Cells in the constant-frequency area are arranged by three characteristics: by the amplitude and frequency to which they best respond and by how they integrate input from the two ears. When the researchers examined cells in a plane parallel to the brain surface, they found that the cells responding best to various frequencies are arranged as nested, imperfect rings, with the neurons sensitive to 61 kilohertz at the center and those sensitive to 63 kilohertz at the circumference. Superimposed on that bull's-eye pattern are spokes of amplitude preference. Cells most sensitive to weak sounds form one wedge, those sensitive to strong sounds form another.

The constant frequency region includes many cells that receive signals from both ears. Some are excited by either ear (E-E) and some are excited by the ear on the other side of the head, but inhibited by the ear on the same side (I-E). Suga found that the neurons excited by both ears are sensitive to weak echoes, but are not sensitive to the direction of the sound. The neurons inhibited by one ear are directionally sensitive, but require intense echoes.

When the researchers tested neurons at different depths in the brain, they found a columnar organization. If a cell excited by both ears is identified near the brain surface, all neurons at increasing depths directly below have the same characteristics. Suga also found columns of I-E cells and of cells that respond to input from only one ear (O-E). Finally, there seems to be a fourth type of column with E-E neurons near the surface, O-E neurons about 500 microns deep and I-E neurons at deeper levels (or the opposite order). Although there have been studies of dog and cat brain auditory areas, only in the mustache bat have the inputs from different ears and the amplitude preferences been mapped in relationship to frequency preferences, the researchers say.

The brain neurons that respond to the dropping-frequency signal show properties quite different from those in the constant-frequency processing area. The majority respond best to a specific sound preceded by a sound from another harmonic. The researchers found 11 combinations of sounds that give strong responses in some cells. The exact frequency and amplitude of the sounds were far less important than for cells processing constant-frequency tones. Instead of being organized on gradients of amplitude and frequency preferences, neurons responsive to each combination form a cluster. From detailed analyses of the cells, Suga and colleagues conclude that the neurons are tuned to a target that has a particular cross-sectional area and is located at a particular distance. They say, "Our series of experiments clearly indicate that each functional division of the auditory cortex is organized differently for processing acoustic signals according to their biological significance." □

Changes in M.D. training and pay urged

Unlike the Soviet Union, China and some European countries, the United States has never had a health care delivery policy. But in 1970 the U.S. National Academy of Sciences chartered the Institute of Medicine to study various U.S. health care problems and to help form national policy on how those problems should be solved (SN: 12/14/71, p.381).

Last week the institute released some of its toughest and most controversial recommendations yet — on how U.S. physicians should be trained and reimbursed to better meet health care needs. Specifically:

- A 10-year moratorium should be placed on increasing the sizes of medical school classes and on building more medical schools, because there are now so many medical students in the pipeline that the number of physicians will increase by 60 percent in the next 12 years.
- In order to get more students into primary care instead of into medical specialties, as is currently the case, the federal government should increase its subsidies for primary care residencies even beyond that called for in 1976 federal health manpower legislation.
- To help encourage more medical students to go into primary care, private health insurance plans and government agencies should pay primary care doctors the same as specialists for the same work (which is not now the case), should refuse to pay for specialized care unless it has been declared necessary by a primary care doctor and should reduce differences in payment levels between primary care procedures and other medical services. In essence these recommendations would raise the incomes of primary care physicians and lower those of specialists, a change bound to be opposed by the nation's thousands of specialists. In 1975 the average net income of a primary care physician was $53,000 compared with $124,000 for radiologists, and with $87,000 for anesthesiologists.

Whether these recommendations will become realities, however, depends on the American Medical Association, Blue Cross-Blue Shield and other private health insurance plans, the Association of American Medical Colleges and federal health manpower legislation affecting federal funding of medical schools. Congress is scheduled to hold hearings this year on changing the existing health manpower law. □

Economic growth tied to biological systems

We cannot sustain exponential growth indefinitely on a finite planet. The concept is hardly new; in fact, it was the cornerstone of the 1972 *Limits to Growth* computer-simulation study which bluntly forecast that humans will outstrip the carrying capacity of their environment if global population growth and economic growth continue unchecked. This week Lester R. Brown, president and senior researcher of the Worldwatch Institute, a Washington-based research group, took up the theme again with publication of *The Global Economic Prospect: New Sources of Economic Stress*. But if the theme is familiar, his focus is less so.

Earlier studies emphasized the depletion of resources, such as minerals and petrochemicals. The principal renewable resource was the human race and its ingenuity for adapting the environment in order to subvert potential crises—such as resource depletion—with technology and social change. Brown picks up this theme to develop another: Biological systems are renewable only so long as they are not destroyed. If biological resources are harvested beyond the rate at which they can regenerate, "fisheries collapse, forests disappear, grasslands are converted into barren wastelands, and croplands deteriorate," he says.

What's more, those four biological systems — fisheries, forests, grasslands and croplands — are the foundation of the global economy, he says. "In addition to supplying all our food, these four systems provide virtually all the raw materials for industry except minerals and petroleum-derived synthetics. The condition of the economy and of these biological systems cannot be separated," he says.

Inseparable or not, Brown says economists are getting into trouble because they "are unaccustomed to thinking about the role of biological systems in the economy, much less the condition of these systems." Their lack of ecological awareness has contributed to shortcomings in economic analysis and policy, he says.

Drawing from research developed for his book *The Twenty-Ninth Day* (published by Norton last month; see p. 334), Brown describes how: Productivity of many oceanic fisheries is falling as the annual catch exceeds regenerative capacity; demand for firewood, paper and lumber is denuding many Third World woodlands; overgrazing of grasslands, which support the world's 2.7 billion ruminants, is now commonplace; and encroachment of cities and deserts on croplands is requiring farmers to till ever more marginal lands to meet the growing world's hunger.

If any one of the systems were pushed to the limit of its regenerative capacity, another probably could substitute. The problem is that all are being pushed toward their limits simultaneously, the agricul-

tural economist says.

Although it may be possible to engineer changes in the environment to at least partially compensate for natural limitations — such as by fertilizing fields to increase yields — a "law" of diminishing returns comes into play, Brown says. A point is reached at which each additional increase in fertilizer brings smaller increments of benefit, he says. At the end, the increased benefit of using more fertilizer is offset by the cost of the fertilizer or of applying it. This same law of diminishing returns applies, he says, to drilling for oil and gas, to mining raw materials, even to the ability of the environment to absorb pollutants. "Technological advances may more than offset declines in resource quality for awhile," Brown writes, "but at some point the most ingenious attempts to compensate for nature's limitations will no longer be adequate."

Ken Chen and Karl Lagler, in their 1974 book *Growth Policy,* further argue that policymakers exacerbate the problem by using technology to relax ecosystem constraints rather than to curb rates of growth and consumption. Technological answers generate many new problems, they say, because until now technology "has been able to wield its power primarily by bleeding natural resources and the environment."

Brown claims that scarcity-induced price hikes in resources are among "new inflationary forces" shaping the expanding world economy. The way to manage these new forces may not be to manipulate economic theory so much as to require simpler life styles among the affluent and new policies that stress sustainability rather than growth, he says.

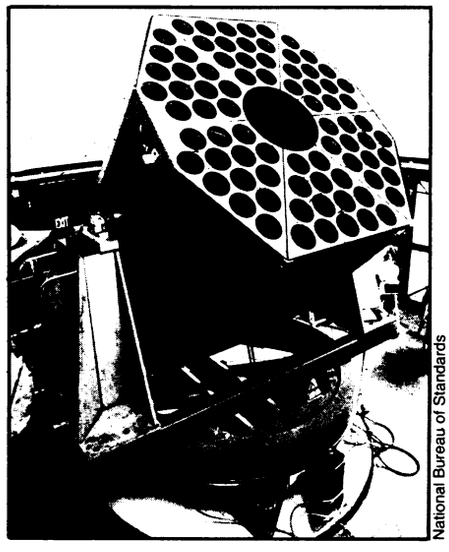
One way nations have maintained "reasonable" unemployment rates with growing populations is by sustaining a growing economy, Brown writes. But as economic growth slows globally — and signs already indicate this is beginning, he says — the unemployment situation will loom more persistently. Coping with a permanently low- or no-growth economy will be a challenge, he predicts; society will have to change radically.

He foresees resource-conserving, labor-intensive societies that require resource recycling and energy conservation. Population planning will have to accompany economic planning, he thinks. And developing countries must detach themselves as much as possible from the economic state of developed countries, he says. Those developing countries may be able to maintain their economic growth — beyond the period or throughout the period that developed countries do — if they look to sharing resources and technologies among themselves, he says.

To tackle the difficult transition ahead, Brown says, economists must learn now to factor the state of biological systems into their forecasts and policies as they now factor in energy considerations. □

Seeing the sky through a fly's eye

People tend to think of a telescope as something to look through. Publicity drawings of even the largest and latest of astronomical telescopes tend to show a human figure bent over an eyepiece. Yet there is little or no actual looking through telescopes nowadays — except possibly for the hell of it. Pointing of modern telescopes is done by computer and the actual observing is done by various photomultipliers or solid-state photoregistration devices.



National Bureau of Standards

An eye at the eyepiece is even more superfluous when what the telescope seeks is a laser beam reflected from the moon. Better a device that can tell precisely where that came from. Also superfluous is the rather large field of view of the usual astronomical telescope. The Apollo 11 astronauts left the retroreflectors that receive the laser beams sent from earth and bounce them back in well-determined locations. What was desirable was a telescope that gathered a lot of light from a small and, by astronomical standards, extremely well-determined area. These considerations led James E. Faller, a physicist with the Joint Institute for Laboratory Astrophysics in Boulder, Colo., an organization jointly operated by the National Bureau of Standards and the University of Colorado, to design what is called for obvious reasons the fly's eye telescope.

Instead of the single fairly large aperture of the usual astronomical telescope, Faller combined 80 small ones, each 19 centimeters in diameter. Because of the small size of the apertures he could use lenses instead of the mirrors customary in ordinary telescopes. The 80 apertures all look at the same narrow area, and the light received by all of them is combined by further optical arrangements inside the instrument. The result is a fairly large total aperture or light-gathering capacity concentrated on a narrow area of the target. The instrument looks ungainly, but is compact, light and portable. In fact, the fly's eye was driven to San Francisco, shipped to Honolulu, transferred by barge to the island of Maui and trucked to an observatory on the 3,000-meter summit of Mt. Haleakala.

The Maui station collaborates in the lunar ranging program with another receiving station at the McDonald Observatory of the University of Texas. Maui was chosen after much discussion because it is on a different geotectonic plate — Hawaii is on the Pacific plate; Texas is on the North American — and it might be possible to detect the difference in plate motion between the two. In addition to the lunar ranging program, the fly's eye can also be useful in stellar spectroscopy, photometry and point-source astronomy. □

Commoner attack on Big Mac, et al

Is nothing sacred? Hamburgers may cause cancer, according to a report at the meeting of the American Society for Microbiology in Las Vegas. Barry Commoner and colleagues at Washington University in St. Louis have found that extracts from beef broth and pan-fried ground beef produce genetic changes in bacteria in the standard Ames test. Mutation-causing agents have been previously identified in meat that was charcoal broiled or cooked directly in a flame. But this is the first example of mutagens formed at ordinary (U.S.) cooking temperatures, researcher David Kreibel told SCIENCE NEWS.

"The cooking condition is essential to effect," Kreibel says. Mutagens are generally rated by the number of revertants, erally rated by the number of revertants, bacterial colonies on a laboratory plate that exhibit a specific genetic change. The beef substances, like many mutagens, had to be activated by enzymes from mammalian liver.

Beef stock cooked down to a paste gives 5,000 revertants per microgram, more than five times the potency of nitrosamine (900 revertants per microgram). A quarter of a well-done hamburger cooked in an electric hamburger maker gives 1,000 to 3,000 revertants, about 100 times the background level. A rare-cooked hamburger, however, shows only 10 percent as much mutagenic activity. No activity was found in hamburger broiled in an oven or cooked in a microwave oven.

The explanation for the various degrees of potency is totally a function of cooking temperature, Kreibel proposes. There is good heat transfer if a hamburger is placed