model] that might be used in the design of a bridge," Martin Hoffert of New York University and Brian Flannery of Exxon Research and Engineering Company in Linden, New Jersey, reviewed climate models that predict how fast, given certain carbon dioxide releases, the climate will warm. They point out that storage of heat in the upper ocean will slow the warming by at least 10 to 20 years. Even with this delay, current models predict a global warming of the order of 1°C relative to the year 1850 by the year 2000. Increasing carbon dioxide would cause an additional warming of 2° to 5°C during the next century.

Carbon dioxide is not the only climatically significant gas whose atmospheric concentration is increasing, as pointed out in the review by Wei-Chyung Wang of Atmospheric and Environmental Research, Inc., in Cambridge, Massachusetts, and his colleagues. Increasing amounts of methane, produced by everything from cattle to rice paddies, and chlorofluorocarbons of ozone-depletion fame, among other trace gases, could upset the earth's radiative balance and warm the climate as much as carbon dioxide by the middle of the next century. This forecast also is circumscribed by uncertainties that are, if anything, greater than those about carbon dioxide.

"The expected climate change could soon be obvious."

Significant uncertainties about the future warming are not limited to climate modeling. The state-of-the-art volume on the global carbon cycle, edited by John Trabalka of Oak Ridge National Laboratory, reveals that geochemists still cannot figure out where all the carbon dioxide being produced today is going. Fossil fuel burning releases 5×10^{15} grams of carbon per year and deforestation releases carbon at 12 to 52% of that rate. That is up to 50% more carbon than they can find accumulating in the atmosphere or can calculate would be absorbed by the oceans. Something is obviously out of whack in the geochemists' models of the carbon cycle, and that something could invalidate projections of the amount of carbon dioxide left in the atmosphere to warm the climate in the next century.

Even greater uncertainties than those in the workings of the carbon cycle are those in the operation of the human economy and its consumption of coal, oil, and gas. The oil crisis interrupted a steady upward trend in fossil fuel burning of 4.4% per year and lowered forecasters' projections of future emissions from the range of 2.0 to 4.5% per year to 0 to 2% per year. Thus, the doubling of carbon dioxide levels that might have occurred by 2025 is now not expected until near the end of the next century, or even later.

The uncertainties presented in good scientific order in chapter after chapter can become daunting, but in their summary of climate projection studies Michael MacCracken and Frederick Luther of the Lawrence Livermore National Laboratory make clear what most researchers believe: carbon dioxide has already increased by 25%, it will in all likelihood continue to increase, and the basic physics of the greenhouse effect is well understood. (A water–carbon dioxide greenhouse has always warmed the earth's surface from −18°C to habitable temperatures.)

"Theoretical understanding provides a firm basis," they write, "for projecting that continuing emissions of CO_2 and trace gases will warm the global climate by a few degrees Celsius during the next century." The important uncertainties concern how and where the temperature and precipitation changes will occur, they say. It is certainly wrong to claim, as has Sherwood Idso of the U.S. Water Conservation Laboratory in Phoenix, that the climate models are fundamentally flawed and the greenhouse effect will be nil, according to an appendix to the modeling volume authored by Luther and Robert Cess of the State University of New York at Stony Brook. They conclude that prior applications of Idso's primary approach "violate the law of conservation of energy (the first law of thermodynamics); therefore, these results are incorrect."

If that kind of confidence is well founded, the expected climate change could soon be obvious. Summing up the volume on detecting such climate effects, MacCracken and Luther find that, in addition to the increase of carbon dioxide since the middle of the last century, "Northern Hemisphere land temperatures, sea surface temperatures, and sea level have also increased during this period. Model projections of the climatic response to an increased CO_2 concentration indicate that such changes should be expected. The apparent agreement strongly suggests a causal relation. . . . If CO_2 and trace gas concentrations continue to rise as projected and model calculations are essentially correct, the increasing global scale warming should become much more evident over the next few decades. If such changes do not become apparent, our understanding of the uncertainties and completeness of current climate models will require extensive reconsideration." ■ RICHARD A. KERR

Briefing:

Did Ancient Humans Make Stone Caches?

Some of the oldest putative living sites of human ancestors have been found at Olduvai Gorge in Tanzania. Dated to almost 2 million years ago, these assemblages of stone artefacts and broken animal bones have frequently been thought of as temporary home bases, rather in the manner of modern hunter-gatherers' campsites. But, according to data recently reported by Richard Potts of the National Museum of Natural History, Washington, D.C., it seems that the analogy might have been stretched just a little too far.

Modern hunter-gatherers usually establish a particular home base for a period of just a few weeks or perhaps a couple of months. The camp becomes the focus of social activities and it is the place to which plant and animal foods are brought, shared out and eaten. The band then moves on to another location, partly to shift the center of gravity of their foraging but also because the accumulated litter and debris make the camp less and less habitable: the insects and scavengers increase uncomfortably.

Now, paleoanthropologists are careful to emphasize that 2-million-year-old hominids were not simply quaint and primitive versions of modern hunter-gatherers. Their brains were little more than half the size of ours, for instance, which is apparently reflected in their simple technology. And it has become clear that active hunting was a less developed aspect of their economy than it is for modern hunter-gatherers. Nevertheless, there has been a very seductive assumption that the overall pattern of life was the same: namely, a small band of individuals, moving from temporary home base to temporary home base throughout the year.

If Potts is correct in his recent work, however, that assumption collapses. He has studied the fossil bone fragments from five archeological sites at Olduvai Gorge, and deduces that the bones accumulated there over a period of between 5 and 10 years. It appears that each site was a place to which hominids of 2 million years ago returned from time to time over a considerable period, apparently to butcher parts of carcasses. This is quite unlike the modern hunter-gatherers' temporary home base, which is occupied briefly and then abandoned. The pattern at Olduvai just happens to be rather more like the bone accumulation that occurs at hyena dens.

Potts bases his estimations on the physical state of the fossilized bone fragments, a measure that was developed a few years ago by Anna K. Behrensmeyer, also of the National Museum. Under the influence of daily fluctuations in temperature, humidity, exposure to sunlight, and bacterial action on organic material, fresh bones pass through a series of stages of deterioration. For instance, initial fine cracks eventually become more extensive and abraded; layers of surface bone begin to peel off; and finally the whole thing disintegrates. The process of deterioration, which takes about 15 years from first to last stage, is halted once the bone is buried.

Now, if all the bone had been deposited at the various Olduvai sites within very short periods of time, as would happen with a typical hunter-gatherers' home base, then the degree of deterioration in the individual pieces in each site would be roughly similar. In fact, Potts finds that there is a considerable spread of stages of deterioration, showing that bone deposition took place over a 5- to 10-year period. He also analyzed bones from the den of a spotted hyena in Kenya, and found a similar pattern.

Potts is careful to point out that the similarity in the dynamics of bone deposition between the Olduvai sites and the spotted hyena den should not be taken to imply that the Olduvai hominids were more like hyenas than humans. Instead, he suggests that the sites might have been formed in the way they apparently were because they included a cache of raw material for making stone tools. Because such material is often not widely distributed, it would have made sense to make collections of it, which would then become the focus of occasional butchering events. Such an activity could indeed have been carried out intermittently over a period of several years.

Archeological sites further north, at Koobi Fora in Kenya, generally do not have the appearance of the long-term bone accumulation seen at Olduvai. Although deposition analysis has not yet been carried out on them, some do look like briefly occupied sites. Potts points out that these sites are later in time than those at Olduvai—dated at about 1.5 million years—and therefore might be the work of more advanced hominids. But it is possible that a difference in environment, which includes availability and nature of raw material for making stone tools, might have some influence too. ■

ROGER LEWIN

ADDITIONAL READING

R. Potts, "Temporal span of bone accumulation at Olduvai Gorge and implications for early hominid foraging behavior," *Paleobiology* 12, 25 (1986).

Manic-Depression: Is It Inherited?

Preliminary evidence from a study on the Amish indicates that manic-depression might be caused by a single dominant gene

It sounds almost simplistic. Mental disorders are complex and relatively common in the population. It would be too much to ask that their genetics be straightforward, that they be caused by single aberrant genes.

Yet there is a precedent. Huntington's disease is caused by a single gene and whoever inherits the gene sooner or later develops the disease. In about half of all cases, the first symptoms of this progressive neurological disease are psychiatric ones. Patients may be depressed or irrational, forgetful or disoriented. Those who do not start out with psychiatric symptoms start with movement disorders—clumsiness and an unsteady gait. So the example of Huntington's disease at least raises the possibility that complex psychiatric syndromes are caused by single genes.

No one expects the genetics of true psychiatric disorders to be as straightforward as that of Huntington's disease. But there are reasons to believe that some psychiatric disorders are largely inherited and that the means exist to find the genes involved. In particular, researchers are on the trail of a gene that may cause many cases of manic-depression.

As Elliott Gershon of the National Institute of Mental Health points out, it has been suspected for years that there is a strong genetic component to manic-depression, which also is called bipolar disorder. For example, if one identical twin has manic-depression, the other has a nearly 80% chance of having it too. If one member of a pair of fraternal twins has the illness, the other member has about a 20% chance of having it. When adopted persons with manic-depressions were studied, investigators found that more than 30% of their biological parents also had manic-depressions, but only 2% of the adoptive parents did.

But it is difficult to go from studies such as these to a search for a gene that causes this mental illness. What would be most useful is large families whose members develop the disease, such as the families studied by the Huntington's disease researchers when they found a genetic marker for that disease. The researchers begin with blood samples from family members. Using the tools of molecular biology, they then chop up the DNA from these blood cells. Then they use molecular probes to search for a piece of DNA so near to the manic-depression gene that it is inherited along with it. If such a genetic marker is found, researchers can start homing in on the gene itself.

Fortunately, in the case of manic-depression, researchers actually have such large families. Living in Lancaster County, Pennsylvania, are 12,500 Old Order Amish, an isolated group of people who are descended from around 50 couples who arrived in Pennsylvania from Germany between 1720 and 1750. They have large families, live by farming, and avoid contact with the rest of the world. Most important for geneticists, the Amish, because they have isolated themselves from the rest of society, constitute a closed population.

An extensive genetic study of the Amish is headed by Janice Egeland of the University of Miami School of Medicine. Egeland, who lived among the Amish for years, finds that although the Amish as a group have no more mental illness than the rest of the population, they do have social values that make mental illnesses easier to diagnose.

Alcohol and drug abuses, for example, are unheard of among the Amish. Psychiatrists suspect that many cases of depression and of manic-depression in the non-Amish, especially among men, are hidden by alcoholism. There are virtually no crimes or acts of violence in the Amish community, so the increased death rate from suicide that is associated with manic-depression can be ascertained.

Egeland, who is a behavioral scientist, called on psychologist Jean Endicott of Columbia University College of Physicians and Surgeons and a team of four independent psychiatrists to diagnose manic-depression in the Amish. "The diagnostic procedure is rather elaborate," says Endicott. She and the four-member psychiatric review board independently receive clinical data and independently make diagnoses. Because their diagnostic criteria are very specific—they use the well-accepted Research Diagnostic Criteria, which were written by Endicott, Robert Switzer of Columbia University, and Eli