



Economic growth versus human survival

Progress could take man exponentially over the edge of the abyss, say MIT researchers

The rich get richer and the poor get poorer. The rich get richer and the poor get children.

—Folk Wisdom

A headline in the March 7 Washington Post states, "Plant Investment Rise Brightens '72 Outlook." The article says U.S. businessmen are projecting a 10.2 percent increase in plant investment this year instead of the 9.1 percent previously forecast. "Because plant and equipment spending generally provides a strong stimulus for the economy—spurring demands for money, material and manpower—the gain . . . could supply the impetus needed for a strong economic recovery," says the article.

A mild young Massachusetts Institute of Technology scholar with a Ph.D. in management, Dennis L. Meadows, and a team of systems dynamics specialists he heads (including his wife) were in Washington last week doing their best to convince the scientific, political and business communities that the conventional economic wisdom of the kind expressed in that article may be dangerous and arrant nonsense. The MIT work was sponsored by a distinguished international group of scientists and businessmen, many of whom had already reached roughly the same conclusions on their own before they commissioned the MIT study. They are convinced that further industrial growth, alone, will result in mankind's overshooting the resource limits of a finite world and ending in ecological or sociological collapse. When they add current trends in population growth to the

equation, the collapse comes even sooner.

Meadows and the 16-member MIT team last week released its computer-simulation-based book, *The Limits to Growth* (Universe Books, 381 Park Ave., N.Y.C. 10016, \$2.75), at a day-long symposium sponsored by the Smithsonian Institution, Potomac Associates of Washington, the Woodrow Wilson International Center for Scholars and the Club of Rome. The Club of Rome is the original sponsor of the work, a group of 70 scientists and businessmen founded in 1968 by Aurelio Peccei, vice chairman of the Olivetti Co., vice president of the Fiat Co. and chairman of Italconsult, economic and engineering consultants.

The new study rests on two basic assumptions. The first is that exponential

This introductory look at the MIT/Club of Rome study on the limits of growth will be followed by a more detailed examination in a later issue of SCIENCE NEWS.

growth in a finite system must inevitably overshoot the limits of available resources; for instance, a 10.2 percent increase annually in plant investment will result in a doubling of plant capacity in about seven years, and at some point the resources available for another massive doubling will not exist.

The second theorem is the one expressed by Barry Commoner, that "everything is connected to everything else." Five major related entities are

now undergoing exponential growth: industrialization, population, pollution, food production and resource depletion. In the language of servomechanics used by the MIT researchers, each of these entities is connected to the others through negative or positive "feedback loops." An increase in industrialization inevitably causes an increase in pollution and resource depletion. Increases in population cause increased demands for food and for the products of industry. With the large amounts of capital needed for developing new arable land, as well as for combating the pollution from increasing industrialization, a point is reached where there is not enough capital—or resources—to meet the needs of a growing population. At the same time, other feedback loops exacerbate this "problematic" (as the Club of Rome calls it). The rich do indeed get richer and the poor do indeed get children; as larger and larger numbers of people do without necessary food, their birth rate will go up. And the rich do indeed get richer and the poor do indeed get poorer; as developed nations need more and more resources from lesser developed nations, the gap between the two will grow until a sociological catastrophe such as a world war occurs (although the MIT team dealt with the material limits and only speculated about sociological trends).

Their graph titled "World Model Standard Run" shows what the researchers say *could* happen if present trends continue. As the study explains, "Food, industrial output, and population grow exponentially until the rap-

idly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate [symbolized in the graph by the letter 'D'] due to decreased food and medical services [as well as pollution]." Likely, say the researchers, it would not happen this way; instead, some less predictable event, such as world war, would intervene sooner. The graph illustrates the *best* possible outcome of unchecked current trends.

Their graph "Stabilized World Model II," represents one possible rationally planned alternative. It is not the ideal one, according to the researchers, but the one they believe most closely approaches what could realistically be accomplished given inevitable constraints. The model is of a world approaching a "steady state" or "equilibrium" condition, where an average family size of two children is achieved by 1975, where death rate (D) and birth rate (B) are thus approximately equal and where capital investment in new equipment is likewise approximately equal to depreciation of old equipment. Nearly all economic growth in this model is in services (S) rather than in goods. Resources are declining, but at a slow enough rate so that technological innovations such as recycling, substitutions and longer-lasting and more easily repaired machinery can cope with depletion.

The widespread belief that purely technological solutions will be found was expressed at last week's symposium by Philip G. Abelson, editor of the journal *SCIENCE*. Abelson was particularly optimistic about the potential for new sources of energy, such as fusion power, to create vast new technological alternatives. The MIT authors point out, however, that entropy, not just in the production of energy but in its use, as well, could knock such optimistic views into a cocked hat. Already, say the authors, man-caused heat losses in the Los Angeles Basin are 5 percent of absorbed solar radiation; they project that the figure will go to 18 percent in the year 2000.

But the authors themselves agree with some of the criticisms of their work. Their resource projections, they concede, are based on an extremely high degree of aggregation of many variables. The projections of the effects of pollution on human morbidity and mortality are virtually without an empirical base because the data are not available. And the book itself is sometimes grossly oversimplified for a popular audience; in the graphs shown with this article, for instance, relative quantities are not expressed—sometimes because they

would complicate beyond easy comprehension but sometimes because figures do not exist. The authors insist, however, that they are fully aware of these flaws and that they still stand firmly by their basic conclusions.

The largest objections are bound to be ideological ones. A clear implication of the study is that equality of distribution must be achieved between individuals within nations as well as between nations (with an equilibrium worldwide per capita income of about \$1,800 annually). "... Let [the equilibrium condition, if it must be] be an equilibrium in which equality has not forced the destruction of freedom and liberty," cautioned Health, Education and Welfare Secretary Elliot L. Richardson at the symposium.

And, added Edward P. Morgan, ABC radio commentator, "I suspect that the reaction to this book is going to be sharp from the reactionaries . . . who are so wedded to a life style the Chamber of Commerce has made sacred." □

NAL accelerator makes first 200-GeV beam

After years of preparatory work and design studies and some stiff political fighting over the site, ground was broken for the National Accelerator Laboratory near Batavia, Ill., on Dec. 1, 1968. Last week, on March 1, a beam of protons at the design energy, 200 billion electron-volts (GeV), was run through the accelerator for the first time.

The first test beam to pass through the accelerator was on June 30, 1971. At the time the laboratory management hoped to tune it up to the design energy by some time later that summer, but they were suddenly faced with a massive problem regarding the machine's large magnets. Difficulties in the electrical insulation in the magnets (thought by some to be due to moisture) caused short circuits. The process of identifying the faulty magnets, removing them from the accelerator ring and reconditioning them severely slowed the tune-up program, but the achievement of a beam at design energy still comes before the date envisioned in the original planning, summer 1972.

In the international accelerator sweepstakes—if there is still such a race after the beating that fundamental physics budgets have taken in the last few years—the energy leadership now returns to the United States after several years' sojourn in the Soviet Union. Actually Batavia took the lead three weeks before March 1, when a 100-GeV beam was run. This surpassed the 76-GeV energy of the synchrotron at Serpukhov in Russia, previously the world's most energetic. To

celebrate, the Batavia staff opened a bottle of vodka that Soviet visitors had left them for the occasion.

The Batavia management is aiming at still higher energies. During construction a way was found to get a 500-GeV beam from the accelerator. It involves work on the power supply, and this will be undertaken after the water cooling system for the magnets is brought into operation.

At present, the magnets are air-cooled, and this limits the accelerator's pulse rate. The 200-GeV beam was run at one pulse per second to allow the magnets to cool. As soon as the water-cooling system has been tested, the Batavia management intends to extract a beam and run it into a 30-inch bubble chamber for a series of exploratory exposures to show what it does there.

Meanwhile, one experiment is already running and has been since the energy reached 100-GeV. It is a proton-scattering experiment, in which the accelerator beam is run against a target of plastic material made from melted-down Baggies and placed inside the accelerator. No one in the world yet knows what happens when 100-GeV protons strike other protons in an accelerator, but in a few months, if all goes well, the group from the University of Rochester, Rockefeller University and NAL that is doing the experiment will have the answer. □

NHLI's calf has a nuclear heartbeat



NIH

NHLI heart (left) and nuclear engine.

When a human heart becomes diseased or wears out, it must be repaired or replaced or death results. Heart transplants provide one way of replacing a defective heart, but the process is extremely costly and the new heart may be rejected by the body.

An alternative is an artificial heart. Last week the National Heart and Lung Institute announced that a team of researchers led by Lowell T. Harrison, head of the Medical Devices Applications Branch has developed a total heart-replacement system and a small nuclear engine to drive it.