Searching for Geodiversity

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***In the great book of nature,* man has scarcely read more than the title-page or the preface.— Joseph Henry, First Secretary of the Smithsonian Institution, on the laying of the cornerstone for the American Museum of Natural History (June 2, 1874)**

It's hard to spend much time at a natural history museum and not run into exhortations on the importance of biodiversity. Some biologists estimate that humans are driving life forms to extinction at a rate of 50 to 150 species per day. At the same time, we have identified fewer than a quarter of the total number of animals estimated to populate our planet. The tropics are thought to contain 15 to 20 unknown species for every one that has been classified.

Does it Matter?

Most life scientists argue that it matters a lot. Eight of the top ten prescription drugs (including amoxicillin and Zantac) are derived from animals, fungi, or plants. The rosy periwinkle, an herb that is native only to the rain forests of Madagascar, has yielded two major anticancer agents. The need to sustain diversity in the organic world goes beyond its medical exploitation. E.O. Wilson points out that the integrity of Earth's ecosystems is maintained by conserving the elements of which they are composed. Because the species in these ecosystems serve to clean our waters and soils, cycle chemicals between the organic and inorganic worlds, and generate the gases in our atmosphere, the persistence of our species is intrinsically bound to the perpetuation of the ferns, insects, and algae whose specific identity may yet be eluding us.

Systematic biologists of all types—from botanists to entomologists to zoologists—cite the disappearance of species as a primary justification for their own existence. The loss of biodiversity, they assert, can be measured only by mapping the breadth of organic variation as quickly and comprehensively as possible. New discoveries of drugs, pesticides, adhesives, and other prizes then will emerge serendipitously. Life scientists inescapably conclude that money must be directed their way and fast, and their pleas have been effective. The World Bank has spent $4.7 billion between 1988 and 2004 on a variety of biodiversity programs. The US Agency for International Development increased its Biodiversity Conservation Assistance Program from $64 million in 1996 to $165 million in 2003, and in 2003 the US National Science Foundation launched a $14 million initiative for a planetary biodiversity inventory.

One wonders whether those of us who categorize the inorganic world can steal a page from the biodiversity playbook. At first sight, the analogy seems a stretch. Mineral extinction usually is associated with optical behavior rather than the loss of habitat. Nevertheless, hundreds of minerals can be considered extinct in that their sole known occurrences have been eliminated because of destruction of their type localities or by overzealous collection. The critical role of mineral museums in preserving these species is equal to the biological curation of dodos and passenger pigeons.

Perhaps a deeper disparity between bio- and geodiversity is that there is a lot less of the latter. In contrast to the biological world, in which a single order can number in the hundreds of thousands (there are 400,000 known species in the order of beetles, with several millions more yet to be discovered), the International Mineralogical Association recognizes only about 4100 minerals. Between 30 and 75 minerals are added to the IMA database every year, and it seems unlikely that the total number of minerals on Earth will be found to exceed 10,000 by very much.

But we can turn this line of reasoning around. Isn't it remarkable that the total terrestrial variability with respect to time, temperature, pressure, and chemistry is expressed in fewer than 5000 known natural compounds? What's more, these minerals combine to generate an assortment of rock and soil types with about the same degree of heterogeneity. Thus, the exploration of geodiversity can be justified precisely on the basis of its limited scope relative to the biological world. In contrast to entomologists, Earth scientists who aim to describe geodiversity are confronting a tractable problem.

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Why is it imperative that we describe geodiversity? There was a time (known to some geologists as "the good old days") when the simple identification of a new mineral or rock type was considered a meaningful achievement, worthy of admiration and government funding. Priorities have shifted such that taxonomical studies of Earth materials are dramatically less valued than investigations of their functional roles. Paradoxically, this evolution in scientific incentive elevates the need to quantify geodiversity for the same reasons that ecologists must map biological variability. In conjunction with the organic retinue, minerals filter pollutants from waters and gases; they cycle nutrients from one venue to another; and they control the chemistry of the atmosphere. As we develop analytical tools with ever higher spatial and temporal resolution, we discover that these functions often involve new mineral species so miniscule or transient that they escaped prior detection. To understand this environmental drama, we must construct a complete roster of the supporting cast of characters.

In addition, geodiversity promises the same element of surprise as was delivered by the rosy periwinkle—a new superionic conductor that will perhaps revolutionize battery technology, or an exceptionally stable host of radionuclides for the sequestration of nuclear waste. No experimentalist can cook with the one ingredient that Earth holds in abundance: Time is the ace up nature's sleeve that ensures its capacity to trump our inventiveness. Minerals and rocks store time, and they thereby offer our clearest and deepest views into the past. Earth's array of natural materials may be limited in size but not in function, and our exploration of geodiversity acknowledges our dependence on the refined opulence of our planet's chemical riches.

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