gravis is caused by an antibody-mediated attack on the acetylcholine receptor. During their studies, the Erlanger group noted that rabbits that had been immunized with antibody to BisQ and were producing anti-idiotype antibody to it developed symptoms characteristic of the disease. "This raises the possibility that autoimmune diseases could be caused by aberrant network regulation," Erlanger suggests.

Although the standard view holds that the acetylcholine receptor somehow elicits production of the harmful antibodies, he proposes that the trigger might be the production of antibody against a substance with a shape similar to that of acetylcholine. If the antibody, which is the receptor image, elicits the production of anti-idiotype antibodies the result might be destruction of the receptor.

The trigger might even be a virus that binds to the acetylcholine receptor, Erlanger suggests, although presumably not the rabies virus which uses that receptor to enter nerve cells. There is a long history of anecdotal evidence suggesting that viruses might initiate autoimmune diseases, and Greene's work shows that it is possible to make an anti-idiotype antibody to an antibody to a virus that will recognize a cellular receptor.

Graves's disease is also caused by antibodies to a receptor, in this case the one for thyroid-stimulating hormone (TSH). Instead of destroying the receptor, the antibodies activate it, much as the hormone does, and the thyroid gland becomes overactive. Leonard Kohn of the National Institue of Allergy and Infectious Disease thinks that anti-idiotype antibodies may play a role in Graves' disease, but opposite to that suggested by Erlanger for myasthenia gravis. According to Kohn, they are more likely to ameliorate the symptoms of the autoimmune disease by blocking the antibodies that react with the TSH receptor.

He points out, however, that it is very difficult to determine which antibody in an interlocking idiotype network might have initiated an abnormal immune response. Nevertheless, regardless of whether antibody to the receptor or its ligand came first, a defect in the regulatory network might have contributed to the autoimmunity. And in either case, an anti-idiotype antibody to the receptor-binding antibody might aid in controlling the disease, which is another path of inquiry currently being explored by immunologists.—**JEAN L. MARX**

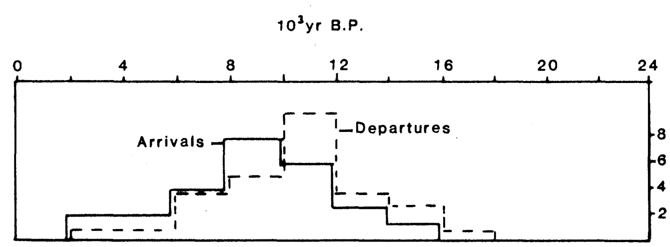
Plant Communities Resist Climatic Change

A combination of self-generated microclimates and the dynamics of seedling competition gives plant communities an unexpected stability

The change in vegetation coverage through time represents a clear record of climatic change. For instance, the replacement of deciduous forest by conifers betokens cooler times. However, the response of plant communities to shifting climes, when viewed in relatively close focus, is more complex than is often imagined. In a detailed study of vegetation patterns of the Grand Canyon through the past 24,000 years Kenneth Cole of the Indiana Dunes National Lakeshore records a dynamic set of interactions—plants with climate and plants with plants—that clearly reveals this sometimes hidden complexity (*1*).

The past 24,000 years includes the Pleistocene/Holocene boundary—the transition between the last ice age and the current interglacial. The retreat of the Northern Hemisphere ice sheets, which began between 16,000 and 13,000 years ago, triggered dramatic biotic change, as temperature and rainfall patterns ameliorated. Specifically, sub-Arctic vegetation was replaced by temperate plant assemblages. In the eastern United States, there was a general northward migration of vegetation. In the west, where the great mountain ranges presented both geographical barriers and opportunities, this latitudinal migration was accompanied in places by altitudinal shifts.

Where geological and paleoecological records have coincided in locality and quality, it has become apparent that a significant lag time—some 2000 years or so—separates the climatic and consequent vegetational change at this boundary. The constraints of migration in essentially immobile organisms have, very reasonably, been adduced to explain this. From his analysis of the Grand Canyon record, Cole deduces an additional constraint: to wit, vegetational inertia, an idea that has a mature pedigree in plant ecology but one that until now has been given little prominence.



Species flux
A compilation of the appearances and disappearances of species over the Pleistocene/Holocene boundary shows a clear separation of peaks of activity, which implies a period of species paucity.

Put simply, the model suggests that a combination of factors, including competition and physical microenvironment, allows a plant community to persist long after the disappearance of conditions that were necessary for its initial establishment. Eventually, such a community will be replaced but rather more slowly than might have been predicted. This evanescent uncoupling of flora from prevailing environment means that if climatic change has been rapid, such as at the Pleistocene/Holocene boundary, plant fossil records might be less reliable as climatic indicators than is usually the case.

The precipitous slopes of the Grand Canyon offer excellent conditions from which to determine patterns of vegetational change through time. Not only do the high cliff sides encompass several different vegetational zones, ranging from ponderosa pine to sagebrush and desert environments, but their inaccessibility has protected them from disturbance by all but the most nimble bighorn sheep and deer.

The paleoecologist is also blessed by the existence there of so-called pack rats (of the genus *Neotoma*). These little rodents, of the size of Norwegian rats, live in rock crevices and have the curious habit of collecting more or less anything transportable within a 30 meter radius of their nest, piling it up, and urinating on it. Now, as the urine of pack rats is a viscous liquid very high in uric acid, the effect of all this is to preserve in dessicated condition a representative sample of contemporary vegetation, which can be dated by radiocarbon methods.

Cole has shown from modern pack rat "middens" that the representation of flora is often as good as 90 percent. This, together with the fact that plant remains in middens as old as 52,000 years have been shown to be as suitable as modern material for thin sectioning, makes the pack rat midden an invaluable field resource. Cole exploited 52 such fossil middens in a region of the eastern Grand Canyon. He was also able to draw on similar data from the western Grand Canyon, which were collected by A. M. Phillips of the University of Arizona.

Pack-rat midden

This dessicated heap in Bida cave gives a clear record of vegetational cover in the area in the late Pleistocene.

There are several ways of assessing the change of plant communities through time. One of these, Sørensen's index, gives a relatively sensitive reflection of the similarity of a fossil flora with that of today's. Cole therefore plotted the Sørensen index for the plant assemblages in the pack-rat middens through the past 24,000 years. From this curve he then derived the rate of change of the index through time, which, theoretically, should give an indication of peaks of faster activity. It did: high rates of change are concentrated between 10,000 and 6,000 years ago, which is significantly displaced from the Pleistocene/Holocene boundary, typically placed at 10,000 or 11,000 years ago.

Now, the Sørensen index is useful as far as it goes. Because it focuses on a comparison with the modern flora it does not reflect the coming and going of species in fossil communities that are not represented today. By plotting a measure of species flux—a combination of the appearance and disappearance of species—Cole was able to identify a peak of activity that predated the high rate of influx of modern species. Species flux peaked between 12,000 and 10,000 years ago, but the most interesting part of this was the breakdown into appearances and disappearances.

It turned out that species disappearance peaked between 12,000 and 10,000 years ago, while the rate of appearances was highest in the 10,000- to 8,000-year interval. This was something of a shock, because it implied a period of reduced species diversity. Although the number of middens in this critical time range is less than Cole would like, those he does have do appear to contain a lowered species number in the 12,000- to 10,000-year-ago interval. He sees the same pattern in the Phillips' data from the western Grand Canyon and from middens in the Sheep Range in southern Nevada, collected by W. G. Spaulding of the University of Arizona. However, some observers wonder how widely this pattern will apply. For instance, Tom Van Davender of the Arizona-Sonora Desert Museum believes it might be restricted to a particular elevational setting.

Cole began to develop the notion of a certain inbuilt stability in plant communities, which, he thought, might explain the observed lag. He termed this stability "vegetational inertia." He then discovered reference to a similar phenomenon in a paper on peat ecology, published in 1957. The author, E. Gorham, had used the phrase "biological inertia." Since that time, the notion has received only limited attention.

One aspect of vegetation inertia derives from the fact that a dominant species in a community can significantly influence the microenvironment, including the availability of sunlight and moisture and the character of the soil chemistry. Once established, such a community is somewhat buffered from many external changes. Species in more marginal environments will, however, be much more vulnerable, and the loss of such species is what shows up rapidly in measurements of flux.

A second, and crucial, aspect of vegetational inertia is competition, specifically the establishment of seedlings, which represents a critical phase in the life cycle of plants. The game here is simply one of numbers, so that a potential invading species will fail to penetrate if its propagules are few, even if individually each is superior to the established species. Cole notes, therefore, that the time required for vegetational change depends on the reproductive vigor of invading species and how close the prevailing climate is to the optimum of the resident species.

Cole suggests that the vegetational patterns he sees in the Grand Canyon record fit well with his model. Specifically, the initial climate change at the end of the Pleistocene eliminated species from unfavorable habitats, which thus lowered species diversity. Although the dominant species of the time would have disappeared from marginal habitats, they would have persisted in more favorable locations, eventually to be competitively displaced through the following 1000 to 3000 years. "Thus, although the major shift in climate may have occurred earlier, the peak values in vegetation change are recorded between 12,000 and 8,000 years Before Present, when the Holocene dominants arrived and outcompeted the remaining Wisconsin climax types. Species with slower migration rates and lower rates of establishment arrived throughout the Holocene."

The coincidence of the climatic warming at the end of the Pleistocene and the extinction of many large mammal species about 11,000 years ago in the Americas has been interpreted by some to be causally significant: to wit, the loss of the natural food plants precipitated the animals' demise. Others—primarily Paul Martin of the University of Arizona—see the extinctions coinciding more significantly with the arrival of big game hunters in the New World. The elimination of the major herbivores could then be argued to be responsible for the fall in plant diversity, following R. T. Paine's keystone predator concept.

As significant changes in the plant communities began to occur well before the large mammal extinction, the latter idea seems to be less likely.

—ROGER LEWIN

Reference

1. K. Cole, *Am. Nat.* **125**, 289 (1985).