reached the surface about 100 million years before that. Most significant for the study of the moon, however, is the fact that both rocks may have come from as little as six feet below the original surface of Mare Tranquilitatis, which could mean that unaltered relics of the moon's earliest days are within easy reach of astronauts equipped with simple digging tools.

Many scientists have hoped to find the moon in a well-preserved state, at least in part because it would reveal much about the evolution of earth if the two bodies turn out to be related. Most of them, however, have regretfully predicted that it would turn out to be well mixed and differentiated, with all of earth's decoding problems.

Crater counts and other evidence have caused some researchers, such as Dr. Eugene Shoemaker of California Institute of Technology, to believe that the lunar maria may be as little as 500 million years old. The new evidence, Dr. Schaeffer suggests, may force researchers to consider the possibility that the rate of meteor impacts on the moon—heretofore the most common method of dating parts of the lunar surface—may not have been uniform.

Instead, meteor bombardment may have been heavier during the early days of the solar system. If the rate did indeed drop off sharply, perhaps several billion years ago, the maria could date all the way back to the drop-off point and still appear relatively young by a crater-count standard.

If the moon's ancient self is actually within a few feet of the surface, upcoming Apollo missions, possibly as early as Apollo 13 next March, could be particularly interesting. Apollo 13 is tentatively scheduled to bring back the first samples from the lunar highlands, which many scientists including Drs. Schaeffer and Shoemaker feel are older than the maria.

It is within the realm of possibility, therefore, that an Apollo mission could present scientists with an incredibly exciting prize: rocks almost as old as the moon itself, perhaps still bearing traces of the throes of its formation.

Another possibility suggested by the ancient rocks is that the moon is even drier than the arid wasteland it had been supposed to be. This, according to Dr. John O'Keefe of the National Aeronautics and Space Administration's Goddard Space Flight Center in Greenbelt, Md., is likely if the basaltic glass found in the samples (SN: 8/2, p. 95), which apparently still retains its glassy structure, is also billions of years old.

On earth, says Dr. O'Keefe, such glass would long since have reverted to the crystalline structure from which it was formed. The fact that the lunar glass stayed glassy, he believes, means either that the moon is radically different from the earth or that the rocks contain very little water trapped within their molecular structure.

The latter conclusion could in turn add weight to the theory that the moon was originally spun off from the earth, Dr. O'Keefe says. Such a process—one of the main ideas competing for advocates as the origin of the moon—would create a great deal of heat, which would drive off most volatile materials, including water.

The critical factor in such informed guesswork, of course, is that the dating of the apparently ancient rocks holds up under close scientific scrutiny. The best check, Dr. Schaeffer says, is rubidium-strontium dating, which involves the ratio of rubidium 87 to its decay product, strontium 87. This is the most common form of dating for extremely old earth rocks, and will be tried on lunar samples, once they leave the LRL in mid-September, by Dr. Gerald J. Wasserburg of California Institute of Technology.

CANCER THERAPY

Titillating but inconclusive

Not long ago, leukemia killed within months. Now, with the judicious use of a combination of anticancer drugs, sometimes coupled with radiation treatments to destroy leukemia cells, physicians induce remissions of the disease, giving patients a temporary stay from death (SN: 12/21, p. 626). At the hands of a skilled physician, abreast of the newest gains in cancer research, a leukemia patient can now hope to live for three to five years. But the stay is still only temporary. Researchers continue to fight for total victory.

Perhaps the most promising new line of attack is an immunological approach to cancer, based on the fact that the disease is inevitably associated with a weakening of the body's protective immune system (SN: 5/10, p. 457). For some unknown reason, the immune system fails to recognize and fight the wildly proliferating cancer cells that will ultimately destroy the body. Or, in any case, it fails to marshall a sufficiently strong army of lymphocytes to destroy these abnormal cells completely. In view of this, investigators seek ways of enhancing immune activity.

One new approach to the therapy that has growing support limits the use of known anticancer drugs. It reduces doses to the lowest acceptable level because these agents, while killing cancer cells, also suppress the immune system. And that takes away what natural defense a patient may have.

A second approach is to stimulate a sluggish immune system by introducing foreign cells, in the hope of inducing a rejection process like that which occurs when the heart or liver of one man is transplated to another.

Russian scientists, reporting in the Aug. 2 NATURE, declare they have achieved success with this second approach by injecting the leukemic cells of one patient into another victim. Foreign cells are used because an individual's own leukemia cells stimulate no strong immune response.

Leukemia cells from another person, the Russians say, do the job as any antigen does. Dr. S. V. Skurkovich of the Central Institute of Hematology and Blood Transfusion in Moscow, with Drs. N. S. Kisljak, L. A. Machonova and S. A. Begunenko of the Second Moscow Medical Institute, experimentally treated 12 children, separated into six pairs, with marked success.

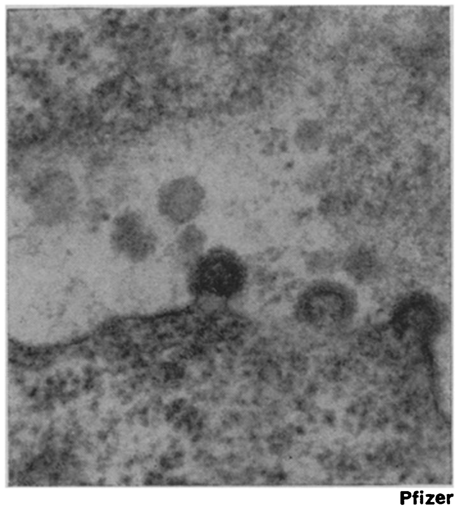
Aged 3 to 10 years, the children had various forms of leukemia. In each pair, live leukemia cells from one child were used to immunize the other and vice versa. The Russians report that after receiving injections of these foreign leukemic cells the patients' immune systems responded.

In 8 of the 12 patients, the number of leukemic cells in the blood decreased by two to three times within a week, continuing to drop more gradually thereafter until the total percent of leukemic cells in the body was reduced from initial levels of between 40 and 89 percent to levels of between zero and 10 percent.

U.S. scientists are skeptical; they find the article lacks convincing data.

"I can understand what they say they did," observes a West Coast immunologist, "but they have not proved to me that they got remissions by using live leukemic cells. Their patients had also been taking drugs that quite routinely induce remissions."

Other observers in the United States



Pfizer

Leukemia viruses emerge from cell.

call the Russian paper "titillating" and "fascinating," while also pointing out that it is unconvincing without further details.

Dr. James T. Grace, director of the Roswell Park Memorial Institute in Buffalo, N.Y., says that similar experiments have been conducted at Roswell and other U.S. institutions. But he cautions, "They were tried on very, very sick children, in only a limited number of cases, and the results are so inconclusive that we really can say nothing yet."

In animal tests, however, transplanting live cancer cells from one leukemic mouse to another has been successful. "Mouse cancers are caused by viruses and we believe the virus itself may be the antigen that stimulates an immune rejection process when it is transplanted from mouse A to mouse B," says Dr. Grace. "Though we do not know that human leukemias are virus-caused, there may be a similar response that we can capitalize on to get an effect. If it works empirically, we do not have to wait until we find a virus or identify the mechanism before we use it."

The possibility of activating a weakened immune system by specifically teaching lymphocytes to reject cancers is also being explored as a route to anti-cancer treatment. At Institut de Cancerologie et d'Immunogenetique in Villejuif, France, Dr. Georges Mathé extracts lymphocytes from leukemia patients, primes them to fight tumors by exposing them to cancer cells in culture, and then gives them back to the patient from whom they came (SN: 8/26, p. 88). Still highly experimental, the procedure shows some promise. ◇

TECHNOLOGICAL AND THEORETICAL

Gaps in high-energy physics

"There are two kinds of physicists," says Dr. H. J. Lipkin of the Weizmann Institute in Rehovoth, Israel, "STU physicists and IBY physicists." The initials stand for mathematical symbols that each group uses in its work.

Physically, the STU people use a dynamic approach; they study what happens when particles collide with one another. The IBY physicists try to predict the properties of elementary particles by mathematically grouping them in categories rather than by watching them collide. Their chief theoretical tool is the quark, a hypothetical sub-particle thought to make up other particles.

"STU physicists and IBY physicists don't talk to each other," says Dr. Lipkin. They work quite independently of each other. The analyses of STU physicists do not need quarks. If the quark people try to calculate dynamic situations using their elusive, theoretical particle, they run into trouble because the dynamic properties of quarks, especially their mass, are not specified in the quark theory. "You can make the dynamical properties be anything you want," says Dr. Lipkin. "You can fit everything and therefore predict nothing."

Physicists now believe a balanced approach, in which the two routes can be combined, is necessary. And Dr. Lipkin feels the particles called exotic resonances may be the key to the combined approach.

Resonances are extremely short-lived particles, and exotic resonances are those that would have combinations of characteristics forbidden by the quark theory.

The experimental STU approach allows exotic resonances, but none has been found. This is a lack which, in fact, is held to support the quark theory.

Dr. Lipkin feels that a higher, more complex symmetry than any now used may unite the two approaches.

The key to the higher symmetry may be the exotic resonances, Dr. Lipkin thinks. If some of them could be found at a higher order of energy and observational refinements than are now used, they might show what sort of higher symmetry is needed. But finding them requires more powerful accelerators and finer experimental techniques than are now available.

The technology gap in physics is not peculiar to exotic resonances. It is especially apparent in work involving interactions that are governed by the so-called weak subatomic force. At the Boulder (Colo.) Conference on High-Energy Physics last week there were many papers dealing with the strong subatomic force, but almost none dealing with the weak.

"I ask whether this is a sign that the weak interaction is not only weak but dying," says Dr. Lincoln Wolfenstein of Carnegie-Mellon Institute. People are rather ashamed to propose new experiments, he suggests, because it takes 10 minutes to write down a description of an experiment which would take five years to do.

The theorists of the weak interaction have worked out a theory that has done quite well as far as it goes. In their theory the action of the weak force is analogous to the already well-known electromagnetic force; electromagnetic theory is successful, says Dr. Wolfenstein, and you can repeat successes.

The theory helps physicists to understand many of the weak force processes they see, but it begins to break down in just those areas of higher order energy mentioned by Dr. Lipkin. The most striking example of this breakdown is in the failure of certain radioactive decays of K mesons to respect the so-called CP symmetry, the principle that nature is evenly balanced between matter and antimatter.

Try as they might to find evidence for breakdown of CP in any other particle event, the physicists have not found any. They now believe, in fact, that the failure in K-meson decay is connected with a very small difference between the masses of two kinds of K mesons.

This mass difference between K mesons is just the sort of thing that would appear at higher orders of energy, and some theorists feel that this particular one is fortuitously large enough to be seen at current energies. If they could find other, smaller higher-order effects, they feel they might be able to explain the CP violation and have a better picture of the nature of the weak interaction.

Here too, says Dr. Wolfenstein, the theory may not be correct but only an approximation. The real theory, supposing higher-order experiments can find it, may be quite different, he says.

Therefore physicists are waiting impatiently for the completion of the next generation of particle accelerators, one of which will be the 200-400-billion-electron volt (GeV) synchrotron now under construction at the National Accelerator Laboratory in Batavia, Ill. The 200-400-GeV machine is not expected to operate before 1972. Meanwhile there is an intermediate-generation machine, 76-GeV, at Serpukhov, U.S.S.R.

Serpukhov already gives bad news for those who would like quarks to be real physical particles instead of merely convenient mathematical counters. The latest quark experiments there, says Dr. Alan D. Krisch of the University of Michigan, who visited Serpukhov earlier in the summer, have set a much lower probability than before that free quarks exist. The probability that they will be produced in particle interactions, customarily measured as a cross-sectional area, is now down to 10^{-39} (one thousand-billion-billion-billion-billionth) of a square centimeter.

In a more hopeful vein, Dr. Krisch reports that Russian physicists at Serpukhov are eager for contact with Western colleagues and are very hospitable to those who visit. An agreement between the U.S. and U.S.S.R. Governments now makes it possible for an American physicist to go to Serpukhov for three or six months and do an experiment. It is not yet possible, says Dr. Krisch, for an American team to go to Serpukhov with its own experimental equipment as some Europeans now do. A new agreement will be necessary for that. ◇