increase the amount of feed available from each acre of land. For example, ammonia may be added to silage where it reacts with organic acids in the material to form stable salts. These salts, in turn, can be transformed to useful protein in a cow's stomach through the fermenting action of microorganisms present there. The process would mean that whole corn stalks could be used to produce animal feed.

As the rest of the world struggles to increase food production, American research will gain in importance, notes Marion Clawson, a committee member. "Basic science is universal, technology is not," so the United States should begin emphasizing this aspect of its achievements, exporting the knowledge and techniques of basic agricultural science, rather than food or advanced farm technology. This will require a new national commitment, says Wittwer, who called for a "Manhattan Project" to improve plant efficiency.

Concludes the report: "There is an urgent need for agricultural research to receive increasing emphasis and much greater support. The future well-being of mankind could be at stake." □

Human cancer viruses: Search is still on

Three scientists at the National Cancer Institute announced last week that they have isolated a virus from the blood of a woman dying with a rare form of cancer of the white blood cells. This evidence strengthens the posture that viruses with cores of RNA as their genetic material cause some kinds of human cancers. Whether it is the strongest evidence so far that an RNA virus causes human cancer, however, is open to some conjecture.

The scientists are Robert Gallo, Robert E. Gallagher and S. Zaki Salahuddin. Their findings will appear in a forthcoming issue of SCIENCE.

The NCI scientists took blood from a woman dying with acute myelogenous leukemia, a rare form of cancer of the white blood cells. They mixed this blood with fluid from human embryo cells grown in the laboratory. The fluid contained a factor that was needed for the leukemia cells to grow. Five weeks later, a C-type RNA virus appeared in the culture. The scientists took more of the patient's blood and repeated the experiment twice. Each time again the cultured blood gave rise to a C-type RNA virus. Biochemical and immunological tests showed that the virus was similar to viruses that cause myelogenous leukemia in apes.

Scientists who are closely following the research of Gallo and his colleagues are enthusiastic, yet cautious. After all, a hunt for a human cancer virus has been on for years now. Says Raymond Gilden of Flow Laboratories in Rockville, Md.: "It sounds reasonably good, but I think it will require some time, really, to work out how significant it really is." Robert Huebner, a noted cancer virologist at the NCI, agrees. He, Gilden and George Todaro of the NCI have received some of the material from Gallo and his co-workers. They are now applying various techniques to confirm what Gallo and his colleagues have found.

Thus it is premature to say whether the virus Gallo and his team have found is the strongest candidate yet for a human RNA cancer virus. Certainly some others are also in the running. For instance, Elizabeth Priori of the M.D. Anderson Hospital in Houston discovered a putative human RNA cancer virus three-and-a-half years ago (SN: 9/18/71, p. 185). Although scientists at the NCI are fairly sure that Priori's virus is a mouse virus that made its way into human cancer tissue in the laboratory, recent studies by Robert Eckner of Roswell Park Memorial Institute in Buffalo suggest that it is not. Priori candidly admits, however, that the one scientist in the country who she thinks "has found a virus closest to a human cancer virus" is Elwin Frayley of the University of Minnesota.

And indeed, the virus that Frayley has found is provocative. First he found particles of an RNA virus in cancerous human bladder tissue. He took fluid from these tissues and passed it through a filter so that nothing larger than a virus could slip through with the fluid. He placed the fluid in the presence of other human cells. The fluid made the cells cancerous, suggesting that the fluid indeed contained a cancer-causing virus. But what is even more interesting, in Frayley's opinion, and what has never been shown before, "is that when these cells were transformed, they expressed an antigen, which was then recognized by the serum and lymphocytes of patients with bladder tumors." Other putative human RNA cancer viruses remain to be linked back immunologically to the cancers they are supposed to cause.

Two challenges, essentially, face scientists looking for human RNA cancer viruses: deciding exactly what such viruses should be compared with animal RNA cancer viruses, and proving that such viruses truly cause human cancer. Although Frayley's findings are perhaps the strongest to date that a RNA virus causes human cancer, he believes that "there is a long, difficult haul ahead before we have any idea of whether there is a human RNA cancer virus." □

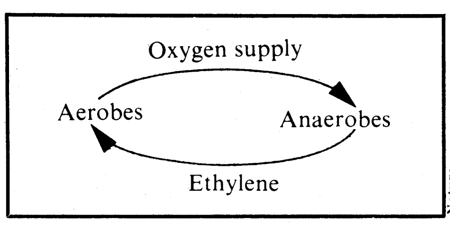
A new soil cycle: A basic link

The beginning of agriculture about 10,000 years ago signaled the beginning of human culture. Nomads became city builders, and architecture and science began to develop. Agriculture, unfortunately, also brought the depletion and sometimes destruction of the soil and an increase in root diseases. Advances have been made in restoring depleted soils and controlling root diseases, but the underlying causes of the problems are not completely known.

A basic discovery about the natural balance of soil microbes now promises to explain the link between cultivation and soil depletion and may lead to less damaging agricultural practices. A. M. Smith of the Biological and Chemical Research Institute in Rydalmere, Australia, and R. James Cook of the USDA's Agricultural Research Service in Pullman, Wash., report the discovery in the Dec. 20/27 NATURE. They describe a new soil cycle involving ethylene (C_2H_4), oxygen, aerobic soil microbes (those that use oxygen for respiration) and anaerobic soil microbes (those that do not use oxygen for respiration).

It was observed three years ago that the "seeds" of some fungi fail to germinate under apparently favorable soil conditions. Smith reported in late 1973 that the production of the volatile gas ethylene by soil microbes was responsible for the inhibition. The current paper goes on to explain the conditions under which ethylene is produced and its relationship to aerobes and anaerobes.

The main producers of ethylene in soil are spore-forming anaerobic bacteria, probably members of the genus *Clostridium*. These live in small pockets devoid of oxygen. The pockets are formed near bits of organic material after aerobic microbes have consumed some of the matter and the available oxygen. As the anaerobes proliferate, they produce ethylene which diffuses through the soil and stops the growth of the aerobes, including fungi, bacteria, actinomycetes and nematodes. But the mechanism is cyclical and self-regulatory. Air eventually seeps back into the pockets of anaerobic activity, shutting it off. Ethylene levels decrease



Cycle prevents microbial imbalances.

and the aerobes resume their activity. The aerobes consume the organic matter, use up the oxygen and turn the anaerobes on again, in a continous cycle. Cook says he is not surprised to find an ethylene cycle effecting plant growth, since ethylene regulates many plant processes, including flowering, fruit ripening and the development of some roots.

The cycle is in balance in undisturbed ecosystems such as grassland and forest soils. There, plant nutrients and organic matter are slowly recycled, root diseases are rare and nitrate fertilizers don't accumulate. But in bare, cultivated soil, the cycle is disturbed, and this seems to explain the link between agriculture and soil depletion. Nitrate fertilizer poisons ethylene production, Cook told SCIENCE NEWS, and tilling augments the effects of nitrate on ethylene and destroys the deoxygenated pockets. Organic matter is therefore broken down more quickly, more nitrogen is released to the atmosphere rather than retained in the soil and the aerobic organisms can proliferate and attack plant roots in greater numbers.

The team is excited by the research, Cook says. It bolsters arguments against the use of nitrate fertilizer (as opposed to ammonium or urea) and full tillage of fields, positions which have been gaining momentum in recent years. It may also lead to the selection of seeds that can be planted in bare, untilled soil and crops that are resistant to the higher ethylene levels in such soil. Ethylene would then act as a natural deterrent to root diseases, and alleviate the need for some chemical agents.

"This research puts the field of microbiology a giant step forward and into the limelight," Cook says, "and may begin to answer a lot of our basic questions about soils and agriculture." □

Relativity for computers: All arithmetic

Three hundred years ago Isaac Newton discovered that to solve the problems of universal gravitation he had set himself he had to invent the branch of mathematics called calculus. Eighty years ago, in formulating special relativity, Einstein caused a revolution in physics by making mass a variable and uniting space and time, but his equations, though changing the content of Newton's, followed Newton's calculus lead. Calculus, in fact dominates classical and most modern physics. For three centuries it has been the physicist's best mathematical friend.

But now the world has digital computers. Digital computers can do calculations with incredible speed. They have prodigious memories. People want to use them wherever a lot of computation must be done in a short time. But computers are not as smart as Newton, let alone Einstein, or even a college freshman. They can't do calculus. They can only do arithmetic, but they do it very fast.

So a group at the Computer Sciences Department of the University of Wisconsin at Madison under the direction of Donald Greenspan is working out a reformulation of Newton's and Einstein's work, not conceptually, but mathematically, trying to get it on an arithmetic basis so a computer can handle it. They have been successful with Newtonian classical mechanics and fluid dynamics. Greenspan's latest paper (UW's Computer Sciences Technical Report #232) details the first part of a method for special relativity. Later they hope to go to general relativity.

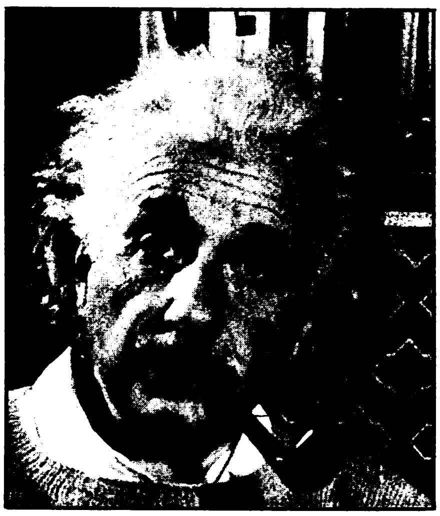
The sticking points in calculus are the concepts of limit and continuity. Limit is a way of getting around Zeno's paradox, which so bedeviled ancient Greek mathematicians, and showing that an infinite succession of infinitely small steps can in fact lead up to but never surpass a limit that is nevertheless a finite number. Continuity is a property of the sort of equations called functions. A function sets up a relation between an (independent) variable quantity or quantities and another (dependent) variable, so that, knowing the value of the independent variable, one can calculate the dependent one. A function is continuous at a point if an infinitesimal change in the independent variable yields a new finite value for the dependent variable that is only infinitesimally different from the previous one. These two concepts are the keys to the development of integral and differential calculus, and when they had been evolved, 18th-, 19th- and 20th-century physics and engineering were on their way.

What the Wisconsin group has achieved is a way of replacing the infinitesimal steps with finite ones—finite-difference equations— that nevertheless come out to the same thing, in the limit, as the continuous processes of calculus. And it works in practice. "What we do runs," says Greenspan. "Everything we do must go on the computer. Doing it in theory is not enough."

Greenspan says the method should be of wide use to physicists and engineers with all kinds of mechanical, fluid dynamical and special relativistic computations to do. But it is much more than that.

As they were working through the method, the group found, in Greenspan's words, that they were doing physics arithmetically. The conservation laws that define and characterize Newtonian and Einsteinian physics come out of the arithmetic procedure. It is thus not merely a crutch for the computer but an alternate way of deriving and justifying the physically meaningful mathematical statements that have traditionally been gotten by calculus methods. And that could work an important change in high-school curricula.

Calculus—for reasons considered good and sufficient by mathematics teacher—has traditionally been reserved for the first or even second year of college. High-school physics teaching has suffered from the lack. Much of its content had to be brought in on faith or justified by handwaving methods. The new formulation could provide a way of making high-school physics more interesting by deriving its contents in a satisfactory way that the pupils could follow. Greenspan is enthusiastic about the idea of a change, but also extremely realistic. "You have 300 years of vested interest in calculus to overcome," he says. □



If Newton looks disapproving and Einstein surprised, it may be because the calculus is being calculated out of their theoretical derivations.