This is probably due, at least in part, to the great speed of scientific development in the past 50 years. In 1900 X-rays and radioactive elements had just been discovered, nuclear physics hardly begun, and the nature and carriers of yellow fever and malaria only recently learned, modern genetics barely started, antibiotics unknown—the list could be expanded for pages. Progress in science almost stuns us, yet it is easy to take for granted. We fail to realize that it comes from deep devotion, hard work, sacrifices, and the popular support of our academic institutions. Wider public understanding of science, scientists, and the implications of scientific development is of vital concern not only to the National Science Foundation, but to the Federal and state governments, academic institutions, and industrial concerns.

"The very rapid progress outlined above has wrought radical changes in, what I shall call, the economics of basic scientific research. Perhaps 50, certainly one hundred, years ago, it was uneconomic to give general support to basic scientific research. The lag between a scientific discovery and its practical application was so great that even a large ultimate value had little present worth. The isolation of scientific discovery caused the lag. Scientific knowledge was not dense. A glance at present-day textbooks, encyclopedias, libraries, and the voluminous digests convinces one of how this has changed. There are and probably will continue to be new isolated discoveries, but for the most part new knowledge is quickly tied to old knowledge, and the inferences from the combination rapidly lead to further expansion of knowledge or new practical applications.

"We ask today: How much can we afford to spend for basic research? The answer is: We cannot spend as much as would be economically advantageous. The bottleneck, I believe, will be lack of men and women who have the capacity, the interest, and the willingness to pursue science. In numbers they constitute a restricted part of the population; and science is not the only profession calling for high intelligence and disciplined capabilities.

"The upshot is that an economic test of basic research is now irrelevant. This does not mean that we should disregard budgetary, fiscal, and short-term administrative problems. It does mean that solutions to many current problems reside in the long-term functions of the National Science Foundation. It is the duty of the National Science Board to make this clear.

"What are the relatively immediate consequences of basic research? First, the development of scientists. These are the people who by training and experience know how to use scientific knowledge, scientific techniques, and scientific instruments. Second, the production of new scientific knowledge, a high proportion of which may prove useful in ways unforeseeable today. Third, the application of the results of research to the solution of practical problems by a body of men who know how to apply scientific methods. An example is what has been called "Operations Analysis", which has for its objective not knowledge, but the best practical decisions. More and more we shall depend upon such talent for both military and industrial operations.

"The National Science Foundation Act of 1950 authorizes and directs the Foundation 'to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences.' Except for certain specified operating functions, the Foundation is essentially an authoritative advisory body, potentially capable of securing factual knowledge and advisory opinion, that makes its advice authentic but not determinative. Whom does it advise? Obviously, the President and the Congress; but also, through publication and consultation, other agencies and institutions, public and private, and individuals. The point to these observations is that the Foundation can neither police nor direct activities of other agencies, of academic institutions, of industrial research, or of individual scientists.

"The Board believes it important to emphasize this view, because there is, on one hand, a natural tendency to utilize the Foundation for secondary purposes and immediate administrative convenience and, on the other, a fear that the interposition of government in science will lead to attempts to dominate science and thus to destroy it. The Board is aware of these dangers. It believes that its major function is to operate so as to minimize both dangers. But we realize that a new era has come when the interest of governments and of societies in the development of science is great and the need exists for large financial support to scientific research and for the development of adequate numbers of scientists."

It should be noted that the President's budget message to Congress, also submitted in January, recommends the appropriation of $14 million for NSF operations during the 1955 fiscal year, which begins next July 1st. Previous NSF appropriations approved by Congress have been $225 000 for 1951, $3.5 million for 1952, $4.74 million for 1953, and $8 million for 1954.

Budget Message

ADDITIONAL BASIC RESEARCH, President Eisenhower told Congress, "is needed to build up the fund of knowledge on which will be based the development of new crops for agriculture, new methods of safeguarding health, new tools for industry, and new weapons. A further important result is the training which basic research projects provide for graduate students in our universities. The number of trained scientists graduating each year falls short of the needs of our growing economy and is still declining. Enlargement of the research program and the related fellowship program will help counteract this trend."

The President, emphasizing the importance of NSF's role in formulating an "adequate scientific research policy for the Nation", added that approximately one-half of the recommended $6 million increase in NSF appropriations "is in reality a transfer of the responsibility and the financing for certain basic research programs from the Department of Defense to the National Science Foundation. The remainder of the increase is needed to expand basic research."

The budget message contains recommendations for Federal expenditures of $2.01 billion on scientific research and development in the 1955 fiscal year, of which \$1.35 billion would be spent by the Defense Department and \$261 million by the Atomic Energy Commission. The total amount requested is \$113 million less than is expected to be spent on research and development during 1954. Two-thirds of the cut is to be borne by the Defense Department with roughly equal reductions in research and development funds for the Army, Navy, and Air Force. The Office of Naval Research, however, is budgeted to receive \$60.6 million—an increase of almost \$5 million over 1954. An increase of \$5 million is also recommended for the actual conduct of research by the Atomic Energy Commission, although the budget calls for a reduction in funds for constructing new research facilities that drops the total for research and development \$11 million below the AEC's 1954 expenditures. A requested appropriation of \$8 million for the basic programs of the National Bureau of Standards, representing an increase of \$2 million over 1954, would bring the NBS budget back to what it was in 1953. The Kelly Committee, it will be recalled, reported that the Bureau's basic programs, in terms of man-years of effort, were then supported at a level about 20% below that required to meet the nation's needs.

Neutrino Hunt

THE TROUBLESOME STATUS of the neutrino was recently summarized by W. F. G. Swann in this way: "the neutrino has never been known to do anything but own energy, and just as it is very difficult to apprehend an ordinary thief who never spends any of his stolen money, so it has been very difficult for science to place its finger upon this neutrino and say: 'Ha, I have caught you in the act,' because the neutrino appears to have no act."

Actually, the neurino should interact very slightly with matter, the reaction neutrino + proton $\rightarrow$ neutron + positron, for example, having a cross section of about 6×10^{-20} barn $(= 6 \times 10^{-44}\ \text{cm}^2 = 6$ "sheds"). This process has been made use of by F. Reines and C. L. Cowan, Jr. of the Los Alamos Scientific Laboratory in an attempt to detect the free neutrino experimentally, with one of the Hanford reactors being the source and a massive ten-cubic-foot scintillation counter the detector. The scintillator solution was loaded with cadmium to enable neutron detection, since the capture of a neutron by a cadmium atom gives rise to a gamma ray. The above reaction would manifest itself by an initial positron count, followed a few microseconds later by a gamma count from a slightly delayed neutron capture. Elaborate shielding and anticoincidence counter arrangements were employed to reduce background, and runs were made with the pile at zero and at full power. A difference in the counting rate of 0.41 ± 0.20 counts per minute was found, compared with a rough prediction of 0.2 counts per minute. The experiment was described in an invited paper at the New York Meeting of the American Physical Society in January and had previously been reported in the May 1 and November 1 issues of *The Physical Review*.

After Ylem, What?

THE TIMETABLE OF EVENTS that occurred during the first moments of the expansion of the universe is discussed in some detail by Ralph A. Alpher, James W. Follin, Jr., and Robert C. Herman, all of the Applied Physics Laboratory, Johns Hopkins, in their article, "Physical Conditions in the Initial Stages of the Expanding Universe", which has appeared in the December 15th *Physical Review*. Going back three billion years, according to the authors, one would find the primordial matter (the "ylem") to be an extremely hot mixture of neutrons and radiation. As the universe expanded and cooled some of the neutrons decayed into protons, and when the temperature of the universe had decreased sufficiently for nuclei to be thermally stable these protons proceeded to capture the remaining neutrons. Since beta decays can convert a nucleus having too many neutrons into one of higher charge, successive neutron captures and beta decays could thus have been responsible for the formation of the various elements. This interpretation, which agrees with the observed abundances of all but the lightest elements, has become known as the neutron-capture theory, with the stipulation that "for the lightest elements the processes of neutron capture and beta decay, while adequate to explain the formation of the heavier elements, must be supplemented by thermonuclear reactions involving protons, deuterons, and other light nuclei". In this model of nucleogenesis the relative concentrations of protons and neutrons as a function of time in the early stages of the universe "plays a most important role in determining the relative abundances of the nuclear species", and evaluating this ratio was the stimulus for the present calculations.

The Alpher-Follin-Herman analysis gave a proton-neutron ratio lying within the range of about 4.5:1 and 6.0:1. Among other phases of the expanding universe the problem of the neutrinos turned out to be important, since neutrinos interact with other particles substantially only at very high temperatures. Although in equilibrium at such high temperatures, the neutrino component becomes "frozen in" at lower temperatures and expands adiabatically from then on independently of the other components of the universe.

While the nonequilibrium neutron-capture theory seems to be leading the field it has no lack of competition. Chief among the latter are the equilibrium theory, which holds that nuclear abundances can be traced to a "frozen equilibrium" among the various nuclei, and the polyneutron and primeval atom hypothesis. George Gamow, an enthusiastic expositor who was one of the initiators of the neutron-capture theory, has examined these and other related topics at some length in his entertaining book *The Creation of the Universe* (The Viking Press, 1952, \$3.75).