anything in his native England. "I don't begin to understand this: it doesn't make social sense: but it was so" (Snow, 1959). Goethe's immense role in this cultural history has already been mentioned. The British Dawkins wrote a popular book on science and its relation to the arts called *Unweaving the Rainbow*, particularly focused on poetry of the 18th and 19th centuries, and titled after a poem of Keats that is critical of Newton's optics. Dawkins' book contains no reference to Goethe. Yet Goethe, by far the greatest poet-scientist in history, and surely one of the most influential figures over more than a century of Western culture, also wrote an important scientific work called *Theory of Colors*, at once stemming from his own *scientific* critique of the same work of Newton, and, in a sense, poetically inspired at the same time. It has been said that the color wheel used in our modern day printers is closer to Goethe's than Newton's, although this is hardly what matters: stemming from his interest in *chiaroscuro* painting seen during his Italian journey, Goethe was fascinated by the human *perception* of color, and thus much of what had alienated Keats from Newton was removed. The rainbow was never unwoven. Dawkins' book appears somewhat empty and rhetorical. But more importantly, could it not be that the German story of Darwinismus I have unfolded is instructive when considering C.P. Snow's famous divide, what Snow himself noted about the German educational system, or what Dawkins lamented, with figures like Blake and Keats disparaging science? Goethe well knew what delimited 'science,' but saw no reason to disparage it. Neo-Darwinists like Dawkins should be curious that Darwin was never widely rejected in German culture, and rapidly became central to it. In part this took place because Haeckel showed how Darwin could be fit into a cohesive way of viewing the world. All this took place because there hadn't yet been the "scientific revolution" that C.P. Snow never questioned the values of.

Such thinking lays some of the blame for our current dilemma – a society that could soon tip into full-blown catastrophe, and a culture that has just barely begun to acknowledge any problem – within the scientific establishment itself. In 2001, a few years before the premiere of *Gaian Variations*, the Amsterdam Declaration on Global Change was signed by over 1,000 scientists from more than 100 countries under the aegis of the United Nations. It begins by stating, "The Earth System behaves as a single, self-regulating system" (Schneider et al., 2004), a huge victory for Lovelock and Gaia theory. For two decades Richard Dawkins and his colleagues consistently used to claim that this was impossible, and even silly, because the laws of natural selection could not lead to a planet that self-regulated. In his *Unweaving the Rainbow*, in fact, Dawkins singles out Lovelock's theory, calling it, "bad poetic science" (see Dawkins, 1998, Chapter 9). William Hamilton, the spiritual father of modern neo-Darwinism (and particularly important in developing the gene-centric view espoused by Dawkins), eventually changed his mind, agreeing that Lovelock's concept of global-scale self-regulation had been right all along. In *Science and Poetry* philosopher Mary Midgley ridicules Dawkins and the neo-Darwinists, although even she neglects to discuss Goethe and his immense importance in bridging science and poetry, and therefore some of the most pertinent history is missing from her account as well. The blame cannot be directly transferred back and confined to scientists, either, as it must involve things like small sectors of entrenched power, Anglo-American academic currents in biology, philosophical traditions, fashionably deconstructive modes of theory, etc.

The resurrection of something akin to Haeckelian Monism might be needed to heal the rifts of the "dualist culture" that grew up after Haeckel's death. His use of the name Monism for his philosophy and his use of the similar-sounding word Monera to describe single-celled organisms was hardly a coincidence: he first argued for his philosophy of Monism in the very work, *General Morphology*, in which he introduced his tree with three Kingdoms and named the Monera (and introduced the word ecology). Indeed, his own argument against Cartesian dualism was founded on the idea that life and non-life only differed in a matter of degree of organization – an argument that has been reborn in our time through Ilya Prigogene's work on 'dissipative structures' (see Prigogene, 1985), and more modern thermodynamics generally (see Schneider and Sagan, 2005; Sagan, 2013).

It was the simple, early life – his Kingdom of Protists, his phylum of Monera – that convinced Haeckel of this Monist unity, as he felt that mind grew from motion, as we shall explore later. If this turns out correct, it points to a special place for music, and for the approach to ecomusicology I have been proposing, as it was precisely the representation of this early life that formed the subject matter of the opening of Mahler's largest work, depicting the transformation from the 'still uncrystallized

inorganic matter,' as Mahler referred to it, to the living planet.

A Symphony of global ecology

Mahler, disagreeing with Sibelius, told his colleague that a symphony "must be like the world. It must embrace everything" (Mitchell, 1975). Let us look a little more at Mahler and his Monist Third Symphony. This Darwinian-Haeckelian work – the longest symphony in the standard repertory – is cast in six movements, and the first three exactly parallel the three big branches of Haeckel's famous 1866 tree in *General Morphology* – the central protists, along with the plants and animals. The first protist movement is by far the longest, and so he makes this into Part I by itself. Although they went through various versions and were ultimately removed, the titles of the movements in the autograph are:

I. Pan Awakes, Summer Marches In
II. What the Flowers in the Meadow Tell Me
III. What the Animals in the Forest Tell Me
IV. What Man Tells Me
V. What the Angels Tell Me
VI. What Love Tells Me (Floros, 2003, p83)

When Mahler suggested that the opening movement depicted the raw material of inorganic nature and the beginnings of early life, it means this movement is among the first and only microbially-inspired works in the repertory. It is clear that it is not, as one might otherwise assume, the beautiful views from his hut at Steinbach am Attersee (where he wrote it) that inform this movement directly, or any immediate experience of nature, as in most nature-inspired music from the *Pastoral* to today. He was quite explicit about its program in writing to friends. To Natalie Bauer-Lechner he wrote:

> This almost ceases to be music, containing mostly sounds from nature. And it is eerie how from lifeless nature, life gradually breaks forth, evolving step-by-step into ever-higher life forms (in Floros, 2003, p89).

The introduction of the voice in the fourth movement herald's the second part of the work in another sense: the injection of the word represents the arrival of the human spirit, which then predominates until the end, even though the last movement is once again entirely instrumental.

The musical iconography of the third movement might seem poor or even haphazard at first. In reality, it contains great metaphoric complexity – and depth – that is difficult to grasp. It belongs to a series of related movements that run through the first four Symphonies. These four have rightly been considered a set, unified by such factors as their each having been conceived around a program. In these "Scherzo" movements, Mahler makes reference to various 'pagan' and folk idioms from earlier music history, and they can sound at times both Baroque and Medieval, but there is also something far deeper uniting them. Adorno begins his exploration of this music's 'physiognomy' discussing its signature sense of *Durchbruch* (breakthrough), that unique sense of some rupture that "originates from beyond the music's intrinsic movement, intervening from outside." In trying to describe such *Durchbruch* in the First, he writes: "For a few moments the symphony imagines that something has become reality that for a lifetime the gaze from the earth has fearfully yearned for in the sky" (Adorno, 1992), a fascinating statement which could already lead to deeper thoughts about Gaia and our human place. In the Second's Scherzo, the music depicts the humdrum triviality of everyday life, the 'world's course,' and is based on his earlier song *St. Anthony Preaches to the Fishes*. That movement, which culminates with perhaps the most famous such moment of *Durchbruch* – an overwhelming cry of despair – represents Mahler concretizing and better controlling this element of his language, Adorno feels (I might personally liken this to the evolution of the seizure passages, both literal and figurative, that run through the five great interrelated novels of Dostoyesvsky – works particularly dear to Mahler, moreover). In this third movement of the Third, it is fascinating how this same facet of Mahler's language, again bound to animal imagery, now depicts its animal world so otherwise. As Adorno says, "Its music has the same quality of confused bustle as the fish sermon. This, however, is not answered by despair but by sympathy. The music comports itself like animals: as if its empathy with their closed world were meant to mitigate something of the curse of closedness" (Adorno, 1992).

Adorno does not mention how the 'scherzo' aspect of the animals movement leaves its marked impression relative to the microbial monumentality of the opening chapter of evolution. It seems almost as though Mahler were saying, "Animals, those furry critters in the forest? Why, *they* aren't what really counts." It were almost as though, in his evolutionary Symphony, Mahler were making fun of the neo-Darwinists and their zoological bias even before they existed. A similar spirit probably lies behind a popular anecdote about the composer: it is often related how he said to Bruno Walter, when Walter admired the view from Mahler's hut in Steinbach, when he was working there on the Third, "No need to look up there." This was clearly not stemming from Mahler's being insensitive to its

beauty, and probably was not stemming from his knowing it so well or having depicted it already. Rather, Mahler's quip likely expressed his absorption with the *deeper* forces that have shaped the visible and familiar nature around us, but which are not themselves visible, since they are mostly microscopic.

The end of the *St. Anthony* song reads:

> The sermon has pleased them,
> but they remain the same as before.
>
> The crabs still walk backwards,
> the stockfish stay rotund,
> the carps still stuff themselves,
> the sermon is forgotten!
>
> The sermon has pleased them,
> but they remain the same as before.

Seen from the evolutionary stance of the Third, how fitting both for making fun of the traditional anti-evolutionary view of species (the crabs still walk backwards), and for depicting stodgy academics, like those in our time who lavishly praised Margulis' work once they could no longer fully reject it, yet have still never really embraced it either. As Margulis has said bitingly, "Even today most scientists still don't take symbiosis seriously as an evolutionary mechanism. If they were to take symbiogenesis seriously, they'd have to change their behavior. The only way behavior changes in science is that certain people die and differently behaving people take their places" (in Brockman, 1995). Adorno suggests this same spirit and tone in Mahler, whose works "plead anew against the world's course. They imitate it in order to *accuse*; the moments where they breach it are also moments of *protest*."

But the Scherzo of the Third is even more complex. Mahler called it, "the most farcical and at the same time the most tragic piece that ever existed....It is as though all nature is making faces and sticking out its tongue" (LaGrange, 1995). If it is the bustling of mammalian existence itself that is in a sense parodied in the Third, the *Durchbruch* of this movement is a powerful expression of the opposite, such that the animals somehow trivialize us. As Adorno writes:

> The menacing rhythm of the trampling animals, oxen with linked hoofs dancing triumphal rounds, prophetically marks the thin fragility of culture, as long as it nurtures catastrophes that could swiftly invite the forest to devour the devastated cities.

While Adorno agrees that the movement contains parody, he never explains just what he feels is parodied. But as to the movement's tragic side and its *Durchbruch*, he writes:

> Its light-beam falls on that perverted human condition that, under the spell of the self-preservation of the species, erodes its essential self and makes ready to annihilate the species by fatefully substituting the means for the end it has conjured away. Through animals humanity becomes aware of itself as impeded nature and of its activity as deluded natural history; for this reason Mahler meditates on them (Adorno, 1992).

Far from mere verbiage, this fascinating criticism reflects the deepest knowledge of the score (for example, the "Great Summons" music from the apocalyptic ending of the *Resurrection* is specifically alluded to), and it also suggests why Mahler is still the most important composer to explore, if one is interested in the address through music of the existential crisis we are facing in coming decades: for this reason I meditate on him. Although Adorno feels even closer to our contemporary dilemma, Lewis Thomas more recently expressed similar feelings, albeit in a Cold War context, in his *Late Night Thoughts on Listening to Mahler's Ninth*. Thomas, as President of Memorial Sloan-Kettering Cancer Center, oversaw their series of science publications at Norton, and thus became the editor of Lovelock's most important book, *The Ages of Gaia: A Biography of Our Living Earth*. In his preface he called it, "a set of observations about the life of our planet which may, one day, be recognized as one of the major discontinuities in human thought," a *Durchbruch* in human evolution.

Music's happy science: nature's chord in the 21st century

Theory has long been seen as the 'science' of music and organized music theory predates historical musicology by centuries if not millennia, so it should not be surprising if, in advocating a more science-based view of ecomusicology, I would want to include theoretical ideas. Mahler's close friend Guido Adler, in setting out to define musicology, formalized the division between theoretical and historical musicology in the very first issue of the first periodical devoted to the subject, which Adler began with Spitta, the *Musicology Quarterly*. (Somewhat arbitrarily, Adler considered 'comparative musicology', which became our ethnomusicology, as a subdiscipline of the theoretical branch.)

Essentially, music theory starts with the harmonic series. Some have called it 'nature's chord,' but it is more like a primary facet of the physics of pitched sound, and has come to be treated more like

a philosophical object ensconced in pitch. The 20th century saw a marked politicization of pitch, ranging from some who saw the harmonic series as justifying the manifest destiny of atonal and microtonal music, with human culture 'climbing up' the series, to those who conversely saw it as a justification for tonality, evidenced by the triadic nature of the basis of the series.

Today such pitched battles have subsided, and ecomusicology, to the extent it has dealt with issues of music theory, has not sought to revive them. Perhaps this is in part because, in attempting to align itself more directly and concretely with the 'environment,' ambient sounds have at times come to seem more germane to some ecomusicologists than pitched music made by traditional instruments. Yet clearly, that thing that has beguiled the human mind since flutes were first built to play pentatonic scales, 30,000 years before the Neolithic revolution began, still has a special power and place among all sounds – and that thing is pitch.

It might be time to revisit 'nature's chord.' One thing that was missed in the last century's debates, or even in the more recent fascination with graphic representations of spectra interpreted as compositional information, was the simple underlying holonic nature of the series and musical pitch. Indeed, musical pitch provides an excellent example of holonic structuring in nature. Holons are things which are both parts and wholes at once. Such structuring is also endemic to the phenomenon called life, and provides a key for understanding how the mechanics of planetary self-regulation operate. The term holism, coined in 1926 by Jan Christian Smuts, was inspired by Frederic Clements' superorganism concept. Clements had published the first American work on ecology, in 1905, presenting the idea that plant communities act as a superorganism. Thus, the origins of holism and the superorganism idea have long been innately joined. Gaia is the largest superorganism, the biosphere taken as a whole. When we strike a string, and it vibrates in parts and as a whole at once, it is a direct demonstration of the embodied 'magic' that we still haven't fully unraveled of wholes and parts interacting – it is a holarchy. A thing which is both a part and a whole, somewhat like Russian Matryoshka dolls, is characterized by a quality one could call infolding. When we blow on a flute, though we have now begun to directly observe the structure of the air's eddies, akin to the infolded segments of a vibrating string, there is still a certain magic in it. Lovelock, in comparing the 'dissipative structures' of thermodynamicist Ilya Prigogene with life and Gaia, discussed such structures' relative simplicity and lack of solidity or permanency, and how they turn off as soon as the energy flux is lowered, using the example of a flute which only makes eddies leading to pitched sound when it is blown on sufficiently (Lovelock, 1988). The earliest verifiable musical instrument, a flute made from a vulture's wing bone, was found in a cave in Hohle Fels, Germany, just a few feet from where the earliest known work of figurative art was found, a 'Venus' statuette, prefiguring Gaia.

Once we recognize the importance of the holonic nature of pitch, it is then easy to see this extended into the higher holarchy of musical structure: forms within forms, even one aesthetic style nested within another. Indeed, this is precisely what we see in some of the greatest classical music of the past, and it certainly describes Mahler's music, and how one could arrive at the largest and most cosmological work starting from Haeckel's monera. Since this kind of holonic structuring is innately tied up with the superorganism concept, and Mahler's subject was biological evolution, Mahler's Third might even be rightly considered the first "Gaian" composition. And this intense holarchy runs from its evolutionary macro-structure and resolves down to the detailed level of its harmonic practice.

Eeriness within the happy science

In looking back at Mahler's Gaian symphony, it might be of interest to briefly explore some technical harmonic features of the first movement. Mahler repeatedly wrote about it in terms of its eeriness:

> No one will hear, of course, that nature encompasses everything that is eerie, great, and even lovely (this is precisely what I wanted to express using the whole work as a kind of evolutionistic development). It always seems strange to me that most people, when they talk about nature, can think only of flowers, little birds, forest fragrance, etc. No one mentions the god Dionysus or the great Pan. There, now you have a kind of program, that is, a sample of how I make music – always and everywhere only the sound of nature! (in Floros, 2003, p90)

It is very clear what gives the opening movement its eeriness: specifically, what sounds eerie is a D minor triad sounding together with a C#, what might be called a dissonance of infolding. The augmented triad on III appears as far back as Gesualdo, in some of his more dissonant madrigals, and occurs occasionally during the common practice period as an expressive chord in the minor mode. One might consider this the same chord over a tonic pedal (i.e. III+/I pedal point), but clearly the C# is heard as a long drawn out appoggiatura, and the

eeriness seems like it might be coming from the ambivalence of a dissonance and its resolution heard together. It is clear that the timing, its prolongation, is critical to the feeling and function here: it is, in the end, just an upward rising appoggiatura, but is sustained so long that it is impossible not to hear it as a harmony.

What is less clear, outside of its infolded quality, is how this relates to 'nature's chord.' In the pitched battles over the harmonic series, Babbitt represented one extreme, and claimed that the series said nothing about tonality since the minor triad was not basic to it. A new approach might be to try to look at harmony through the language of cybernetics, seeing notes within chords as feeding back on one another relative to their placement in the series, with positive feedback creating instability: the minor triad would be somewhat less stable than the major one (harmonics 4,5,6 create the major triad, by far the most stable triad, while harmonics 6,7,9 give a minor triad), as is well reflected in common practice in the minor mode. The chord Mahler uses here is far less stable, and it is this instability that sounds eerie. However, a curiosity about this sonority is that it is more basic (i.e. lower down) in the series than the major or minor seventh chords (i.e., it is formed from harmonics 6,7,9,11), although, of all available seventh chords within the diatonic system, this was one of only two that remained relatively unexploited at the time of his writing, having previously appeared as a rare passing dissonance, quickly resolved.

In the harmonic revolution that Chopin helped usher in, an added sixth could start to function as a metastable unit of "harmonic color," and just as Chopin opened his *Preludes* with something of a proud annunciation of his novel approach, Mahler, what with the primal quality of his material and the sheer novelty of it, makes this an annunciation of its own, literally trumpeting his idea near the opening. While I refer to this as novel, it should be noted that both the harmony and its rising arpeggio gesture were intriguingly adumbrated in Schumann's *The Prophetic Bird*. If each Symphony must be "like the world," and these worlds become interconnected and reincarnate their elements, it is interesting to consider the ending of the Second, its commingling of the Last Trump and the Bird of Death – which he changed to a Nightingale in the program of one performance – in relation to this material that opens the Third. In the third movement of the Third, Mahler draws on his song *Ablösung im Sommer*, the text of which involves Lady Nightingale. In the autograph of the fourth movement, Mahler wrote over one passage, *Der Vogel der Nacht*. Whether or not *The Prophetic Bird* somehow speaks within the primordial beginnings of this evolution, this eerie chord and its drawn out 'suspension' (in Adorno's sense) create the primary expression of the program of Part I of the Symphony – and from Mahler's discussion of the importance of eeriness in Nature, it is clear that this is just how he intended it.

It is interesting to note how this sense of eeriness then continued in the development of atonality shortly thereafter (this same chord was of considerable importance to the Second Viennese School composers). Indeed, for many listeners, eeriness became the pervading characteristic of atonal music. It is also interesting to note the shifts in extra-musical nature metaphors associated with such eeriness. The first atonal musical movement was the last movement of Schoenberg's *Second String Quartet*. Like the history of introducing voice into the Symphony (Mahler felt that it was something one should do only to express things inexpressible without words), Schoenberg introduces the soprano voice while first entering the atonal realm in the last two movements. The texts Schoenberg chose were from Stephan George, and the last movement, where his music becomes truly atonal for the first time, opens, "I feel the air of another planet." Thus, the sense of eeriness has shifted from a Gaian symphony imagining the raw stuff of Earth before life, or at least before its evolution into the familiar everyday world around us, to the complete sense of alienation from the biosphere that comes with thoughts of outer space and other planets. Schoenberg later carried his outer space metaphor further, when describing his technique of the twelve tones "being relative only to each other," expressly trying to draw an analogy to Einstein and relativity theory. Implicitly, Schoenberg's metaphor was that the fundamental sense of gravity in the tonal system, where all tones gravitate towards a single triad or note, had been broken, or escaped, as in outer space.

It becomes even more fascinating to ponder these differing musical metaphors in light of how Gaia theory started. Lovelock had been invited to be part of NASA's first Viking mission to Mars (initially called Voyager), and later became head of its life detection team. In September 1965 we first came to know the air of another planet in a literal way, when the French Pic de Midi Observatory analyzed the atmosphere of Mars, and their readout was sent the same day to NASA's Jet Propulsion Lab in Pasadena. Lovelock was in his office which he shared with Carl Sagan, and when he was told of the findings – that the atmosphere was mostly carbon dioxide (which he had already assumed) – it suddenly led him to his

profound insight that the thermodynamic state of our own atmosphere, its low entropy compared to that of the neighboring planets, must stem from the activities of its organisms (Lovelock, 2000). He mentioned the idea to Sagan that afternoon. The very same day that we really "felt the air of another planet," a great revolution started, but it came from turning around, and looking back from another planet to our own. Away from Schoenberg, back toward Mahler.

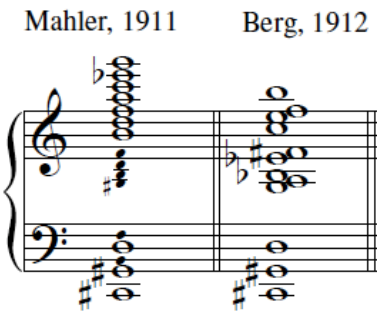
Like the earliest musical instrument being found next to an ancient 'pre-Gaia figurine', there has been an intentional desire here to set the language of harmony down next to the modern theory of Gaia. A matter of remaining controversy, and a question for 21st century science, is how one gets to global scaled self-regulation from the mechanics of selection. William Hamilton, a leader of the neo-Darwinists, acknowledged before his death that our planet indeed must self-regulate, writing that we "need another Newton" to figure out how. Lovelock had proposed with Andrew Watson a model known as Daisyworld, to demonstrate global self-regulation as compatible with the laws of selection. At the end of Margulis' book *Symbiotic Planet*, which sets out to describe the relationship between her own work on symbiosis and her work on Gaia theory, she points to Daisyworld. Perhaps she is too close to see the simple truth sitting in her lap: Daisyworld, while a good mathematical demonstration of principle, is not the biological mechanism itself. She starts the book quoting her graduate student Greg Hinkle, who said, "Gaia is just symbiosis as seen from space," but never quite brings this quip to its logical conclusion. The new Newton that Hamilton called for will more likely find Margulis' own endosymbiotic theory at the heart of the mechanism for planetary self-regulation. A study of the thermodynamics of symbioses seems likely to show that the greatest 'Negentropy', to use Schrödinger's word (meaning the opposite of entropy – but in practice, the export of entropy outside of a system), will come from endosymbioses. The 'endo' part is important, as it is the driver of that holonic structuring which we see throughout the biosphere – things that come to live inside of other things (if this seems a bit exotic to you, consider that inside your body the DNA that is not your nucleic DNA is a hundred times more plentiful than 'your' nucleic DNA, and the number of cells that do not contain your nucleic DNA at all are ten times greater than those that do, thus making you a kind of superorganism yourself – see Wade, 2008). If this idea is correct, pitched sounds, which have beguiled the human ear since that Gaia figurine was laid down in a German cave, and were elaborated into a full language of harmony in Western classical music, delight us – like other complex phenomena that share features with life but are not part of life – because they implicitly suggest that holarchies like ourselves are an inherent truth of the universe.

Holarchies, harmonic and horizontal

In the context of reexamining the harmonic series' structure, and exploring its relationship to harmonic practice as well as to parallel paradigms of science, it might be interesting to make a comparison between two complex, dissonant harmonies, one from Mahler, the other from Berg. They were composed around the same time, and use all or most of the series sounding together – itself a fascinating extension of the holarchic nature of pitch. If we accept Mahler as the end of the common practice, then we are looking near the end of the last completed movement of common practice music, and will compare it to one of the very earliest works of true modernism. At the climax of the first movement of Mahler's 10th Symphony, a work left incomplete when he died in 1911, there is a chord with 9 of the 12 chromatic notes in it (meas. 206, and repeated in 208) – in other words, most of 'nature's chord' sounding together. If the Ur-chord of "uncrystallized, inorganic" Nature in the Third sounded eerie, this one is terrifying. Just the following year, Alban Berg (who worshipped Mahler), in his early *Altenberg Lieder*, began the third song with a chord containing all 12 notes, the first appearance of such a chord. Berg's song sets a text by Peter Altenberg, *Über die Grenzen des All* (*Over the Edge of the Universe),* carrying the outer space metaphor of Schoenberg's earlier atonal quartet movement (1908) as far as it could go.

The two chords (Figure 1) are strikingly related, since a foundational fact of harmony is that chords are at least to some degree perceived from the bass up (itself a lesson from 'nature's chord,' long

Figure 1.



For the Mahler chord, what is considered a reasonable voicing of primary chord members is represented in whole notes, with doublings filled in black; the Berg has no doublings.

observed in orchestration, but one which reduces a good deal of "set theory" in post-war academia to something of a joke), and both chords contain the same members in the bass – C#-G#-(D) are at the bottom of both chords. Indeed, it is odd to consider that when Berg proofread the first fair copy of the Mahler movement (created by Ernst Krenek), it was twelve years later, and thus seemingly implausible that the similarity is anything more than uncanny coincidence.

The *Altenberg Lieder* was Berg's first orchestral work, and at the premiere of two of the other songs such a riot ensued that Berg never again tried to have the work played. Thus neither Mahler nor Berg ever heard these dissonant sonorities performed. Berg's 12-note chord is treated as a 'Klangfarben' chord, but with some of the members also exchanging octave as well as color.

Even outside of musical context, the Mahler is deeply impressive, the Berg comparatively ineffectual (later, Berg learned to do precisely this kind of thing with aplomb). I referred before to an 'infolding' in the holonic nature of the series, and some might retort that tonality itself is an infolding system, which is true. But how do we find a language for discussing 9- or 12-note sonorities, where we avoid talk of "pitch-class sets" and the like? After all, in that language, all 12-note sonorities are identical, by definition (stemming from an extremist position on octave equivalency, its assumption that chords are heard in some vacuum like Schoenberg's relativistic outer space metaphors of pitch without gravity, when in fact harmonies are perceived more like Zarlino suggested in the 1500s, with the bass functioning like Atlas holding up the Earth, i.e., heard from the bottom up).

No 9-note sonority could work like the chord we examined in the Third. But if there were an 'infolding' in Mahler's harmonic construction, then you might expect that some parts of this massive sonority would resolve into others. In a brute sense, the whole complex could just be tonally resolved directly into the tonic 6/4 chord. Indeed, this eventually happens, but an immediate resolution would certainly sound belittling and trite. Instead, certain members of the sonority fold inward in resolution into others. Mahler has been in Ab min., ii of the tonic F# Major. Like many Romantic composers, he was obsessed with the potential of the half-diminished seventh chord, and here a half-diminished created by an added 6th on an Ab minor chord moves by chromatic motion to a dominant seventh chord on G, and then the upper melodic G (with a D against it) moves to A. This will eventually resolve up to A#, the third of the tonic chord (and the D down to C#), but now he builds his dissonant edifice outwards: first, he builds down (mostly in thirds) the minor ninth, making a diminished 7th chord on the Ab (now G#) with added minor ninth (that is, the A). Thus far, this initial minor ninth chord is somewhat akin to the dissonant chord at the opening of the last movement of Beethoven's Ninth (the second time, at measure 17 – which is also a diminished 7th with an added dissonance, also constructed such that a minor ninth is prominent). Then, when he adds a lower register (repeating the whole diminished 7than octave lower), he also adds a low C# bass, creating a whole new set of dissonances, including another prominent minor ninth, from C# to D, as well as adding an upper C (natural). After that, he adds more upper dissonances – Eb and G. (Figure 2.)

In a sense, the A and D are part of a central half diminished chord, itself the central core of the initial Beethoven-like minor ninth chord. Yet in another sense, the whole 'bass chord' (the initial ninth chord plus the C# bass) could be seen as a dominant thirteenth (V7 with minor 9th and 13th) chord in F#,

Figure 2.

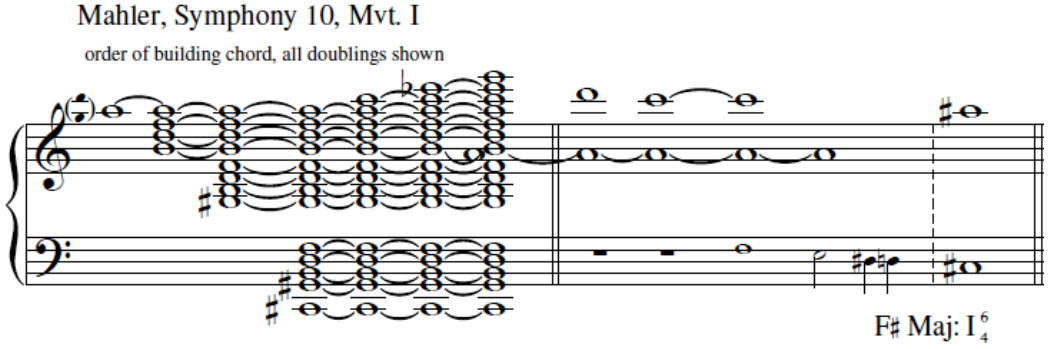
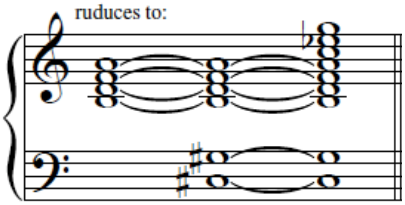


Figure 3.

Mahler, Symphony 10, Mvt. I



which, indeed, ultimately moves by conventional Romantic chromatic motion to I 6/4. (Figure 3.)

Immediately, just looking at Mahler's chord on the page, the tertiary nature of the construction strikes the eye: in fact, another way of considering it is as a chord constructed of stacked alternating minor and major thirds, such that it forms two chained half diminished seventh chords, above the bottom fifth.

Mahler's 9-pitch chord holds an almost endless fascination for the ear, capable of multiple interpretations, and capable of being seen as having an infolding not just of physical structure, but of music history as well, built up from Beethoven's earlier dissonant chord. The Berg chord/chords, despite their similarities, have far less aural interest. Part of this is just the context (or lack thereof), but part of it is also the precise disposition of notes, and the lack of interiority, the rich infolded structures of Mahler's sonority I have just described.

We have looked at a single dissonant harmony, the 'vertical' component of music, as an extension of the holonic nature of pitch. What about the horizontal component, time? Charles Rosen, at the outset of *The Classical Style* noted that we still hardly have a language to express all that happens in the rhythmic component of classical music, and Mahler's music includes all that complexity. I wish to briefly look at some conventional views of Mahler and nature and time, and show how they might be reinterpreted, with more coherence, through the lens of modern ecology.

Julian Johnson, in *Mahler and the idea of Nature*, (see Johnson in Barham, 2005, Chapter 2) discusses how for Heinrich Eggebrecht, who extensively studied the *Naturlaut* (nature sound) in Mahler, a fundamental idea is that nature always appears as that which is 'Other' to the world of civilization, the normal fabric and flow of the music. This is in some sense related to Adorno's idea of the *Durchbruch*. But Eggebrecht uses the term 'transplantation' to portray a quite different sense of something exterior and imported into the fabric of the music which never fits in – like the cowbells in the Seventh. Johnson himself, however, feels that Mahler's music is not concerned with a *representation of nature* – which of course the *Naturlaut* inherently plays into – but more deeply with a *discourse on nature*, an approach offering a far more flexible interpretation. Johnson notes, however, that there are, throughout Mahler's work, discreet, self-contained sections that seem to represent natural process, which he calls 'nature episodes': harmonic stasis, pedal tones, motivic fragments, a lack of any sense of meter, all of these typify the nature episodes. As Johnson says, this interrupts the narrative unfolding, and "all of these contribute toward a loss of forward energy in the music," calling it is "a means by which the music confronts its own model of time." Of course, these descriptions call to mind the discussion of the arrow of time, thermodynamics, and musical construction made at the outset, perhaps suggesting that Mahler was defying precisely the correlation I seemed to draw earlier.

Johnson goes on to describe how the nature episodes always have a complex relationship to the material around them, and intriguingly uses the word 'threshold' to describe them. Until this point, one might think of these episodes as being like moments in Ligeti's music when a sudden open interval arrives, interrupts the flow, and brings with it a new sense of space. But with Johnson's discussion of the threshold and how it operates, we enter relationships that are seemingly too complex for anything but advanced tonality to convey in music. Note the language Johnson uses: he says they "*cut across the more familiar temporal patterning,*" they "exert a structural function that is definitive for the outcome of the *narrative blockages,"* and "as thresholds, nature episodes *radically alter the direction and character.*" What is so fascinating is that this is precisely the language used in contemporary thermodynamics in describing complex systems. 'Nature abhors a gradient' is the theme of this more modern thermodynamics of open systems, needed to describe complex phenomena like tornadoes and other 'dissipative structures,' to use the term of Ilya Prigogene, which self-organize and export entropy outside of themselves (Schneider and Sagan, 2005). Johnson's 'threshold' is the 'gradient' in natural systems – it might be a difference of temperature in a cold front, or a chemical gradient as we go deeper into the marine environment. In studying complex systems like weather, one looks at phenomena that *cut across normal patterning*, interactions that *change direction and character* of systems, *blockages* like the one that made Sandy turn back and hit New York

City, etc. What Mahler does in the incredibly rich holonic temporal world of his creation – in no way separate from that holonic harmonic world just described, but completely wrapped up with it – is derive energies from complex differences and relationships, creating gradients, or thresholds, that alter the old conventional flow of time in the narrative structure that is layered within it, a holarchy far more complex than anything in popular music. This is no longer the thermodynamics of Boltzmann, but rather that of Prigogene, Odum, Schneider and Sagan, which looks at open systems.

Alongside these vertical and horizontal holarchies, one might also mention the aspect of physical space in Mahler. Johnson mentions how the use of offstage players in Mahler is often confined within these nature thresholds, and represents an expansion of physical space, both literal and figurative, which often arrives with them, discussing the Eighth in particular. Johnson notes that in *Das Lied von der Erde* even the pentatonicism itself functions as "a realization of the tendency towards spaciousness and a refusal of the linear insistency of tonal music." It might seem like a rejection of the law of entropy, but in fact a key element of the new thermodynamics is that Schrödinger's "Negentropy" – life's seeming rejection of the laws of entropy, a concept on Lovelock's mind when he first came upon the idea of Gaia – is actually just a continuous export of entropy outside of the local system (see Schneider and Sagan, 2005, or Sagan, 2013). And as Johnson says, in discussing Mahler's ability to create an extreme expansion of spaciousness in *Das Lied*, and Adorno's perception of it – "the 'earth' in this work, Adorno suggests, takes on the aspect of the planet seen from space."

Gaia pedagogy, Gaia's chord and the flute lying next to Venus

In thinking about ecological musicology and Gaia, it might be interesting to consider the primary nature of resonance and resonating boxes. A careful reconstruction was made of the 40,000 year old Hohle Fels flute, it plays a fine pentatonic scale, and the cave where it and the Gaia figurine were found is one of the largest in Southern Germany. Imagine how it must have sounded there! Like the great cathedrals of the Middle Ages, one can see the cave itself as an immense resonating box, a kind of extension of the musical instrument itself, a holarchy of instruments. French researcher Iegor Reznikoff has found evidence that the cave paintings in France were placed in particularly resonant locations, and that this resonance seems fundamental to their siting and function (Reznikoff, 2005). Gaia, in this holarchy of instruments, is the largest musical instrument, and provide us the conditions needed for sounds waves to propagate.

Within an ecocritical musicology, the name 'nature's chord' might be best for the harmonic series. But within the ecological musicology I am proposing, the name might no longer be appropriate: in fact, there is not really much sound to speak of, at least for human ears, in the nature we have thus far found outside of our terrestrial biosphere. When the astronauts were on the surface of the moon, they could hear nothing at all, since there is no atmosphere at the moon's surface, and while some hammer strikes were audible on a recording from Apollo 17, this was later determined to be caused by Gene Cernan's space suit functioning somewhat like a drum. On Mars, where there *is* an atmosphere, consisting mostly of carbon dioxide, some researchers have made modeled recordings, available online, that purport to show how a voice might sound relatively similar on Mars to how it sounds here on Earth, based on the simple principle that the *speed* of sound is not all that different from on Earth, once the huge but somewhat compensatory differences in atmospheric pressure, density, and extreme temperature changes are all considered, mostly balancing each other out. The problem with this approach is that, quite aside from issues of speed, since there is only 1% of the Earth atmosphere's surface density on the Martian surface, it is almost like a vacuum by our Earthly standards. If the receiver's audition is to function like a human being's, then a planet's atmosphere must propagate the sound waves, functioning almost like an extension of the sounding box for an instrument. Mars is a lousy instrument. We would hear almost nothing on Mars. We would all basically be deaf there.

Earth is the only good musical instrument thus far known in the universe. Thus, the harmonic series isn't so much 'nature's chord', although its series should remain the same anywhere, but more properly 'Gaia's chord.' Moreover, 'Gaia's chord' truly becomes the series' rightful name when we consider that the atmosphere we have here is mostly a *biological product,* as Gaia theory has predicted since its outset: even the nitrogen, the bulk of our atmosphere (79%), is in its most stable form not in atmospheric N_2, but in dissolved nitrate ions in the sea, and so it is thought to be biological activity that has kept such a great abundance of it in the atmosphere over geological time (Lovelock, 2000).

The question becomes, then, how do we teach Gaia's chord?

E.O. Wilson's notion of 'consilience' (Wilson, 1998) is surely important, but it might be that he has chosen the wrong field to organize around, and that the basis should not be neuroscience. Rather, the 'attractor' for Wilson's consilience should be Gaia theory itself, in a sense reinvigorating an old approach to learning – for example, look at the evidence suggesting that the idea of an 'animate Earth' (Harding, 2006) was at the core of Leonardo's vast learning, with spokes of knowledge radiating out in all directions from this simple inner core. People can call it 'Earth System Science,' but whatever it is called, it should not just be the basis of higher education, it should be at the heart of learning itself, such that cybernetic relationships, notoriously difficult to grasp for our minds, are introduced when children first learn basic concepts like telling time.

Gaia and consciousness

It was Haeckel who was capable, more than anybody else, of carrying into the early 20th century, and until the outbreak of modernism, a vision of science, philosophy and the arts together, and this is what provided a rich model for the first ecomusicology. Yet the separate threads of ecology and selection in Haeckel's work really only came together fully in the recent past, with Gaia theory. Haeckel coined the term ecology just one year before the dual theory of lichen as symbiotic partners was first proposed. Haeckel later produced fine drawings of lichen himself, much like his drawings of radiolarian. But the evolution of Darwin's theory in the years just after Haeckel's death still did not draw together a fully dynamic environment with the idea of selection (the environment was always considered in selection, but it was not circularly connected back to the organisms).

The so-called "modern synthesis" (Huxley, 1942) first had to combine Mendel's idea of heredity with Darwin's idea of selection. While chromosomes were first observed in the 1880s, it took decades before they were assimilated, following the rediscovery of Mendel's work, into a coherent view of evolution. While the term neo-Darwinism goes back to Wallace, today it connotes a complete dependence upon selection plus random mutation for genetic novelty, as opposed to various ideas of saltation. The modern synthesis, while it was certainly important for the early combination of heredity and selection, took place in an exclusionary environment from which such ideas of saltation were shut out. Theodosius Dobzhansky's *Genetics and the Origin of Species* (1937) suggested through research on fruit flies that this synthesis indeed explained what was seen in natural populations. Meanwhile, the other side of Haeckel's work, his ecology and lichenology, made progress, in a quite separate scientific lineage further East, in Russia, where botanist Konstantin Merezhkovsky, an important researcher in lichenology, developed a theory of symbiosis as a source for evolutionary novelty, which he called "symbiogenesis", and where geochemist Vladimir Vernadsky also founded modern biogeochemistry.

Watson and Crick's discovery of the spiral helix in the 1950s led to the revolution of modern molecular biology. In a sense, the work of Lynn Margulis could be seen as using the new tools of molecular biology to finally make a broader "modern synthesis" than the earlier one, in which aspects of the work of Merezhkovsky, Ivan Wallin and others are put together into a coherent view in her SET (serial endosymbiosis theory) with the rest of Darwinism. It is at least a delicious curiosity that of the two cited examples of species originating in a laboratory – one of them in Dobzhansky's lab involving a microbial parasite of some fruit flies, the other involving ameobas accidentally infected with a parastic bacteria in the lab of biologist Kwang Joen (which eventually could no longer survive without their parasite – see Margulis and Sagan, 1986, and Sagan 2013) – both were saltational and took place just as Margulis predicted, and neither took place as Dobzhansky and the rest involved in the earlier "synthesis" would have imagined.

A striking parallel between Margulis and the earlier thinking of Haeckel concerns the one remaining controversy of her SET. Haeckel intuited that the origins of thought and mind must have come from the origins of motion in early life. In Margulis' SET, the first of the great mergers that led to the eukaryotic cell involved a spirochete-like eubacteria, some early master of motility, merging with a host cell (Margulis, 1981, 1998, Margulis and Sagan 1986,1997, 2002) . Because it took place so long ago (some recent estimates place the earliest eukaryotes much farther back than previously thought – perhaps even 3 billion years ago), almost no direct evidence of it is left (in 1989 three cell biologists at Rockefeller University first reported that they had found what would provide evidence of this, something called c-kDNA, and the Margulis lab also claimed to have observed such c-kDNA subsequently – see Margulis and Sagan, 1997, Chapter 4). If this merger indeed took place as hypothesized, then these early swimming bacteria in

fact gave their microtubule structure, which conferred their motility, to the microtubules in eukaryotic cells, which eventually became fundamental to nerve cells in animals like us, the basis of all animal perception and human thought. In other words, Margulis' SET might be proving Haeckel right – physical motion near the beginnings of life became thought and mind.

In looking back one last time at the Haeckelian symphony of Mahler, a work that ends with a movement called *What Love Tells Me* might not seem to some like a serious scientific rumination, and probably would not have to C.P. Snow. But in a world where the human nervous system and mind has likely evolved directly from the motility of early bacteria, Mahler's aspirational last movement is still in accord with the thinking of many of the most important scientists in this history I have just unfolded: Vernadsky assumed there must be a 'noosphere', a realm of the mind or spirit, an idea taken up by many others since, including Lovelock, and Margulis' last book, *Chimeras and Consciousness*, was entirely devoted to the topic of the emergence of consciousness from our symbiotic planet.

Geoengineering as ecocritical crucible

In addition to suggesting that the current ecocritical musicology run in parallel with a more ecologically-based one, I have also insisted that there is a difficulty with traditional environmentalism in grappling with the climate crisis, possibly endemic to its nature, which has considerably impacted ecocriticism as a whole. I would now like to turn to ecocriticism, to explore one of the great crucibles of climate consciousness, the intense controversy surrounding geoengineering. Can our literature help us? The surprising fact is that one of the most famous works of world literature – the only work central to the Western canon ever written by a great scientist – climaxes on an adumbration of geoengineering and its moral implications, though composed a hundred and eighty years ago.

But I must preface this look at Goethe's *Faust II* with some remarks. For the first time in our history, science is no longer just the *opportunity* that it represented for the Enlightenment, or a symbol of ambition, such as in the early Faust legend. Rather, science in the last few decades has quietly – almost silently – also become *necessity*. This unexpected development was as unforeseen in *Faust II* as it was everywhere else in our literary canon. As an example of this new 'necessity science,' if we were simply to *stop* all greenhouse gas emissions tomorrow, the result might be a rapid doubling of present warming for the near-term, if not worse (i.e., the so-called 'termination effect' from lost aerosol loading), with considerable consequences. Like deciding one hates flying while in the middle of a flight, anti-science positions must now acknowledge that we can only safely get out our current impasse *through* science and technology. The key science of necessity is Earth System Science, the umbrella for all those sciences that intersect with the global cycling of key life elements – the carbon cycle, nitrogen cycle, all the rest of "CHNOPS" cycling – in addition to all those key physical systems that modulate the biosphere's climate state, things such as large-scale atmospheric circulation and mixing patterns; oceanic pumping, vertical mixing, heat storage capacity; the ice-albedo feedback; atmospheric oxidative chemistry; oceanic pH, etc.

Necessity, of course, is as easy to dislike as opportunities are to enjoy. Maturity, in such framing, is the ability to decouple agency from desire, and the environmental movement, aspirational in essence, finds no mature way to further or embrace something neither attractive nor desirable: I mean, of course, geoengineering. In general, environmentalists are vehemently, even passionately, opposed to geoengineering in principle. As one example, 155 environmental groups signed a declaration of opposition even to the use of biochar in the fight against climate change, in advance of the Copenhagen conference in 2009. Biochar is among the most benign forms of geoengineering (if it is to be considered geoengineering), and is embraced and advocated by many who otherwise reject geoengineering. An early form of its use is demonstrated in the *terra preta* soils created by indigenous people of the Amazon basin between about 450BC and 950AD (some such soils might be 7,000 years old, see Marris, 2006) – still exceptionally fertile soils today.

One can certainly understand the widespread fears: many have suggested that geoengineering inherently creates a disincentive to reduce emissions, and that it could even be misused intentionally. Of course, the other side of the argument is that it is looking more and more as though we are already at or near the point where a drawdown of emissions alone cannot prevent the Earth System from a state shift to a hotter planet (Hansen, 2011). In such a situation, while anti-geoengineering groups call it the ultimate hubris to "play God with the planet," the other side can say that environmentalists intend to "play Christian Scientist," not just with human civilization, but with all known creation. The second analogy is more accurate than the first: trying to

apply global medicine to the climate system *would* be "playing God" if the intention were to improve upon the Earth's climate system (this is by no means the case, although such a problem could eventually arise), whereas rejecting all global climate remedies – even trying to impede research into the subject, as is the case today – *is* like a form of globalized Christian Science in the most provocative sense. Assuming the proposed climate remedies actually work, blocking them would be akin to refusing to give penicillin to a child with bacterial meningitis, and hoping that they live (10% survived before antibiotics).

I suspect that geoengineering will create some of the greatest controversies of the 21st century. Typical environmental positions start to come apart in the face of it. For example, as is often noted, it is difficult if not impossible to make any clear distinction between what is and is not geoengineering: growing forests, which is not controversial, could be considered geoengineering, although it usually is not. And what *is* considered geoengineering more typically, which is far more invasive, no one should ever "want," just as no one should "want" surgery. Yet to impede the development of all such non-desirable but possibly necessary options suggests that traditional environmentalism is no longer performing its primary mission: to help preserve the environment.

It has been considered helpful in this debate to mention that we are currently geoengineering, so I enumerate three ways we are already doing so now: 1. as many have already noted, we are currently engineering the Earth, inadvertently and uncontrollably, through massive injections of greenhouse gases (GHGs), into a hellish state; 2. the co-emission of cooling aerosols with our added GHGs has created a kind of inadvertent "SRM" (solar radiation management) type of geoengineering – although, being unintentional, it is both done very inefficiently and is hence more dangerous than intentional geoengineering; and 3., less often stated, many non-climate related emissions changes that we have already undertaken fit within the National Academy of Sciences (NAS) definition of geoengineering, and have actually all been quite successful: that is, NAS defines geoengineering as, "Large-scale engineering of our environment in order to combat or counteract the effects of changes in atmospheric chemistry," and our significant reduction of oxides of nitrogen and carbon monoxide from transport, for example, came from the great engineering success of the catalytic converter. Mentioned in the introduction was that the catalytic converter – like many of our non-climate global-scale environmental remedies, unfortunately – also *increased* warming. That *was* true. After the problem was fully understood near the end of this past century, though, the largest cause of this effect (involving creation of nitrous oxide) was mitigated through tweaking the converter.

* * *

It was with the appearance of *Faust II*, the apex of German Romanticism, that something resembling geoengineering made its first entrance on the stage of the human imagination. Of course, even to mention Faust and geoengineering together brings to mind frightening and demonic images with which it is already too frequently associated: we think of 'Faustian bargains,' and quite famously in climate science, James Hansen, a quarter of a century ago, called one of the ongoing inadvertent forms of geoengineering – our co-emissions of cooling aerosols along with warming GHGs (2. above) – a Faustian bargain, a statement with which I concur.

But that is why Goethe's *Faust* is particularly interesting as ecocriticism: in fact, while *Faust I*, like the early Faust legends, was about 'Faustian bargains,' *Faust II* could be said to be about *escaping* from them. *Faust II* is about Monism, and this is both what led it to the strange world of geoengineering, and what gives it such an opposing and unfamiliar view, when compared to the prevailing ones of our time.

It is worth recalling the basic structure of Faust's pact in Goethe's drama: the Devil will serve Faust on Earth, but the reverse will happen when Faust dies, after which he will serve the Devil in Hell. Faust will not die, however, until he reaches a moment so beautiful that he wishes to seize and capture it (*Faust I*, scene IV):

> When to the moment I shall say,
> "Linger awhile! so fair thou art!"
> Then mayst thou fetter me straightway,
> Then to the abyss will I depart!

When that moment finally comes, it is the beauty of Faust's geoengineering-like idea which so moves him – once it has evolved and he has understood it properly – that he dies (*Faust II*, Act V):

> Then dared I hail the Moment fleeting
> *"Ah, still delay – thou art so fair!"*
> The traces cannot, of mine earthly being,
> In aeons perish, – they are there! –
> In proud fore-feeling of such lofty bliss,
> I now enjoy the highest Moment – this!
> *[Faust sinks back]* (Tayler, trans., p. 295)

Yet, it is just those words about Faust's engineering that are entirely misunderstood by Mephistopheles:

Mephistopheles cannot recognize that Faust, when he says, "The traces cannot, of mine earthly being/In aeons perish, – they are there!" is actually speaking of his great public works, his geoengineering, as being a gift to the future. In a sense, this misunderstanding then becomes the first step in the escape of Faust's soul, and his final ascent to heaven. Mephistopheles clearly cannot conceive of the cumulative beneficent symbiotic activities of life, at the heart of Monistic belief. The grand terms on which these final misunderstandings take place, shortly before the escape of Faust's soul, make it clear that this was intended to be about humanity's fate and that Faust was all of us, when Mephistopheles hears the heavenly music as ugly shortly afterwards:

> Discords I hear, a harsh, disgusting strumming,
> Flung from above with the unwelcome Day;
> 'T is that emasculate and bungled humming
> Which Pious Cant delights in, every way.
> You know that we, atrociously contented,
> Destruction for the human race have planned:
> But the most infamous that we've invented
> Is just the thing their prayers demand.

So, what exactly is this 'geoengineering-like' passage, why do I assert that it should be considered geoengineering, and how should we understand today what Goethe was saying through it? First, to describe it briefly: it is Faust's final ambition in life to aid all humanity by creating new land through control of the ocean. In critical literature it is sometimes referred to as Faust's 'land reclamation project.' It is not called that in the work itself, and given the immensity and universality of Goethe's canvas – with archaic characters from Greek mythology next to cryptic references from modern science – calling it a 'land reclamation project' does not do it justice, and it can only be fully appreciated with knowledge of Goethe's place in early understanding of the Ice Age and sea level change. The critical literature tends to treat the passage as odd or bizarre. Yet this material covers the whole end of Faust's life, from the beginning of Act IV until Faust's death in Act V, scene VI. The text refers often to dikes, and so on a practical level the image of Holland seems to be a direct model, yet it is also more like the control of global sea level in another sense, when Faust first asks Mephistopheles to guess his "mighty plan," and then describes it: after describing how his eye was "drawn to view the open Ocean," he finally tells Mephistopheles:

> Let that high joy be mine forevermore,
> To shut the lordly Ocean from the shore,
> The watery waste to limit and to bar,
> And push it back upon itself afar!

Because the passage has been understood by some as the ultimate expression of hubris (and initially the characterization might seem apt) – just as many today see geoengineering – it is interesting to note that the existence of Holland, a country won from the sea, is not generally viewed as an outrageous act of human hubris (especially if you are Dutch), although the association of windmills with the Quixotic after Cervantes might make some see futility in the endeavor of pumping the ocean with windmills (the Dutch had already been doing so for four centuries when *Faust* was composed). Yet such a view only supports the notion that the passage *is* intended to symbolize something immense and fundamental about our adaptation of the environment beyond any simple description of dikes.

As soon as Faust has explained his new ambition, we hear martial music in the distance, and Mephistopheles' descriptions appear to draw Faust into the already ongoing war, since Faust's idea of new-claimed land would be able to help the Emperor achieve peace. While it is important that Faust is no longer interested in physical luxury and seeks an immaterial goal, the concept *is* clearly still a symbol of vaunting ambition, albeit a more intellectual one of the mind's capacity to harness the forces of nature at a large scale.

Faust's idea turns out to work very well. At the beginning of Act V, much time has passed, and Faust's project has become a reality. Faust is now very old and much beloved of the Emperor, as he had indeed helped win the war through his new land. But in a careless gesture of vanity and greed, wanting to see the perfect view of his beautiful lands that are obstructed by a crude brown hut inhabited by an old couple, Faust asks Mephistopheles to "clear them out." When the couple are killed rather than relocated, this leads to Faust's being blinded by Care.

After he is blinded Faust becomes even more ardent about his vast undertaking, but initially it is still a 'command and control' concept, with Faust at the head – "One mind suffices for a thousand hands," he says as the scene ends. Act V, Scene VI, is our last view of Faust. The 'reclaimed' land has now partly become a stagnant, infectious marsh, and Faust needs to drain it. Faust now has a somewhat different engineering problem, and needs to drain water out into the sea, rather than blocking the incoming tide. It would not have been lost on Goethe, whose *Italienische Reise* described his "second birthday" and period living in Rome, that massive drainage projects of infectious marshland were an even older and grander achievement of humanity than the Dutch efforts, and possibly the

greatest engineering undertaken in antiquity. As Faust dreams of this next stage of his project, the tone has shifted:

Faust:
To many millions let me furnish soil,
Though not secure, yet free to active toil,
Green, fertile fields, where men and herds go forth
At once, with comfort, on the newest Earth
(Tayler, trans., p294)

As Bayard Taylor explained in his footnotes, a great transformation has taken place, and Faust's idea, which was initially an ambition to see his mind equal the physical forces of nature, is now transfigured: it is recognized as an imperfect and insecure arrangement, because it is less controlling and allows more freedom to the millions to shape themselves. It simply provides people the preconditions for potential success. It is also specifically altered by now becoming a group act of common purpose, which is clearly Goethe's central idea here, and Faust's last great thought:

Faust:
A land like Paradise here, round about:
Up to the brink the tide may roar without,
And though it gnaw, to burst with force the limit,
By common impulse all unite to hem it.
Yes! To this thought I hold with firm persistence;
The last result of wisdom stamps it true:
He only earns his freedom and existence,
Who daily conquers them anew.
Thus here, by dangers girt, shall glide away
Of childhood, manhood, age, the vigorous day:
And such a throng I fain would see, –
Stand on free soil among a people free!
(Tayler, trans., p294)

Faust comes to recognize it not as just his own project, but as a kind of ultimate human symbiotic act – as today we might think of the amoeba Dictyostelium discoideum, with its hundred thousand individuals coming together to form one organism for the purpose of saving the community under environmental threat. This thought, of geonegineering as a group accomplishment of humanity together – *By common impulse all unite to hem it* – indeed, as the ultimate expression of human freedom, is so beautiful to Faust (and clearly to Goethe, who was writing this just before his own death) that he dies.

To understand how Goethe himself might have thought about this material, demands knowledge of Goethe's profoundly scientific life, and his unique place in the early knowledge of sea level change and the Ice Age. Like Leonardo before him, he disdained the superstitions of those who did not strive to comprehend the forces of nature. Goethe makes fun, in the lines just before he first introduces Faust's engineering idea, of simple folk who thought boulders had been cast about by the Devil.

Mephistopheles:
Over all the land the foreign blocks you spy there;
Who solves the force that hurled them to their place?
The lore of learned men is all awry there.....

Only the common, faithful people know,
And nothing shakes them in their firm believing:
Their wisdom ripened long ago, -
A marvel 't is, of Satan's own achieving.
(Tayler, trans. p230)

A thread that runs through much of *Faust II* concerns a raging debate in the early years of geology. Plutonism was the idea of rocks being formed by igneous processes, and Neptunism was the rival idea, of what today we call sedimentary processes. Goethe was very active in the debate, and was a Neptunist. Hutton and Humboldt were Plutonists. Now we know that both are important. But Goethe disliked the high drama in the catastrophist aspect of Plutonism (which is perhaps why he erred too far on the side of Neptunism, through associating Plutonism with superstition, as in the above passage), and delights in making Mephistopheles a Plutonist in *Faust II*.

While Goethe's attitude towards Plutonism was mistaken, this actually led him to some of his most prescient scientific observations. How *could* boulders get flung about, if the Plutonist forces were not at work, he wondered, and it were not done by the devil? Five years after Goethe's death Agassiz was the first to formally propose that the Earth had had an Ice Age, and in doing so he said that he was greatly indebted to the work of Goethe. Indeed, Agassiz said that, of his predecessors, "Goethe alone unified all the indications into a definitive theory" (Cameron, 1964).

Rudolph Steiner, in his book *Goethe's Worldview*, quotes from a letter dealing primarily with fossils, but also showing how aware the poet was of past sea level change.

I am fully convinced that all the bony fragments of which you speak, and which are found everywhere in the upper sand of the earth, originate in the most recent epoch, but this, compared with our ordinary reckoning of time, is very ancient. In this epoch the sea had already receded; on the other hand streams still flowed in broad beds, yet comparatively at the level of the sea, not faster and perhaps not even so fast as now. At the same time the sand, mixed with lime, was deposited in all broad valleys, which gradually, as the sea sank, were forsaken by the water, the

rivers digging only small beds in the middle of them. (Steiner, 1897)

Did Goethe connect his early conception of an Ice Age with the large changes of sea level? Goethe would surely have been surprised to learn, as we know today, that the most recent Ice Age made sea levels almost 400 feet lower, and enacted a 'land reclamation' from the sea roughly equal to the size of Africa.

Some critics have interpreted the engineering passage as depicting the forces of industrialization itself. It more closely resembles a geoengineering project, but the two are related: modern geoengineering is meant as a corrective for industrialization's greatest fault. Faust's project is *not* intended as a corrective (and of course is not involved with the climate, or even the atmosphere) but an *opportunity*, and in that sense is in the spirit of his time, that of early industrialization. But because of the fact that everything about *Faust* – from the opening Prelude in the Theater and Prologue in Heaven of *Faust I* – has cast the work in grand, universal terms, there can be little question of how Faust's late idea should best be considered for the 21st century: it best represents what we now call geoengineering.

Seeing this geoengineering as fundamental to Faust's salvation is straightforward enough in the text:

Angels:
Whoever constantly aspires and toils,
That man can we redeem.

This is something that certainly could not be said of the Faust we have known for most of the drama, yet *could* be said of the late Faust and his zeal for the engineering project, thus suggesting to some critics that Faust's final salvation was actually his belated attempt to engineer the ocean.

In Rehding's look at ecomusicology and apocalyptic imagery (2011), this 'land reclamation' section is pointed to: he recognizes its contemporary relevance, although clearly not in the way I am suggesting:

Renewed topicality can even be discovered in the old masters: in the context of ecocriticism, the curious episode on land reclamation from Goethe's *Faust II* emerges as a harbinger of looming ecological disaster. How can such critical insights be transferred to the musical sphere?

Of course, Mahler's Eighth *was* about transferring the end of *Faust II* to the musical sphere, although he does not directly deal with the geoengineering episode, and picks up just after it ends, with Faust's death and ascent to heaven. The Eighth was the apogee of Mahler's career during his lifetime: if the Third is the largest work in the repertory by scope and length, the Eighth is by scale, and was quickly dubbed the "Symphony of a Thousand," with nearly that many performing the premiere. Mahler's friend Lipiner, one of whose poems was used as the basis of the program for the Third Symphony (and possibly likewise for the Second), had written a thesis analyzing *Faust* as an expression of Monism, and there can be little doubt that Mahler would have been familiar with it. According to friends Mahler also knew large tracts of Goethe's drama by memory. To understand what Mahler was trying to express in his Eighth – and to understand Goethe, his masterpiece, and the primary place he has given the geoengineering sequence – one must go back inside the essence of Monism.

Monism is the absence of Cartesian dualism. It aims to end dualism's sense that the human mind is somehow separate from the world that surrounds it – from our own bodies, other living organisms, and rest of the physical world. More than anything else, *Faust II* is an affirmation of faith, a faith as profound and complex as any religious one, but quite rarely expressed through artistic professions of faith. One could say that Goethe had, in a significant sense, arrived at the end of his life at a position somewhat like that of Lucretius 2,000 years earlier. Lucretius had, in fact, been the only great poet of science before Goethe. Lucretius' primary act of *faith* in *De Rerum Natura* – although it is not generally framed in this way – was to insist that our perceptions of the world must correspond to reality, simply because our minds are clearly made of the same stuff as that world. Goethe's faith – and that is Haeckel's and Mahler's as well – is not that the mind's *perceptions* must reflect reality, but that the *products* of our collective mind must reflect the universal design and the meaning of Nature and therefore be trusted, since we are fully embedded in her – call it Gaia, "Das Ewig Weibliche," or what you will. Mahler's Eighth is a kind of secular oratorio, a religious work expressing this faith as purely and perfectly as Bach did the Protestantism of his time in his Passions.

When the "more perfected angels" say:
When strong spiritual power
Has greedily clutched
The elemental forces,
No angel is able to separate
The united dual nature
Of the two intimates;
Only eternal Love
Is able to part them. (from score, Dover, 1989)

One can only imagine that Mahler would have recognized the strength of this "united dual nature"

as the strength of Haeckel's anti-Cartesian Monism, and understood this passage in terms of the program of his own Third Symphony. This "clutching" of the elemental forces, of course, was primarily depicted in the drama through Faust's geoengineering.

"Yes! To this thought I hold with firm persistence," says Faust just before he dies, about his sense of the human world united through its common act of constant, and conscious, self-maintenance in geoengineering. It represents something like the emergence of Vernadsky's noosphere, following the geosphere and biosphere. Indeed, looked at this way, one must ask whether, in the famous final stanza – perhaps the most famous lines in German literature – the following words, set by Mahler almost unaccompanied in the chorus, pianissimo, the final geoengineering episode has not been a crucial element, perhaps even *the* crucial element:

> The unachievable,
> Here becomes actuality;
> The indescribable,
> Here is performed (from score)

When the stanza is then repeated, very forcefully and loud, these words are the only ones left out, and the setting focuses instead on the famous "Ewig Weibliche." Goethe's *Here* is certainly not some other world, and is the embodied world, if abstracted (indeed, as has been noted by others, much of this ending takes place in the upper atmosphere – precisely where geoengineering is likely to be undertaken): it is manifestly the combination of spiritual and physical at the root of Goethe's philosophy, and the geoengineering episode has been the drama's greatest example of the "unachievable" and "indescribable," the final combination of the mental and physical forces taken together, the furthest expression of Monist faith.

* * *

If one were to consider control of sea level as the lone arbiter for deciding upon geoengineering (although I do not recommend such logic), it must be noted that during the last interglacial, known as the Eemian, CO_2 levels never exceeded 280 ppm yet sea levels reached at least 20 feet higher than today (Hansen, 2011). Greenland's vertical construction is such that it can pass a tipping point (IPCC, 2007) – indeed, from the most recent evidence it seems likely that it is doing this now (Khan et al., 2014) – beyond which it will continue melting for the foreseeable future no matter what happens to the climate. Greenland is in a sense a vestigial remnant of the last Ice Age, could not be reformed except in another one, and its complete loss would add some 20 feet of sea level rise. Of course, since global warming and sea level rise are inherently global, Greenland can't melt alone, and changes in west Antarctica, the mass of which also would add about 20 feet of sea level if it went, are becoming rather ominous. West Antarctica is also more likely to engender abrupt sea level rise, since the ice sheet rests partly below sea level (see IPCC, 2007). Therefore, something like Goethe's late vision in *Faust*, a geoengineering project to help avoid inundation of coastal cities worldwide – possibly causing hundreds of trillions of dollars of damage from all direct and indirect losses stemming from real estate, infrastructure, human relocation costs, etc., and potentially even leading to the collapse of civilization as we know it – is not something that should be dismissed without careful consideration. It might require only a relatively small-scale use around polar regions of solar radiation management (releasing cooling aerosols, possibly SO_2, into the stratosphere), as one recent paper suggests (see MacCracken et al., 2013), when combined with appropriate emissions changes. Continued for a number of decades, until radiative forcing can be brought lower by other means – including, of course, the near total decarbonization of the global economy, which in any event is urgently needed – such an intervention could potentially make a vast difference in the prognosis for the civilization we have. There is no question but that geoengineering contains some risk (perturbations in hydrology), although those risks are not long-term (it could be turned off at any time, and the aerosol lifetime is very short, although some consider *that* a risk), and are surely far lower than the risks of consciously allowing a change in the global mean surface temperature of the planet, which on humans terms is likely to be exceedingly long-term.

Geoengineering was not widely discussed in public until Nobel laureate Paul Crutzen wrote a paper that appeared in *Climatic Change* in 2006, following Lovelock's more broad-based discussion in *The Revenge of Gaia* earlier that year. Like the general shift in science from opportunity to necessity, the real geoengineering, if it takes place, will arise from necessity, and is unlikely to resemble Faust's final vision. That said, it seems likely that it would cause relatively few problems once initiated, as in the Faust episode. Of course, geoengineering also won't "solve" our problems, but could help give us the chance to solve them, if we wish to come together to do so.

It was also Crutzen who suggested we have now entered a new geological period – what he called the Anthropocene. Music, of course, has no direct role in resolving the dilemma of potential self-extermination that opens this new period, but is nevertheless an art form that somehow goes to the heart of human perception and human performance – our species' agency on planet Earth.

The ecomusicology I have sketched here juts out in new directions while taking cues from old scores and old questions. Time can progress, as it does in some of Bach's music, in multiple rates at once, and while the industrial revolution is old, its meaning has still not been decided, and it will likely be up to our time. Will Mephistopheles win? Or will Faust? Or Goethe? CO_2 molecules can last a long time, and some from the 19th century's "dark satanic mills" might still be floating among us. We are in the Anthropocene, but we are still back *there*, too. It is fascinating that Rehding's *Ecomusicology between Apocalypse and Nostalgia* both seems to imagine that contemporary climate science and its dire predictions are mere "subjective framing", and that what Goethe clearly saw as hope is "a harbinger of looming ecological disaster."

Because Goethe was so much more of a scientist than any other great writer in history, he also could be far more of a mystic as well. Haeckel spoke of "the indissoluble connection between energy and matter, between mind and embodiment – or, as we may also say, between God and the world – to which Goethe, Germany's greatest poet and thinker, has given poetical expression in his *Faust*." I concur with Goethe's faith that our geoengineering and Nature's own incessant engineering are one and the same thing, that the *Here* that ends *Faust II* is far stranger than any of us can fathom, stranger than simply including Earth's stratosphere within our daily thoughts and practices, and that books on atmospheric chemistry can be the basis for acts of faith as surely as any others:

> Faust:
> The Spirits, forced from the level land to sever,
> Are of the rocky hills more fain than ever.
> Silent, they work through labyrinthine passages,
> In rich metallic fumes of noble gases,
> On solving, testing, blending, most intent:
> Their only passion, something to invent.
> With gentle touch of spiritual power
> They build transparent fabrics, hour by hour:
> For they, in crystals and their silence, furled,
> Behold events that rule the Upper World.
> (Tayler, trans., p244)

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