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The Biologist as Historian

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Department Editor

Usually, we see history in terms of human exploits; even when we relate history to science, we think of the great scientists of the past. But history is a record of the effects of time, not only on people, but on other living things as well. In this sense, many biologists are historians exploring the past. This isn't easy to do. The past is gone; time has moved on. Anyone involved with the past must try to recreate it from bits and pieces. This is difficult because it is hard to know how important a particular piece might be, or where it might fit into the rather amorphous jigsaw puzzle which the past is.

Though I know very little history, I do know a bit about how historians work because I'm married to one. The more I see him at work, poring over old letters and newspapers and documents, the more I see that what he does is very similar to what a student of evolution does in poring over fossils and other evidence of life in the past. In both cases they build on earlier analyses, carrying them further and viewing the past in the light of recent research. Researchers studying eurypterids, a group of extinct Paleozoic swimming arthropods, serve as an example of this process. Provided with just fossil remains, it is difficult for them to determine just how eurypterids swam (Briggs 1986). An early hypothesis came from comparisons with the horseshoe crab and pictured eurypterids as swimming ventral side up, but more detailed study made this posture unlikely. Recent work by Paul Selden involves more careful analysis of a pair of appendages that are flattened into paddles, and which, he suggests, functioned like oars. Now R. Plotnick, in turn, has built on Selden's work by comparing eurypterids to portunid crabs which have similar paddles (the fifth pereiopod). Plotnick sees eurypterids as performing a type of lift-based swimming or hovering.

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Plotnick's technique of comparing a present-day organism to one now extinct in order to better understand the latter is a powerful tool often used by biologists to piece together the past. For example, it has shed light on stromatolites, remants of the deep past. Sedimentary structures formed by the activity of blue-green algae, they were first produced during the Archean period more than 2.5 billion years ago. Technically, stromatolites are not true fossils because they are not the remains of organisms but rather organo-sedimentary structures produced from the sediments trapped by filamentous blue-green algae as they spread out to form algal mats. All this is obvious from the remains of ancient stromatolites, some of which are hundreds of meters wide and tens of meters high. But it is difficult to determine from these remains the precise conditions under which the mats formed. At least some of this information can be derived from study of present-day stromatolites that are still being generated in a few suitable freshwater and marine environments (Smith 1986). One that has been extensively studied is in dolomite sediments in South Africa's Transvaal. It has yielded information on the pH and on calcium and magnesium concentrations conducive to stromatolite development—information impossible to derive from ancient formations.

There is another way in which study of present-day organisms can help us deal with the past. It can remind us just how limited our information on the past is. A recent issue of *Natural History* vividly brought this point home to me. An article by Stephen Jay Gould (1986) discussed the interpretation of fossils that have been found in the Cambrian Burgess Shale and are over 600 million years old. Even though these fossils are extremely well preserved and include the remains of many soft-bodied organisms that are rarely fossilized (Gambles 1985), they still leave a great deal untold, not so much about the structures of these organisms, but about how they lived. The second article (Janson 1986) clearly illustrated this in describing the very different habits of two closely related monkey species. These species would leave fossil remains differing little from each other and giving few hints of these animals' very different lifestyles. Brown capuchin monkeys are slightly larger than white-fronted capuchins, and being more robust, they can feed on tougher fruit and hard seeds. Both these properties might be apparent to paleontologists of the future who may find these animals' fossilized bones in proximity to the seeds or pollen of the plants they habitually fed upon. But it would be less apparent that the brown capuchins travel in smaller groups and that their dominant males are more aggressive than white-fronted capuchin males. There are also several differences in these two species' mating systems. Female brown capuchins preferentially pursue and try to mate with the dominant male, while female white-fronted capuchins seem not to prefer any one male. Janson goes on to cite other differences and to speculate on how they originated, perhaps as a result of an initial divergence in diet. This interesting and detailed comparative study, the result of four years' work in Peru's Manu National Park, is a good reminder that no matter how well preserved a fossil may be, there is a limit to the amount of information it can yield, particularly about social behavior.

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Yet, such behavior can play an important role in evolution. Recently, David Crews and Michael Moore (1986) reviewed the mechanisms that can control mating behavior. A variety of hormonal, environmental and social cues are used by different species to activate such behavior, as Crews and Moore state: "Which cues are used by particular species depends on differences in environmental and physiological constraints imposed by particular reproductive strategies. Study of the diversity of mechanisms promises to identify specific selective forces that have shaped their evolution." But many of these cues, particularly those involving social behavior, would be difficult if not impossible to reconstruct from the fossil record. One way to obtain information on behavioral evolution is to compare mating behavior in closely related species. For example, Crews and Moore trace the evolution of true parthenogenesis on whiptail lizards by comparing them to related species that retain the two sexes, and show how the latter use hormonal cues differently from the former.

Not only do fossils give limited information about the living organisms from which they are derived, but very few organisms even leave fossils. David Raup (1986) cites estimates that, while up to four billion species of plants and animals may have lived at some time in the geologic past, most of these in the last 600 million years, only about 250,000 fossil species are known. This points up the rarity of preservation, and then of discovery of a given species' remains. Students of American history would be driven to despair if they had to reconstruct an adequate history of the United States with access to only 0.00006% of the acts of Congress and of the names of government leaders. Faced with this scarcity of documentation, scientists are challenged to use their ingenuity to eke out as much information as possible, not only from the fossils of ancient organisms, but from other remains as well. For example, coccolithophorids, widely distributed marine phytoplankton, leave a record of ocean temperature in the form of long-chain alkenones, the lipid remains of their cell membranes. These lipids control the fluidity of the membrane and respond to temperature stress with changes in their degree of saturation (Suess 1986). The relationship between saturation and water temperature can be affected by a variety of factors, so the alkenones do not yield fool-proof information on conditions in ancient oceans, but they can be used to corroborate other evidence. Also, the success with this biomarker has spurred the search for other paleoceanographic biomarkers including a dinosterol from dinoflagellate algae, and protein with characteristic amino acid assemblages from calcareous and siliceous marine plankton.

The pollen record is another good source of information about the past. Peter Moore (1986a) noted recently that paleobotanists and archeologists use "pollen analyses of peats and lake sediments as a guide to the use of land by prehistoric communities. Certain characteristic pollen types and particular changes in pollen frequency are now accepted as evidence for the involvement of prehistoric man in the modification of vegetation." For example, in the excavation of an Iron Age field system in Germany, high pollen levels of cultivated plants such as rye are found together with their associated weed flora, particularly cornflowers. Other strong indicators of human activity are pollen of sorrel and heather since these plants "owe their presence to the general disturbance of the sandy soils and the opening up of woodland canopies."

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But, like all historical records, pollen remains can be difficult to interpret. In Great Britain, the alder is a species whose post-glacial expansion was interpreted as resulting from climatic changes, particularly increased wetness rather than increasing temperature (Moore 1986b). But new evidence suggests that, by disturbing forest inertia, mesolithic humans may have been involved in the alder's spread. In a mesolithic site in South Wales, researchers have found charcoal present in those horizons where the alder pollen becomes more abundant. Moore cites several other examples in Britain of prehistoric environmental change linked to human activity. These include the decline in elms about 5,000 years ago and the spread of heathland, moorland and blanket bog.

It is becoming increasingly clear that humans have had a profound influence on the environment for millenia. The capacity to alter ecosystems radically is not a recently acquired human power. Humans may be to blame for the extinction of many large mammals during the late Pleistocene era about 10 thousand years ago, though some paleontologists see climatic changes at the end of the last ice age as the primary cause. In reviewing recent research on mammoths, Jared Diamond (1986) describes how Soviet scientists have examined soft tissue remains of mammoths found in permafrost. From gallons of frozen stomach contents they have learned that these animals ate mainly grasses and sedges, as well as willow, birch and alder shoots. These scientists also have explained how the mammoths were able to find vegetation under dense snow cover during long Siberian winters; older animals used their curved tusks as snow plows. The tusks of younger animals, though more useful in combat, would not yet be curved enough for snow removal. Diamond goes on to cite evidence from North America, including a mammoth skeleton with two projectile points among its ribs, that paleolithic hunters played a role in the mammoth's extinction. He says that it is suspicious "that the abundant mammoths and many other large New World mammals survived at least 22 Pleistocene glacial cycles, to disappear about the time that Clovis hunters arrived."

Humans also have apparently had a devastating effect on bird life in several now uninhabited Pacific islands. Henderson Island, with an area of only 15 square miles, is located about 100 miles east of Pitcairn Island. Sixteen bird species are found there, and it has been assumed that the island was little affected by humans (Diamond 1985). But archeologists have discovered the remains of a human settlement dating from about 1200 to 1500 AD. There is evidence that these settlers depended heavily on birds for their food; one third of the species of land birds that once lived on the island can no longer be found there (Lewin 1986). This same pattern of extinction is probably typical of other Pacific islands. As Roger Lewin notes, "The much more complete fossil studies on the Hawaiian islands show that in historic times there were more than twice as many bird species as there are now."

Such information from the fossil record is important for two reasons that indicate how, as with all history, the biological past can be used to throw light on the present. Many surveys of Pacific island bird populations have been done under the as-

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sumption that the populations were in a natural state, little affected by humans. The results of these surveys have been used to develop models of the composition and dynamics of natural ecosystems: for example, models of the relationship between island area and the number of bird species that can be sustained in that area. Obviously these models need correction in light of the fact that, in their natural state before human settlement, these islands sustained a significantly greater variety of species.

While this may be bad news for theoretical ecologists who must go back to the drawing boards, it may turn out to be good news for those ecologists concerned with saving endangered bird species. The Marquesas pigeon population has been reduced to about 100 individuals found along forested mountain ridges on only one island, Nuku Hiva, in the Marquesas group. Fossil evidence from Henderson Island indicates that these pigeons thrived there in lowland areas. Not only does this mean that if relocated, the pigeons could adapt to a wider variety of habitats than was originally thought, but also that Henderson might make a suitable site. As Lewin says, "The argument that it is somehow improper to introduce species to islands that have never supported them can in some cases now be overcome, given the historical perspective derived from the archeological material."

Biochemistry is also being used to delve into the past of Pacific islands. Comparisons of DNA sequences and of proteins from different species have enabled researchers to measure the evolutionary distances between species. Though these results don't always agree with those obtained from morphological studies, they can provide some interesting clues as to when and how related species diverge from each other. Researchers have recently raised sera against the larval hemolymph protein (LHP) from some of the 800 species of drosophilines or fruit flies found in the Hawaiian Islands (Lewin 1985). They then used an immunological distance technique which involves pairwise comparisons of the sera. For example, sera raised against LHP from *Drosophila crucigera* will only react weakly with that from a distant cousin *Scaptomyza elmoi*, but strongly with that of *D. punaluo*, a closely related species. Thus, differences in reaction strength are correlated with differences in evolutionary distances. Using these data, researchers have constructed a tree indicating times of divergence for the various species. The tree shows that the two major genuses, *Drosophila* and *Scaptomyza*, colonized the islands about 40 million years ago. But there is a problem. The Hawaiian Islands are only six million years old! This apparently huge discrepancy is explained by the fact that the present islands are the products of a "hot spot" in the Pacific that has been creating volcanic islands for 70 million years. So the flies originally colonized one of the earlier islands that has since drowned, but not before some flies had gone on to colonize younger islands in the chain.

This is a fascinating story, and I think that's what attracts people to the study of history and the study of life —the stories are so good. Historians make the story of human history fuller and richer, and biologists are doing the same for the history of life on earth.

References

Briggs, D. (1986). How did eurypterids swim? *Nature, 320,* 400.

Crews, D., & Moore, M. (1986). Evolution of mechanisms controlling mating behavior. *Science, 231,* 121-125.

Diamond, J. (1985). Why did the Polynesians abandon their mystery islands? *Nature, 317,* 764.

Diamond, J. (1986). The mammoths' last migration. *Nature, 319,* 265-266.

Gambles, P. (1985). Outlines of the distant past. *Nature, 314,* 403-404.

Gould, S.J. (1986). Play it again, life. *Natural History, 95*(2), 18-26.

Janson, C. (1986). Capuchin counterpoint. *Natural History, 95*(2), 44-53.

Lewin, R. (1985). Hawaiian Drosophila: Young islands, old flies. *Science, 229,* 1072-1074.

Lewin, R. (1986). Polynesians' litter gives clues to islands' history. *Science, 231,* 453-454.

Moore, P. (1986a). Clues from the pollen record. *Nature, 319,* 361-362.

Moore, P. (1986b). Unravelling human effects. *Nature, 321,* 204.

Raup, D. (1986). Biological extinction in earth history. *Science, 231,* 1528-1533.

Smith, P. (1986). Growing stromatolites. *Nature, 320,* 396.

Suess, E. (1986). Biomarkers for ancient climates. *Nature, 320,* 107-108.

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