Research Article

Community and an Ethos of Science

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Abstract | A great synthesis of scientific ideas around the 17th century CE marked the emergence of modern science that later accelerated especially with the emergence of ecology and evolutionary thinking. However, the strict determinism and mechanistic assumptions inherent in the physical sciences delayed unification and, thereby, contributed inadvertently to the present-day scourges of fragmentation such as human-accelerated climate change and biodepletion. A *philosophia prima* is now required to repair and reunite human thought to achieve a consilient valuing as a platform for our survival. One such system of consilient valuing is presently available for our consideration as stewards of the planet: Gaia theory. Under the guidance of such "big picture" thinking, we may be able to unify the sciences, indeed all human belief, into an ecological and cultural equilibrium as encompassed by Gaia theory.

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> " … [W]ould it be too bold to imagine, that all warm-blooded animals have arisen from one living filament, which THE GREAT FIRST CAUSE endued with animality … and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity, world without end?" (Darwin 1803. 397).

Introduction: Diversity and Unity in the Sciences

In the exotic Roman pantheon of gods, one of the most intriguing, and little known, deities is Janus. He was an immortal being molded from the elements of creation and given to Hecate, queen of the Underworld, by the lecherous Father Sky (or Uranus). Janus was gentle and kindly, wise and honest; but he was as ugly as sin with scores of knotty limbs and faces all around his monstrous head. When Saturn's children – upstarts such as Jupiter, Neptune, and Pluto – challenged the Titans, Janus betrayed Saturn's hiding place to Jupiter. Later Jupiter, the new king of the gods, punished Janus for his treachery by making him two-faced and by taking away his power of movement. Janus then stood forever as heaven's gatekeeper with one face fixed on yesterday and the other on tomorrow. The Romans regarded him, consequently, as the janitor of the seasons and named the first month of the calendar year in his honor (McLeish 1987).

Levi-Strauss (1963) believed that the meaning of myths is relational, not essential. One should not bother to examine single elements in myths for their particular meanings but attempt instead to ferret out their relationship or application to the human experience. "Mythical thinking is the opposite of scientific thinking," (Bultmann 1984. 95). Myths are the articulations of opposites. They express contradictions. We do not like contradictions in our lives so, unconscionably, we make them palatable in myths. Thus, we do

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not have to sort out any literal meaning of Janus's two watchful faces. We simply look for application to our own modern experience and, suddenly, the myth is our own, not some antiquated Roman story.

How might the dual nature of Janus's guarded countenance be applicable to our modern scientific communities? The demic[1] structure of science materialized early in its history with traces apparent even in the epistemological endeavors of Aristotle (384 to 322 BCE) and the Scholastics (9th to the 17th centuries CE). Small groups of collaborating scientists formed – schools, research teams, federations, associations, and the like – as they pursued solutions to nature's puzzles. They passed on their own ideas into later generations (a successful cultural counterpart to Lamarck's unsuccessful biological mechanism of acquired characteristics[2]) and cooperated with contemporaries in promoting their collective goals (Hull 1988). However, arrogance, elitism, infighting, and jealousy marked these groups early on and even today are not atypical behaviors for scientists as members of their pluralistic social institutions. These deportments very clearly show the diverse nature of scientists and, in fact, may facilitate their manifest goals through the ensuing controversies. (Recall the public outcry, albeit premature and unfair, of scientists like Stephen Jay Gould and Richard C. Lewontin when E.O. Wilson published his now-mainstream *Sociobiology* in 1975 in which he biologicized our cultural evolution to include aesthetics, communication, ethics, and ritual.) Scientific communities then have two immortal and watchful faces, one of common cause and the other of diversity, that strengthen and guide them in their research pursuits. In fact, the aggressive, dualistic endeavors of these communities may provide the knowledge and wisdom necessary for us to emerge from the calamitous global troubles threatening to consume us. Strict economic and political reforms (e.g., capitalism and Marxism) have had their day and have failed us. They have not succeeded beyond a temporary ascendancy because they could not connect us naturally and sustainably to the cosmos. Clearly, science can do this and, thereby, can help to furnish a common path for our continued development as a species.

That common path, a *philosophia prima,* for our 21st-century calling as stewards of the planet, is a transformative approach called Gaia theory. It is also a reconciling tactic to unify the seeming contrary faces of modern science (viz., common cause and diversity). As stressed by Campbell (1991, 41), "Myths and dreams come from the same place. They come from the realizations of some kind that have then to find expression in symbolic form. And the only myth that is going to be worth thinking about in the immediate future is *one that is talking about the planet* …," (emphasis added). I will return to this key point in my argument toward the end of this essay as a way of contextualizing its content. In an organic sense, Gaia theory is a "higher science" (to borrow from the English philosopher and statesman Francis Bacon) that can help us heal a planet wounded by the extravagances and self-interests of an errant humanity.

The Essence and Certainty of Science

What is science? Popper (1959, 278) wrote that "Science is not a system of certain, or well-established, statements; nor is it a system which steadily advances towards a state of finality. Our science is not knowledge; it can never claim to have attained truth, or even a substitute for it, such as probability …. Although it can attain neither truth nor probability, the striving for knowledge and the search for truth are still the strongest motives of scientific discovery." Science is curiosity. It is a way of knowing based on evidence and rational thinking; other valid ways of knowing, based on different rules and methods, include religious, philosophic, and cultural wisdom. Science is the persistent, critical, and irreversible (Kuhn 1970)[3] *quest* for truth – not any smug, conclusive, and idolatrous possession of knowledge. Science is the search for classes of natural phenomena that are lawfully related (Hull 1988). For example, anything that has mass is necessarily related to Newton's law of universal gravitation. In ordinary chemical reactions, matter changes according to Lavoisier's law of mass conservation. More like a verb than a noun, science is wonder and discovery about the natural world.

Science attempts to proceed in a somewhat orderly fashion from observation to theory to prediction to verification. Further, it advances in a direction from theories of a lower level of universality to theories of a higher level. These higher-level theories are called natural laws because they have stood the test of time. Constant observation and independent experimentation have verified them again and again. Even then, they are not absolutes and must be modified, or even discarded, in the face of a single contradictory event (Karl Popper's principle of falsifiability). Strahler

(1987) discussed these levels of increasing universality as gambling odds, partly contradicting Popper's warning about science's use of probability, where P_t is a scientific statement's likelihood of being true or long-lived and P_f is its likelihood of being false or short-lived. It is important to note that neither value can actually reach unity or zero even though $P_t + P_f = 1$. These limits can only be approached. A theory may survive continued testing and may grow in complexity, unifying diverse phenomena; but "the concept remains one of probabilities, rather than one of absolute acceptance or rejection," (Strahler 1987, 14). Further, "There is a time when a hypothesis unifies experiences and is accepted, and a time when it must be renounced lest it prevent a further understanding. Thus, the truth as we know it is not final; it is part of a process. It is found in any comprehension that gives coherence to the present data and then leads to a further development," (King 1981, 38). Scientists make no claims for perpetual truth. After all, apples – and not the Sun – may rise tomorrow.

Two significant issues arise here, both related to current sociological trends. One deals with the meaning of the words, fact and theory. Nonscientists (including certain unschooled newscasters, politicians, and fundamentalist Christians who identify themselves as advocates of creationism or, alternatively, of intelligent design[4]) have interpreted fact as absolute certainty and theory as imperfect fact or merely guesswork. In the scientific vernacular, however, facts are the world's data and theories are structures of ideas that explain and interpret facts (Gould 1983). Science is a conjugal bundle of whats (facts) and whys (theories). Darwin's theory of evolution by natural selection is a far cry from mere guesswork about the historical operations of nature. His theory was and is supported by countless observations and experiments in a plethora of disciplines (e.g., anthropology, botany, ecology, geology, and medicine). Other theories have emerged from time to time for the mechanisms of biological evolution. Some have failed (e.g., acquired characteristics), and still others have been generally accepted (e.g., punctuated equilibria; see Eldredge and Gould 1972). Further, Darwin's widely accepted theory of evolution could be replaced eventually by a more satisfactory interpretation of natural phenomena. And even the fact of evolution could very well be overturned tomorrow by a more promising certainty, however unlikely such an occurrence might seem to a confirmed evolutionist. In sum, no scientists emerge from their laboratories to proclaim, "I have a theory," though others may attribute such systems of ideas to their founders (e.g., Darwin's theory of evolution or Einstein's theory of relativity). Rather their individual hypotheses, experimentally tested and peer-reviewed, may or may not coalesce into high-level theory over time.

The second issue deals with cultural relativism. This is the point of view, anathema to most scientists, that holds there is no way of making choices between competing ideas, that science is wholly dependent upon its cultural context, and that scientific results have no validity outside of culture. Certainly the proposition of theories to explain the cosmos (and our position in it) is influenced by the cultural milieu in which scientists find themselves. Could Aristotle have proposed natural selection as a mechanism for organic evolution? Could Newton have conceived Einstein's theory of relativity (not connected at all, of course, to the relativism aforementioned)? The creation of a new idea or theory in science is *largely* bound by cultural restraints. But the testing of a scientific theory is an almost completely independent process, a fairly objective verification that is, essentially, culture-free and lacking in most other disciplines. Repeated experimentation, peer review in professional journals, conference proceedings, textbooks, and professional debates are among the means to ensure this objectivity. One can safely discard the notion that modern science is bound entirely by culture. "After all, gravity pulls on the Bushman as well as on the European," (Trefil 1989, 42).

Before modern science became firmly established in the 17th century, certainly there were numerous creative individuals around the globe who were doing science. Aristotle, Ptolemy, and Leonardo da Vinci (1452 to 1510 CE) come to mind immediately (see Swanson 1973). A continuous tradition of systematic discovery connects the investigations of Aristotle to those of E.O. Wilson. However, the reasoning and methods of these two men are hardly the same. As Hull (1988, 77) noted, "the issue is similarity versus descent." There are vertical and horizontal elements in the development of modern science (respectively, its historical progress called evolution and its heterogeneous but intertwined practices today called ecology) that make the science of yesterday very different from the science of today or tomorrow.

A great synthesis of scientific ideas around the 17th century marked the emergence of *modern* science. A partial list of some of the more notable individuals involved with this synthesis reads like a litany of saints invoked during Divine Liturgy: Nicolaus Copernicus, Vesalius, Tycho Brahe, Galileo Galilei, Johannes Kepler, William Harvey, Blaise Pascal, Robert Boyle, Robert Hooke, Francis Bacon.[5] ("*Ora pro nobis*," we mutter solemnly, hoping our own contributions to scientific progress will not be chaff in the winds of time.) The rate of synthesis accelerated through the 18th and 19th centuries, especially because of the insights provided by five key publications:

- Newton's *Principia Mathematica* (1687): Illustrating the law of gravitation and showing its universal application to space;
- Hutton's *Theory of the Earth* (1788/1795): Proving that geological processes have operated uniformly through time;
- Lamarck's *Philosophie Zoologique* (1809): Arguing that change, i.e., organic evolution, is evident among living things;
- Lyell's *Principles of Geology* (1830-1833): Finally shattering the concept of immutability in the physical world and promoting the idea of deep time for Earth;
- Darwin's *On the Origin of Species* (1859): Providing the framework for a new world view of the cosmos and the position of humankind in it.

Darwin's great work, published in 1859, and his later *Descent of Man* in 1871 were revolutionary writings that – unlike the significant but less far-reaching achievements of Newton, Lavoisier, and Einstein – affected every thinking individual (see Mayr 1988). As Dobzhansky, Ayala, Stebbins, and Valentine (1977) exclaimed in their prefatory quote: "Nothing in biology makes sense except in the light of evolution."[6] Indeed one could argue that nothing in the human experience makes sense except in the context of evolution. Thus, Darwin's *On the Origin of Species*, viewed by Darwin himself as an introductory "chapter" for the entirety of his life's work, is both a descriptive and prescriptive systemic approach to life on a living planet.

The word, scientist, was coined by Reverend William Whewell (1794 to 1866 CE), Darwin's professor of mineralogy at Cambridge University, in a discussion on the nature of the physical sciences. Initially, the great scientific synthesis of the 17th century was almost exclusively a movement in the physical sciences. The life sciences really did not emerge until the early part of the 19th century CE. Thus, for centuries, the proper way to study the natural world was to define phenomena in terms of the strict determinism of classical physics (Mayr 1988). And, to compound the difficulties of the budding life sciences, the universality that characterized the laws about the physical world was missing from biology. Nearly every generalization made about animate objects was followed by a flood of exceptions. Consequently, scientists like the British physicist Ernest Rutherford[7] labeled biology as a "dirty science" (Mayr 1988) and likened it to postage stamp collecting. In the meantime, physics burgeoned into a host of individual sciences such as acoustics, electromagnetism, optics, atomic and nuclear physics. And biology, ignoring the reproofs of physicists, fragmented into botany, cytology, ecology, genetics, physiology, zoology, and many other sub-disciplines. Suddenly, there was a threat that science as a whole would be lost among its numerous offspring, and an attempt to unify the disciplines began.

How could unification be achieved? Mayr (1988) offered two possibilities: either by reducing all sciences to physics or by adopting a new, broader concept of science. The first has been a failure. The extraordinary molecular complexity and hierarchical organization of living things, the genetic program, and the pluralism of causations and solutions in the biosphere all made this an intractable problem. The conceptual framework of the biological sciences is entirely different from that of the physical sciences. All the processes that play significant roles in the lives of organisms simply cannot be explained by chemical reactions and physical laws.[8] "Phenomena that are due to a chain of historical events cannot be ascribed to simple laws and can therefore not be proven in the same way as are phenomena studied in the physical sciences," (Mayr 1988, 254). Worms and mockingbirds are not stars and rocks. And even something as simple as a bacterium seems to be more than the sum of its cellular components, metabolic processes, and environment.[9]

Yet unification of the sciences is still achievable, and Mayr's second possibility provides the direction. The classical philosophy of science, presuming an overwhelmingly reductionist stance, must be abandoned. What is needed is a broader concept of science that includes a more harmonious bond between the physical sciences and biology (including their various

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laws and theories). Additionally, what is needed is a broader concept that bridges the gap into the humanities and other key disciplines. The works of Gerard Manley Hopkins (1844 to 1889 CE) and Teilhard de Chardin (1881 to 1955 CE) seem apropos for our consideration (see Cuenot 1965; King 1981; Zaniello 1988). Halle (1957, 232-233) best summed our deficiency when he wrote, "What we need is a unified Field Theory that will embrace Einstein's equations, natural selection, the plays of Shakespeare, the Sermon on the Mount, the death of Socrates, and the behavior of crows. What we need is the one word that reveals the Kingdom of God. It trembles on the tip of the tongue …. It is in the world of eternal things, the world that renews its beatitude perennially." This expanded concept might allow us to repair the dreadful fragmentation in our cultures and to cure through intensive, collaborative effort such symptomatic scourges as human-accelerated climate change; species extinction; tropical deforestation; the pollution of air, soil, and water; overflowing garbage heaps; and the overexploitation of natural resources. In a world that depends on healthy community-living for its survival, we can no longer afford the rituals of isolated privilege in the scientific community.

Bacon and Unity in the Scientific Community

Trefil (1989, 33-34) authored a delightful historical account of science in which he recalled a story about medieval Aristotelian logic:

> "It seems that there was a debate concerning the number of teeth in a horse's mouth. One by one the scholars got up and cited their sources – one quoted Aristotle, another, one of the church fathers, and so on. Eventually, a very junior member of the company rose and pointed out that there was a horse outside, and everyone could go out and count its teeth. At this suggestion, according to the manuscript, the brothers 'fell upon him, smote him hip and thigh, and cast him from the company of educated men.'"

This was the Aristotelian ideal: the use of pure logic to arrive at conclusions about natural phenomena. No observations were needed, no experimentation prescribed. This metaphysical speculation was totally rejected by Francis Bacon (1561 to 1626 CE), chancellor of England under James I and advocate of the inductive method.[10] He exhorted the common man and even the king to "Put nature to the question," (Swanson 1973, 78). "For as water will not ascend higher than the level of the first spring-head from whence it descendeth, so knowledge derived from Aristotle, and exempted from liberty of examination, will not rise again higher than the knowledge of Aristotle," (Bacon 1824, I, 34). Someone once said that Francis Bacon was probably the last man of his time who could be acquainted with all available scientific knowledge in the Western World. Bacon had a passion for unity and attempted to combine scores of individual sciences into one great encyclopedia of natural philosophy.

Yet few modern scientists – outside of Newton and Darwin – openly acknowledge their debt to him. Why? Probably for three reasons. First, inductivism does not account fully for the actual process of science. What scientist would have as his singular goal the careful recording of every observed event in his life? How would this perfunctory undertaking contribute to science's progress? In a letter to Asa Gray, Darwin wrote, "As careful observation is far harder work than generalization [sic], and still harder than speculation, do you not think it very possible that it may be overvalued? How many astronomers have labored their whole lives on observations, and have not drawn a single conclusion; I think it is Herschel who has remarked how much better it would be if they had paused in their devoted work and seen what they could have deduced from their work …," (Darwin 1903, II, 252). And again in another letter: "How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service!" (Darwin 1903, I, 195). The process of science clearly depends upon the creative intermingling of both inductive and deductive thought.[11] Second, Bacon, as an overworked and debt-ridden man, actually had no time "for toilsome investigations," (Durant 1961, 108). Consequently, he failed to keep abreast of some of the scientific developments of his day. Copernicus, Brahe, Kepler, Harvey: the works of these men were rejected, ignored, or scorned by Bacon. And, third, he was – as any educated Westerner at the time – a believer in natural theology, an organized attempt to read the mind of God in all aspects of creation. His writings are filled with references to God, reading almost like a Thomistic discourse. Even Bacon's fabled society, described in his *New Atlantis*, harbors a great college of science called Solomon's House that is "dedicated to the study of the works and creatures of God … for the finding out of the true nature of all things, whereby God might have the more glory in the workmanship of them, and men the more fruit in the use of them …," (Bacon 1824, I, 37). Perhaps these three points have detracted from Bacon's rich contributions to the evolution of modern science.

Bacon's inductivism was a centuries-old tradition of studying the natural world widely viewed in post-Darwin modernity as singularly insufficient as an epistemological approach to natural phenomena. Yet there still emerged among qualitative investigators in the United States in the late 1960s a research strategy called grounded theory, a seeming attempt by sociologists to legitimize their standing in a positivist cultural paradigm. However, grounded theory was neither theoretical nor new but a revived Baconism with a lust for glitzy epithets. "[G]rounded theory is not a theory at all [and] is best defined as a research strategy whose purpose is to generate theory from data," (Punch 1998, 163). It simply modified "the usual canons of good (positivist) science to fit their own post-positivist conception of rigorous research," (Denzin and Lincoln 1998, 9). Of course, post-positivists believed that reality could only be approximated, never studied, captured, and understood as the positivist science tradition held. Yet embracing an *approximation* of reality was admitting the *existence* of a reality outside the human condition. Admittedly, modern science is not a values-free systematic inquiry about the natural world (nor should it try to be); but it is an ever-building, asymptotic approach to that reality that requires a messy, tightly woven fabric of induction and deduction as its working canvas. Newfangled sociological attempts to fragment scientific methodologies have only served to postpone our joint task of repairing our societal and ecological ills, also interwoven and relational.

Bacon was the first to see science as a systematic study and as a complex, collective enterprise (Edwards 1972). He wrote that "[M]en have abandoned universality, or *philosophia prima*: which cannot but cease, and stop all progression. For no perfect discovery can be made upon a flat or a level: neither is it possible to discover the more remote, and deeper parts of any science, if you stand but upon the level of the same science, and ascend not to a higher science," (Bacon 1824, I, 37). A coordination of scientific purpose is necessary that acts as a guiding, unidirectional force. Since there is unity in nature,[12] there must be unity in the sciences that study it. Furthermore, the results of the scientific enterprise must be available for all humankind. "[K]knowledge may not be, as a courtesan, for pleasure and vanity only, or, as a bondwoman, to acquire and gain to her master's use; but, as a spouse, for generation, fruit, and comfort," (Bacon 1824, I, 40).

But can there truly be unity in the scientific community? The experiential world is a very large field for study. Naturally, scientists have narrowed their focus in order to understand their chosen fields. And some of the expected outcomes of their biased turnings? An odd combination of opposites: factionalism and cooperation, confidentiality and openness, individualism and community, diversity and common cause. The double-faced nature of scientists can be like the duality of Janus' mythological visage. Any resulting social isolation from this fragmentation of the sciences is precisely what Bacon warned against, but does bias necessarily mean isolation? Hull (1988, 22) reminded us that "One of the strengths of science is that it does not require that scientists be unbiased, only that different scientists have different biases." Today's scientists are not isolated and completely independent workers. They each inherit huge amounts of information from their educational institutions, on-site experiences, and professional organizations. Each generation of scientists does not have to start anew its studies of the empirical world. These workers build upon yesterday's insights. So there is headway made in the individual disciplines, resulting in multi-linear avenues of progress (and bias) in science as a historical enterprise.

What about the whole of science? Where is Bacon's *philosophia prima*? How can we deal with the surfeit of scientific biases? In our age of specialization, who studies the whole organism or its environment? Does our quest for truth have to be a disparate undertaking? How can we reconcile the natural sciences that advocate an accessible reality with the social sciences that attempt to splinter that reality into petty, self-servicing islands of individual "theory?" Or can we, feisty and independent though we tend to be, tolerate a guiding force in the scientific enterprise? Can the multi-linear avenues be united, drawn together, organized into a uni-linear endeavor? Can we not sit back, as Darwin suggested to the astronomers of his day, from our gadgets and emanations and consider our direction as a whole community? It is a good and desirable decision that we can make. With our knowledge and our uniqueness as a species, we have the great ability to mold the future of the globe. "No species before man could select its evolutionary destiny," (Dobzhansky, Ayala, Stebbins, and Valentine 1977, 459). Considering the urgency and the interrelatedness of the world's major environmental crises, the guiding force in the scientific enterprise could be a unified attempt to achieve cultural and ecological equilibrium (see Dobzhansky, Ayala, Stebbins, and Valentine 1977, especially pp. 472-473), a conscious endeavor toward an ecological steady state (Wilson 1975). And that requires an active collaboration with all other aspects of society:

> "In short, as soon as science outgrows the analytic investigations which constitute its lower and preliminary stages, and passes on to synthesis – synthesis which naturally culminates in the realization [sic] of some superior state of humanity – it is at once led to foresee and place its stakes on the *future* and on the *all*. And with that it out-distances itself and emerges in terms of *option* and *adoration* …. When we turn towards the summit, towards the *totality* and the *future*, we cannot help engaging in religion. Religion and science are the two conjugated faces or phases of one and the same act of complete knowledge – the only one which can embrace the past and future of evolution so as to contemplate, measure, and fulfill them." (de Chardin 1959, 284-285).

Thus, a modern-day *philosophia prima* may include key elements from science, religion, and other arenas of thought to transcend the near-intrinsic restrictions in each discipline (e.g., vocabularies, perspectives, and values) to find – perhaps to create – that indispensable equilibrium between our cultures and their natural settings to answer a multifaceted call to stewardship.

Warnings on the Horizon: Gaia Theory as a *Philosophia Prima*

Tropical rainforests, as a biome with a self-renewing, or autopoietic (see Margulis and Sagan 1995; Margulis and Sagan 1997), integrity, may vanish outside the boundaries of protected areas in the next half-century. Nonrenewable natural resources such as oil and natural gas may be completely exhausted within the next 100 years. The human population may double by the end of the 21st century; and that crush of humanity will exert even stronger, uglier pressures on the land, air, and water that support us. And what about science education, a powerful tool that could, at least in large part, help us overcome some of these conundrums through the proper training of tomorrow's leaders? Unfortunately, its status is not very hopeful at the moment, considering widespread budget cuts, overemphasis on the fragmented sciences such as genetics and biochemistry (often geared toward beleaguered students taking standardized exams competitively, thereby passing inordinate sums of money to a for-profit educational testing organization; see Rinker 2013), and incessant assaults from politicians and fundamentalist organizations bent on introducing off-putting religious topics into science curricula as "science." Of course, disciplines such as genetics and biochemistry are important; but, again, who studies the whole organism with its environment? That is where part of the problem lies. Enamored and even seduced by narrow specialties and their technological trappings, we have de-emphasized broad disciplines such as ecology, environmental studies (not just environmental science), macro-biology, and taxonomy. It is time to remember Bacon's call for unity along with Darwin's reminder to pause in our devoted work to see what we can deduce from our *combined* efforts.

Scientists for nearly 500 years – from Bacon and Darwin to Dobzhansky and Wilson – have been calling for an organized unity in the sciences, a broader concept of science that shows thoughtful direction, while simultaneously permitting different biases, and tries to repair the dreadful fragmentation in our cultures. Our ecological woes are symptomatic of this fragmentation. As we propagate with maddeningly little moderation, as we sap our food and water supplies, as we pollute the biosphere irreparably, and as we widen the gap between rich and poor nations (and the rich and poor communities within them), we clearly show the twisted imbalance between our cultures and Earth's ecological systems. A broader philosophy of science is crucial: one that unites and directs, not one that fragments. A robust, far-reaching overhaul of science's ethos – its aspirations, beliefs, and practices as well as its milieu – is essential for our sustained evolution as one species among millions entwined in community on a fragile, living planet.

Consilience is required, a "jumping together of knowledge" *sensu* William Whewell, Howard T. Odum, and E.O. Wilson (see Whewell 1847; Odum 1983, 1994,

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1995; Wilson 1998). Further, a quasi-religious valuing of biodiversity's multi-scaled links seems a requisite for a sustainable relationship with Earth's natural resources *sensu* Paul Ehrlich and James Lovelock.[13] Then perhaps we may call their de rigueur combination a "consilient valuing" to highlight the need to transcend the silos of science and its recurrent prickly belittling of an emotional, even spiritual, commitment to Earth so that we may all reverence native biodiversity as the platform for our survival.

One such "big picture" system of consilient valuing is presently available for our consideration: Gaia theory. Already, its interdisciplinary nature is evident in the welding of life, geological, and space sciences as denoted, for example, by Earth System Science. It is also manifest in the intersection of Gaian inquiry with the natural sciences, social sciences, and the humanities including moral philosophy. Gaia theory proposes that Earth is the ultimate object of ecological and evolutionary study, thus transcending the boundaries of any single field of inquiry:

> "The Earth System behaves as a single, self-regulating system comprised of physical, chemical, biological, and human components. The interactions and feedbacks between the component parts are complex and exhibit multi-scale temporal and spatial variability. The understanding of the natural dynamics of the Earth System has advanced greatly in recent years and provides a sound basis for evaluating the effects and consequences of human-driven change," (International Geosphere-Biosphere Programme 2001).

Therefore, Gaia theory may be viewed as a *philosophia prima* for modernity as we struggle with our too-often irresolute role as stewards of the planet's natural and cultural resources. With our seven-billion-plus points of gray matter and heartstring dispersed across the globe in a diversity of community settings, our species has the unequaled potential as an agent of change – for better or for worse – to direct our collective future in communion with the rest of Earth's biodiversity.

Gaia theory reflects humankind's long-standing belief that Earth is not a fossil planet but a living world, animate, bejeweled, and watery in a far-flung corner of an ever-evolving cosmos (Rinker 2014). It is ironic, then, that we continue to act so abysmally and selfishly – much like a lung-cancer patient who, knowing the hazards of smoking tobacco, continues to puff away at his cigarettes, loathing yet inhaling their perilous array of toxins. Gaia theory represents an opportunity to reform and even transcend our profligate nature in all our multi-scale points of contact with the world around us.

As a *philosophia prima*, Gaian thinking provides an effective approach to transform the two faces of science (i.e., common cause and diversity) into a credible community distinguished by its broadened commitment to the planet as a living, evolving system. It will not be enough to despise our environmental contaminants while we continue to allow industries and businesses to pollute. It will not be enough to bemoan our lagging national status of leadership in the sciences while we continue to tolerate incompetence, fundamentalism, and tedium in science education. It will not be enough to wish for a better world while we continue to allow our elected officials to become the circus tricks of the one-percent. It's now time for us to unify the sciences, indeed all human belief, into an enriching ecological and cultural equilibrium as encompassed by Gaia theory.[14]

> "Gaia has evolved a species with the ability to think and communicate its thoughts. This human species has allowed the Earth to see itself from space in all its beauty and has begun to understand its place in the universe and itself. Yes, we are a part of Gaia, and therefore that top-down view was worth her waiting a quarter the age of the universe," (Lovelock 2010, 24).

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indelible and far-reaching marks on me and on society at-large. *Deo gratias*.

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Endnotes

[1]A deme is a genealogical term denoting a local population of closely related organisms. Its ecological counterpart is the avatar (divorced from any reproductive interactions that would thereby make it demic). Both terms seem appropriate when describing scientific communities; however, their demic, or generative, nature is emphasized here.

[2]"A watchmaker sends out very few defective watches: why? Because he makes his watches on a preconceived plan. Even when an improvement in watch construction is introduced, he can draw up his plan beforehand and, at the worst, waste only time and paper, instead of metal and far more time. Ideas do not need to be embodied before selection can act upon them; thus an increasing amount of evolutionary change will take place through the natural selection of ideas than through the older and far more wasteful process, natural selection of individuals and species," (Huxley 1923, 257).

[3]See also de Chardin 1966 (102) where he wrote: "Ideas, like life of which they are the highest manifestation, never turn back."

[4]Such advocates often employ the religious euphemism, *irreducible* complexity, to describe the foundational aspects of natural phenomena, thereby implying a "First Cause" that is God and then attempt to insert such verbiage into the science curricula of public schools. Alternatively, the scientific community eschews such theological labels and embraces instead a term such as *indescribable* complexity to denote the near-infinite, but eventually logical intricacies of the cosmos.

[5]Nicolaus Copernicus (1473 to 1543 CE) was a Polish mathematician and astronomer who formulated a heliocentric model of the universe that revolutionized the science of his day. Vesalius (1514 to 1564 CE) was a Flemish anatomist who wrote *De Humani Corporis Fabrica*, a landmark descriptive text on human anatomy. Tycho Brahe (1546 to 1601 CE) was a Dutch nobleman and astronomer who kept precise records on the changing position of planets, meas-

ured angles between stars, and also acted as mentor for Kepler who later inherited his voluminous observational records. Galileo Galilei (1564 to 1642 CE) was an Italian physicist, mathematician, astronomer, and philosopher recognized as the father of modern observational astronomy for his improvements to the telescope and consequent observations that supported Copernican thought. Johannes Kepler (1571 to 1630 CE), a German philosopher and mathematician, was aide to Tycho Brahe and formulated the basic laws of planetary motion. William Harvey (1578 to 1657 CE), an English physician and father of modern human physiology, was the first to chart the circulation of blood in the human body. Blaise Pascal (1623 to 1662 CE) was a French mathematician, physicist, and philosopher noted especially for his *Pensées*, an extraordinary collection of notes in defense of Christianity. Robert Boyle (1627 to 1691 CE) was a British chemist who through experimentation realized that the pressure of a gas varies inversely with its volume. Robert Hooke (1635 to 1703 CE), an English scientist, first described and named the cell though he never realized the significance of his discovery (i.e., that the cell is life's basic unit of structure and function). Francis Bacon is discussed elsewhere in this essay.

[6]Originally, this quote was the title of an article by Dobzhansky in *The American Biology Teacher* (1973, vol. 35, pp. 125-129). See http://www.2think.org/dobzhansky.shtml for a transcript of the article.

[7]Ernest Rutherford (1871 to 1937 CE) was a scientist involved in the investigation of atomic structure. He won the Nobel Prize in chemistry in 1908 for his study of radioactivity. In 1911, he worked out the nuclear theory of the atom for which he was labeled the "father of nuclear science."

[8]It is more than an academic exercise to compare Earth's atmosphere to that of its sister planets, Venus and Mars. The atmospheres of Venus and Mars seem to be in predictable chemical equilibrium (e.g., N_2 = 3.5%, CO_2 = 96%, and traces of O_2 and H_2O for the former; N_2 = 3%, CO_2 = 95%, and traces of O_2 and H_2O for the latter). On the other hand, the atmosphere of Earth seems in remarkable chemical disequilibrium yet, simultaneously, in a fairly constant state: N_2 = 78%, CO_2 = 0.03%, O_2 = 21% and H_2O = 1-4%, thereby suggesting some level of planetary regulation of the atmosphere by Earth's biodiversity. Thus, Earth is a living planet; and Venus and Mars are not, and apparently never have been, making NASA's justification for the Mars Exploration Program (http://mars.nasa.gov/program-missions/overview/) a specious and wasteful stunt for public funding. See Rinker 2010; Rinker 2012.

[9]Whether expressed as a bacterium, worm, or human, what is life? According to J. Craig Venter, a leading voice in genomics research, "life is code," (http://www.edge.org/conversation/what-is-life) or, as first published by physicist Erwin Schrödinger in 1944, life is "code-script," (http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf). But such responses are misleading. As noted by Margulis and Sagan, "DNA is an unquestionably important molecule for life on Earth, but the molecule itself is not alive. DNA molecules replicate but they don't metabolize and they are not autopoietic," (Margulis and Sagan 1995, 23). Margulis and Sagan go on to address the question about life by writing, "Life is the representation, the 'presencing' of past chemistries, a past environment of the early Earth that, because of life, remains on the modern Earth. It is the watery, membrane-bound encapsulation of spacetime" (67). Then, later, these authors surprise us by admitting via a form of biological reductionism that "Life is bacteria" (69). All these definitions fail to satisfy, however, and reflect instead the biases of particular researchers – and are often unconvincingly passé in their oversimplification. On the other hand, most scientists eschew French philosopher Henri Bergson's *élan vital* (1911), an alternative explanation for Darwin's theory of evolution by natural selection or, worse yet, the binding and ubiquitous "force" in George Lucas' "Star Wars" galaxy. See http://web.archive.org/web/20060516195812/http://spartan.ac.brocku.ca/~lward/Bergson/Bergson_1911a/Bergson_1911_toc.html.

[10]Induction is a process of going from a large body of data to a universally quantified generalization or natural law (Langley, Simon, Bradshaw, and Zytkow 1987). Compare to deduction, the construction of a generalization that will explain or anticipate specific statements of fact.

[11]The word, creative, is used here deliberately and denotes an ordered and inspired interaction of ideas, observations, and experimentation as an avenue to truth. However, some modern social thinkers seem to mistrust connections between scientific inquiry and creativity. "A small but illuminating example of the perva-

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siveness of anti-Enlightenment thought today is how scientists themselves have taken to styling themselves as 'creative.' But nothing could be more contrary to the spirit of science than the opinion that the scientist fabricates rather than discovers his results. Scientists are to a man against creationism, recognizing rightly that, if there is anything to it, their science is wrong and useless. But they fail to see that creativity has exactly the same consequences. Either nature has lawful order or it does not; either there can be miracles or there cannot. Scientists do not prove that there are no miracles, they assume it; without this assumption there is not science. It is easy today to deny God's creativity as a thing of the benighted past, overcome by science, but man's creativity, a thing much more improbable and nothing but an imitation of God's, exercises a strange attraction. In honoring it, the scientists' opinions are not the results of science or any serious reflection on science. They are merely conforming to democratic public opinion, which has, unawares, been captured by Romantic notions adapted to flatter it (every man a creator) …. Science may appear creative only because we forget what creativity means and take it to be cleverness at proposing hypotheses, finding proofs or inventing experiments," (Bloom 1987, 181-182). This rather impassive response to the whole phenomenon of humankind (particularly to our relentless investigations of the natural world) dismisses the inspiring cultural milieu of scientists and the first stages of the scientific method that are subjective and, thus, creative.

[12]"For all we know, nature itself is continuous, but to describe change, we must use definitions to slice the world into sectors. The world either fits into our definitions or not. Either way, all definitions are human devices, not parts of nature independent of human activity," (Allen and Hoekstra 1992, 17). Like the incarcerating nature of words, the very nature of fragmented fields of study can incarcerate and thwart unified thought. See the warning from Lynn Margulis ("Our minds are incarcerated by our words.") in Rinker and Jarzen 2004 (491).

[13] "Curiously, scientific analysis points toward the need for a quasi-religious transformation of contemporary cultures," (Ehrlich 1998, 26). Also consider this excerpt: "The recognition that we are agents of planetary change brings a sense of guilt and gives environmentalism a religious significance," (Lovelock 2009, 150).

[14]A descriptive term of equilibrium applicable here is homeorrhesis, rather than homeostasis, in that the internally organized system regulates around moving rather than fixed-from-the-outside setpoints. See Margulis and Sagan 1997; Crist and Rinker 2010.

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