SUSTAINABLE HUMAN DEVELOPMENT: CONNECTING THE SCIENTIFIC AND MORAL DIMENSIONS

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Summary

During this century, the global community must learn how to live in ways that are both sustainable and fulfilling. Doing so will require (1) that we know as much as possible about how Earth systems function; and (2) that we reflect seriously on whether resources of material, time, and intellect should be allocated so as to give priority to meeting human needs or sustaining natural systems, to meeting present needs or those of future generations, and to satisfying the desires of the wealthy or the needs of the poor.

Human society has emerged from an immensely long process of cosmic, geological, biological, and cultural evolution. Learning to live well requires that we respect our heritage in both its natural and its cultural dimensions. The narrative of our evolutionary history is an incredible, rich story that evokes deep feelings of humility and gratitude. It also shows that the creativity of the evolutionary process has emerged from relationships grounded in a mutually constructive reciprocity that has allowed novelty, complexity, and richness to emerge at every level: cosmic, geological, biological, and cultural. The combination of humility and mutuality that has characterized the evolutionary dynamic is consonant with the wisdom of many traditions of moral thought, and seems to offer a sound basis for establishing a global community of people living in harmony with one another and with nature.

1. Introduction

The task facing the global community in this century is to learn how to live on a finite Earth in ways that are both sustainable and fulfilling. Learning to live sustainably obviously requires that we know as much as possible about how the Earth system works

– how the climate system functions, how fisheries and forests can be sustained, how natural resources can be managed most effectively, and so on. The scientific community, commercial interests, and national and international agencies are all making vital contributions to understanding those issues. But learning to live in ways that are authentically fulfilling requires more than managing available material resources efficiently. The quality of people's lives depends on how society chooses to allocate resources of material, of time, and of intellect. Will we emphasize meeting present needs or those of future generations? Address human needs or sustain global ecosystems? Satisfy the desires of the wealthy or the needs of the poor?

These choices raise profound moral issues – what it is to be human and what makes life meaningful – that cannot be answered by science alone, but must draw upon the insights of our moral and religious traditions. So learning to live in ways that are both sustainable and fulfilling requires that we connect the knowledge of science with the insights of moral and religious reflection to create a common understanding of how we ought to live.

Connecting scientific and moral thought has proven difficult, in large part because the questions, methods, and criteria of truth associated with science and with moral and religious thought seem so different. Science seeks objective answers to questions of how the cosmos is put together and how it works, while moral reflection seeks answers to questions of meaning, value, and purpose. Science is generally seen as the domain of experiment, religion the domain of insight or revelation. Science is expected to provide answers that are precise, objective, repeatable, and in some sense universal, while moral truths are often understood in nearly opposite terms – imprecise, subjective, and grounded in personal revelatory insight or blind acceptance of doctrine.

But scientific and religious thoughts are both richer and more complex than these images suggest. In science, the precision of experimental disciplines is complemented by narrative traditions found in disciplines like cosmology, geology, and evolutionary biology, fields in which a major scientific objective is to reconstruct the story of nature. By interpreting features like the succession of fossils found in the geologic column, sedimentary structures preserved in the deeply buried rocks of mountain belts, or the spectral characteristics of light from distant galaxies, scientists attempt to infer a coherent scientific narrative of nature that is consonant with the understandings of biology, chemistry, and physics. Each telling of the story leads to further questions and new observations, which progressively refine the story. At times, compelling new ways of understanding the data emerge from complementary disciplines. In the 1960s, for example, a fertile collaboration between geology and geophysics gave birth to the notion of plate tectonics, a theory which finally allowed us to see connections between the crumpling of mountain ranges, the opening of ocean basins, and rhythmic convection deep within the mantle. This combination of painstaking work and occasional new insight has enabled natural scientists to work out the narratives of biological, geological, and cosmic evolution, epic stories which coherently connect an enormous amount of scientific knowledge.

The subjective insights of moral and religious thought emerge from a remarkably similar process of reflection on human experience, including a modern understanding of how nature works. Much religious thought emerges from the attempt to make sense of life, to uncover meaning in the world as humans experience it, and to find fruitful ways of living that are grounded in that meaning. The philosopher Paul Ricoeur sees the threads of religious narrative as the key to connecting personal experience to the insights of our religious traditions. He writes eloquently on how religious meaning emerges from an inner sense of the ways in which the experiences and the choices of our lives connect with the narratives of our religious traditions. As he sees it, we create a coherent understanding of who we are as individuals and communities by imaginatively connecting our stories with the canonical stories, allowing each to intertwine with and inform the other, and seeing our stories as extending "the itinerary of meaning" of the traditional narratives. In religious thought, tradition and doctrine are of course more important than in science, but religions are more malleable than generally thought. As we shall see in later sections, religious ideas can and do evolve when they are sensed to have lost touch with reality.

The importance of narrative in both science and religion suggests a way of connecting the two. If we try to hear the scientific story of nature in a way that listens for the meaning of the story and encourages us to connect our lives with the story, perhaps we can uncover connections to meanings evoked by religious narrative, and perhaps we can begin to discern an integrative story capable of informing the way we live. The contemporary world urgently needs such an integrative story. We live in a time of deep cultural incoherence in which the religious narratives that guided human living in earlier millennia seem disconnected from a scientific understanding of the world and how it works. Much contemporary moral and religious thought ignores our evolutionary history and the common ground that it offers for connecting particular narratives to those of other traditions and of nature. Developing a common context for our religious narratives is a vital part of learning to live fruitfully and sustainably with Earth and with each other. Important beginnings in that task are found in the work of Thomas Berry, Ursula Goodenough, Brian Swimme, and others. This essay will sift through the cosmic, geological, biological, and cultural dimensions of our human story looking for elements that can frame an integrative vision of our common story and support our attempts to respond fruitfully to the questions of sustainability.

2. The Natural Context of Human Development

The cosmic story began with an incredible burst of creativity that gave birth first to the laws of physics and then to all the protons, neutrons, and electrons of which the universe is now made – Everything! – in just four seconds. At first that mix was plasma so hot that only solitary particles could exist, but the brew cooled rapidly as it expanded. In the first few minutes it condensed into simple atomic nuclei, and in the first few hundred thousand years those nuclei combined with electrons to form atoms of hydrogen and helium. Over the next 8 to 10 billion years, reactions in dense stars and supernovae gradually produced atoms of more and more complexity. Because it requires the simultaneous collision of three helium atoms, the formation of carbon was especially tricky. Had the physical constants of our universe been even slightly different, carbon would never have formed and the possibility of carbon-based life would never have emerged. As atoms became diverse enough to allow ions capable of attracting one another during that first 10 billion years, they began to combine to make molecules – first sulfides, oxides, silicates, and simple organic molecules like methane, then the more complex organic molecules needed for life. Those early organic molecules contained the basis of all life that now exists, but at that point life and all that life could be was merely a possibility lying latent in those fertile atoms and molecules and in the laws of physics which made them possible, a possibility waiting for the moment when it might come into being.

Nearly five billion years ago Earth began to form by condensation of the solar nebula into small chunks of rock. The small chunks gradually grew by attracting other chunks and forming larger and larger meteorites, which eventually collided to form the Earth, Moon, and other planets. That process of accretion lasted a little more than half a billion years, and left a forbidding landscape pockmarked with craters, a surface like that of the Moon today. But Earth's gravitational field was strong enough to retain an atmosphere, and once the surface was cool enough, water condensed into oceans. Those oceans turned out to provide just the right conditions for life to emerge from the organic molecules deposited on Earth during the bombardment. We don't know exactly how or where life first developed, but carbon isotope ratios in ancient rocks from Greenland suggest that a crude biosphere capable of photosynthesis had formed only 100 million years or so after the bombardment ended.

For more than 3 billion years – three quarters of Earth's history – life changed little. It consisted only of single-celled animals like bacteria and algae. But a little more than half a billion years ago, abundant multicellular animals emerged in an almost incredible blossoming of new, sometimes outlandish life forms. Until those multicellular organisms had appeared, most organisms replicated asexually, simply dividing, and passing on their genes almost unchanged. But with the advent of sexual reproduction, it became possible not merely to change genes by mutation, but to reshuffle the genetic cards through recombination, allowing much more rapid change and the sudden blossoming of new life forms. This new diversity of life enabled creatures to organize themselves into rich, complexly connected ecosystems in which real community became possible.

This entire cosmic / geological / biological story is shot through with examples of the emergence of complexity and diversity from simple beginnings. Physics and chemistry gave us first atoms, then molecules. Biology gave us first single-celled organisms, then multicellular organisms, and finally complex ecosystems. This process of emergence is the heart of the evolutionary dynamic. At each step of the way, possibility remained latent until the moment when the emergence of novelty allowed the transition to a new frontier of complexity and creativity. At each level, novelty emerged out of fertile relationships among already existing ingredients – particles, atoms, or genes – through a kind of cosmic tinkering that stirred, mixed, and creatively rearranged those ingredients in new ways, ways that turned out to be fertile ground for the emergence of yet more novelty, yet more creativity. Each level reveals a creative tension between possibility and the need to wait for the right ingredients and the right conditions – the particles to form atoms, the supernovas to form carbon, carbon to form biomolecules, oceans to nurture life, organisms to establish ecosystems, and so on.

The workings of complex ecosystems illustrate the interrelationship between novelty and complexity. Ecosystems are communities in which all of the species are mutually dependent. The energy for life comes from the ability of plants to use solar energy to produce energy-rich biomolecules from atmospheric CO_2, water, and nutrients. That chemical energy and the nutrients are then cycled through the food chain, moving from plants to herbivores, and to one or more levels of carnivores. We often forget that the system doesn't stop with the "top" carnivores, though. Because the entire biochemical system is closed to everything except energy, it must recycle everything else – carbon, nutrients, and water. Plants and animals produce a lot of waste organic matter, and if that waste was allowed to accumulate, the carbon and nutrients in that waste would be lost, and the system would gradually cease to function. Microorganisms, fungi, and bacteria complete the cycle by consuming that dead organic material and converting the carbon and nutrients back into a form in which they can be endlessly recycled.

In short, every species in an ecosystem depends on other species to consume the waste products that it produces and (except for plants) to supply the carbon, water, energy, and nutrients that it needs. So the evolutionary success of a species depends not just upon its ability to reproduce, but also upon its ability to function as part of an integrated system of organisms. The fossil record of the earliest multicellular organisms shows a fascinating picture of developing diversity, with new species appearing in rapid succession, and many becoming extinct within a short period of geologic time. The apparent instability of that early biosphere may be as much an indication of the difficulty of establishing effective ecosystems as a reflection of problems inherent to the species themselves.

A careful look at the way ecosystems work reveals four key factors:

(1) Every healthy ecosystem is an integrated community in which each organism has a role to play. No complex organisms can live alone. Like healthy families, in which individuals are both self-differentiated and mutually dependent, species constituting healthy ecosystems flourish by a balanced combination of individual well-being and fruitful relationship with the community – a fertile mix of individuality and reciprocity.

(2) The health of an ecosystem depends on its ability to recycle energy and nutrients and to continue doing so despite shocks to the system by changes in the environment or even loss of a species or two. It is the system's ability to respond creatively to change – its resilience – that counts in the long run.

(3) The entire system is intensely opportunistic. Whenever there's an opportunity to use waste energy or nutrients productively, changes tend to occur. New species emerge or existing species adapt to use the waste. As they do, they forge another link for circulating energy or nutrients, and so contribute greater resilience to the system as a whole.

(4) Processes of change tend to be highly contingent. The precise way in which the system responds to opportunity can depend very much upon what species or even what individuals happen to be on hand when opportunity emerges, and upon how those particular organisms respond to the opportunities, as they perceive them.

The first ecosystems enlivened by multicellular organisms were confined to marine systems. It took another 130 million years for plants and then animals to venture onto the land, making a terrestrial biosphere possible. After another 210 million years, the dinosaurs became the dominant group of terrestrial animals. They lived as part of a well-adjusted ecosystem that lasted roughly 140 million years until it was disrupted by a catastrophic meteorite impact in Yucatan 65 million years ago. That calamity was one of five major periods of extinction within the last 500 million years. It is the best-known extinction, but not the most intense – that honor belongs to an extinction that occurred 250 million years ago and eliminated about 80 percent of the species then living. It is well to remember that most species have proven to be transient. Estimates vary, but approximately 99 percent of the species that have emerged are now extinct. That was tragic for those species. The animals, at least, wanted to live. They suffered when they died. Presumably some tried to protect their young. But despite the pain and suffering that individual animals experienced, the biosphere as a whole – life – survived those extinctions, always finding a new way of flourishing, always finding some way to bring forth novelty.

The remarkable productivity and vitality revealed by this story is the fruit of the way that ecosystems function, sketched above. As individual organisms respond authentically to the opportunities and challenges they perceive, their choices – whom to mate with, what to eat, and what to run from – stir the genetic mix in ways that brew forth novelty and complexity that is itself fertile, pregnant with yet more possibility. And as communities of organisms respond, those communities too become fertile, and give rise to an intricate array of structures and relationships that enhance community resilience. But because that resilience emerges from relationships among organisms, it can fail when those relationships become unduly distorted. Desertification triggered by over-grazing, the collapse of marine fisheries because of over-fishing, and the extinction of large Pleistocene mammals, apparently due to over-hunting by early hunter-gatherers, serve as warnings of those limits.

The disappearance of the dinosaurs 65 million years ago and the subsequent emergence of mammals shows the profound effect that chance events like a meteorite impact can have on the course of evolution. Mammals had lived as marginal members of the global ecosystem for 150 million years; no contemporary observer would have expected them ever to dominate the scene. But in a scant 10 million years, they diversified to fill the ecological space vacated by the dinosaurs and produced nearly all of the modern mammalian orders. Small at first, many mammalian species became larger and more specialized over time, and eventually our species emerged from the hominid line.

The sweep of cosmic and geological time is so vast that it can be difficult for us to grasp. To picture the immensity of evolutionary time compared to human history, it may be useful to represent time by a journey in which we travel just one millimeter each year. A century is represented then by 100 millimeters, a millennium by one meter, and a million years by one kilometer. Retracing our steps back to the Spanish discovery of the Americas would take a "journey" of half a meter. Returning to the time of Socrates would take a trip of two and a half meters. Moving on to the Sumerian city-states would add another five meters. If we use the Washington Monument in central Washington, D.C. to mark the present, a journey back to the time of the Big Bang at the same rate of one millimeter per year would take us all the way across the United States, and on across the Pacific to Tokyo. We can watch the entire cosmic story unfold by making the trip back from Tokyo to the present in Washington, still moving just one millimeter each year. Cosmic physics and chemistry dominate the journey across the Pacific. We watch the Earth and Solar System begin to form as we reach the coast of California, see life on Earth begin as we travel through central Arizona, revel in the Cambrian radiation of multicellular life in southern Ohio, and watch the dinosaurs struggle and die in northern Virginia, just 65 km west of Washington. We meet the first tool-using hominids only when we cross the Potomac River, barely 2 kilometers west of the Washington Monument. We encounter the Cro-Magnon cave artists of Southern France just 30 meters from the center of the monument. And all of human history – from the Sumerian city-states to the present – fits within the base of the monument itself.

This journey shows what recent additions to the ecological scene we humans are. But patterns of evolution changed markedly when we appeared. Though we depend upon the global ecosystem for everything we need to live, we have begun to transcend that system in important ways. The distinctive step in our evolution was the emergence of our brain, a brain that enables us to do the extraordinary and the tragic. We can celebrate creation with beautiful paintings on cave and museum walls, build soaring cathedrals, write magnificent poetry, and compose symphonies that express feelings too deep for words. We can love. And we can sense, at least dimly, the presence of mystery deep within all creation. But we also invent chemicals that work their dismal way through the entire food chain, technologies that enable us to hunt other species to extinction, and ideologies that lead us to slaughter others of our own species.

All of this, both good and bad, was made possible by two properties of our brain. It is roughly four times the size of our ancestors' brains, and so can accommodate vastly more neurological connections. And it is programmable, enabling us to learn from experience rather than by having all our neurological connections hard-wired at birth. Those twin traits made possible the emergence of human culture with all of its possibilities, both admirable and lamentable. And as culture developed, it gave rise to the principle ways in which we humans cope with our environment and so replaced biology as the domain in which we evolve.

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Biographical Sketch

Dr. Fisher has taught geology at Johns Hopkins since 1966, and served as Chair of the Department of Earth and Planetary Sciences from 1978 to 1983 and as Dean of Arts and Sciences from 1983 to 1987. During the early part of his career, his work focused mainly on the geology of the Appalachians, especially the deep-seated rocks now exposed in the Piedmont. That interest gradually grew into a series of projects to study the chemical processes by which deeply- buried rocks become metamorphosed. In the last decade his Earth science interests have broadened to include questions of how the ocean, the land, the atmosphere, and the biosphere function as an integrated system. He has also begun to examine human interactions with Earth, especially the problem of how the growing human population can live within the limits imposed by the Earth system. Because so many of the limits are experienced as trade-offs rather than rigid ceilings, he argues that the issues of sustainability raise moral as well as scientific questions, and must therefore be approached by a combination of scientific analysis and moral reflection.

He did his undergraduate work at Dartmouth, his doctoral work in geology at Johns Hopkins, and has an MA in theology from St. Mary's Seminary in Baltimore.