THE PRESIDENT'S REPORT

Some highlights from Dr. DuBridge's 1952-53 report on the Institute

IN FUTURE YEARS IT IS almost certain that we will look back on the year 1952-53 as a "turning point" in the history of the nation and of educational institutions. The events following from the 1952 election and the 1953 Korean truce are certain to be of far-reaching importance.

To the extent to which the inflationary spiral is being arrested, there is good news for an institution which has been engaged in the losing race between rising costs and stable or less-rapidly rising income. To the extent to which tax burdens on individuals and on industry will be eventually relieved, there is also good news for private institutions.

The cessation of active hostilities and the re-orientation of the national defense program are certain to have important effects which cannot be fully anticipated. Will a large number of Korean veterans seek college admission? Will draft calls on college students be reduced or increased? Will ROTC programs and quotas be reduced? Will defense research funds be tapered off?

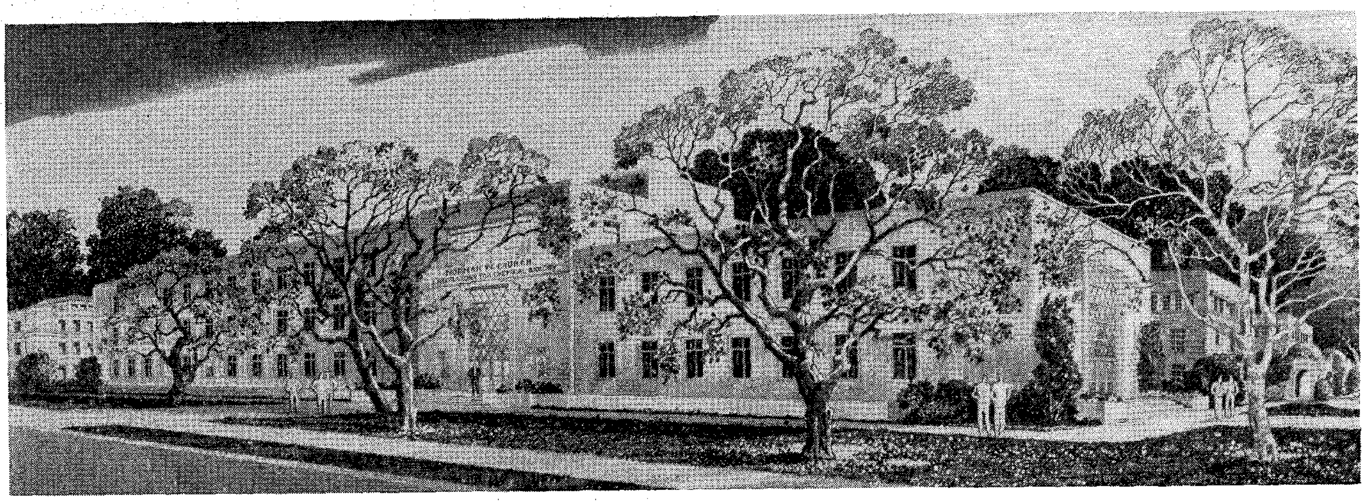
Of these questions, the one relating to federal research funds is the one to which our operations will be most sensitive. Everyone realizes that a military research program which is undertaken while hostilities are actually in progress is bound to be somewhat "wasteful" of effort and funds. When human lives are at stake one will always spend money to speed up progress by examining all lines of development in parallel, by undertaking duplicating or overlapping enterprises in case one should fail or encounter unforeseen difficulties. Even "crazy" ideas will be explored without extended preliminary planning or examination, because lives might be saved if the "crazy" ideas do pay off.

When hostilities cease it is proper that the nation's military research and development program be re-examined; it is proper that it should be reduced. But there is serious danger that the reduction may be "upside down." The reduction should be achieved by eliminating the "crazy" ideas (pending more careful exploration and research); by cutting out duplicating and overlapping projects; and by adopting a more thoughtful and more leisurely pace in development programs and in the building of prototypes.

But *basic research*—the search for new knowledge—should be expanded rather than contracted. As "crash programs" for production of new military equipment are reduced, more scientists are freed for basic research —in universities and in industry. If during hostilities it is true that the short-range and immediately practical projects, which are the expensive ones, must take priority, it is equally true that when hostilities cease (but cold war continues), the more basic long-range research projects—the search for knowledge for *future* use—should be restored and expanded.

It is not yet clear whether this policy is to be followed by the Government. Budget reductions which are uniform and "across the board" are easier to impose than selective ones. Not many people are aware of the importance of basic research—hence not so many voices are raised in its defense. The ill-considered slashing of a relatively small number of dollars could deal a crippling blow to the nation's scientific strength which the federal government has gone to great pains to foster and build up in recent years.

There are hopeful signs, however, that intelligence will be applied to this problem. The new reorganization of the Department of Defense creates a mechanism for more effective management of defense research and development. The slowly increasing support being given to the National Science Foundation is also encouraging.



The Norman W. Church Laboratory for Chemical Biology. Construction should be under way early in 1954.

The Campus

It has been clear for the past two years that our campus program was being stabilized and that current income to finance it could—with effort—be secured. It has been less evident that funds could be found to complete the building of the Caltech campus. Urgently needed campus structures, such as a library, engineering buildings, dormitories, infirmary, and student union, have been dreams for many years and seem destined to remain dreams. Capital funds have not appeared for these purposes.

The past year, however, saw two of our long-cherished dreams approach reality. We will soon have a new athletic center (*E&S*—October 1953) and a new chemical-biology laboratory (*E&S*—February 1953).

The fulfillment of these two dreams should only stimulate us to further efforts toward fulfilling three other terribly urgent ones—a library, a major engineering building, and a graduate dormitory. Preliminary studies for each of these are under way. Indeed a whole new study of the development of the campus is now being carried out by Pereira and Luckman, our consulting architects, so that these and other facilities can be developed in the most efficient and attractive way to make best use of our precious supply of campus space. Fortunately there is just enough such space left to build the essential facilities. There is *not* enough space in sight to take care of the problem of parking 1200 automobiles!

Finances

The report of the Comptroller shows that the Institute expended for its campus program during the past year $5,821,395 and that the income available for this program was less than this by $138,068. In other words our surplus funds had to be reduced by this latter amount—which is about the same as the amount by which they were *increased* as a result of the previous year's operations.

The precise estimate of either income or expenditures a year in advance (when the budget is adopted) is always difficult. The income usually exceeds the original estimate, while the expenditures are less (for no one *exceeds* his budget). The result is that a budgeted "deficit" has frequently turned into a "surplus," or as is the case this year, into a much smaller "deficit" than was expected.

The past five years have seen a most remarkable improvement and expansion in our program and a substantial improvement in faculty salary scales. Our income has risen to meet the new demands—but it has been a close race.

This has been a near-record year as far as increase in the Institute's *total assets* is concerned. The net increase from all sources was $5,200,000. Most of this came from the final settlement of the Balch estate—an estate which had been held in trust and managed for the eventual benefit of the Institute and other beneficiaries for a number of years. Investment transactions during the year added $875,035 to the book value of the portfolio.

The endowment funds of the Institute have now reached the impressive total of $28,843,385, placing it among the top 17 private institutions of the country. However, endowment figures by themselves can be misleading. Many a state university receives annual appropriations which would equal the income on one or two *billion* dollars of endowment. Also an institution with 10,000 students, each paying $600 tuition, receives income equivalent to that on an endowment of $120,000,000. Caltech receives no state appropriations and has only 1,000 students. Our endowment income is about $1,700,000, but we are operating a five-million-dollar-a-year program (excluding off-campus organized research). The endowment provides only three-tenths of the income we use. Student fees provide only one-tenth. The rest (six-tenths) must come from annual gifts, grants and contracts. Clearly the stability of our operations would be more adequately insured if the endowment income were a substantially larger fraction of the total. *Endowment is the assurance of independence.* Our efforts to increase endowment can never cease.

Recent years have seen a satisfying increase in annual support from industry. The Industrial Associates, as a group, now provide an annual income of more than a quarter million dollars. In addition many important research projects and many scholarships and fellowship programs receive industrial support. Industry's debt to educational institutions is now being more and more recognized.

Caltech's appeal to industry has for many years been a very direct one: the new knowledge arising from scientific research is essential to technological progress. The long list of important companies which have helped develop our program is testimony to how well this fact is now recognized.

Faculty

The faculty of the California Institute now comprises 334 members, one for every three students. Almost exactly one-half of these hold the conventional academic titles: professor, associate professor, assistant professor, or instructor. One hundred and thirty hold titles of research associate, senior research fellow, or research fellow. The remainder are professors emeriti, visiting professors, lecturers, etc.

The many honors and awards received by members of the faculty this year bear witness again to the fact that this group of men is one of the most distinguished bodies of scientists, engineers and scholars to be found in the country. It is fitting, however, to emphasize that, though these men are active and distinguished in the field of scholarship, they are also vitally concerned and heavily involved in the teaching activities of the Institute. They not only spend long hours in classroom, laboratory, and in preparation but they also give a large amount of time to student counseling; to the study and improvement of the curriculum; to advising and assisting with student activities and to contributing in many other ways to the operation, advancement and development of our educational program. The results obtained in the research laboratory may more often make newspaper headlines but the vital work of the California Institute goes forward in the classroom, the student laboratory and the conference room.

Undergraduates

The student body in September 1953 was of almost exactly the same size as in 1952 and 1951. The policy of accepting only 180 freshmen each year naturally stabilizes the undergraduate body at approximately 600 students. Our graduate body is not limited in quite the same way but the standards imposed for admission keep the numbers fairly constant at slightly over 400. There is no reason to expect or to desire any change in this situation.

The number of applicants for freshman admission has increased sharply in recent years and in the spring of 1953 reached a high point (755), second only to the veteran flood of 1946 (861). These applicants also were of generally high quality, as demonstrated by scores on College Entrance Board examinations. Because they stood high they were also sought by other colleges and we received a larger than normal number of "regrets" from those who had been admitted and had decided to enroll elsewhere.

While it appears that a freshman class of 180 is about the maximum that our present facilities can accommodate, it is also true that we could accommodate somewhat larger classes than we now have in the junior and senior years. Some transfer students from junior colleges are accepted each year but only a few such students have had the preparation required to pass our transfer examinations.

As a result of this situation, and of inquiries and requests by a number of liberal arts colleges, the faculty has voted to initiate on a limited scale a "3-2 plan" with certain selected colleges. Under this plan a student may enroll in one of these colleges for an agreed-upon program for three years. On recommendation of the college he will then be admitted as a junior at Caltech. Upon satisfactory completion of two additional years of work here he will receive simultaneously our B.S. degree and a Bachelor of Arts degree from the cooperating college.

This program will appeal to certain types of students who will obtain in this way a most valuable college experience. In such a five-year course the student will have more opportunity for work in nonscientific fields than in our four-year course. Also this plan allows in the early years for a somewhat more leisurely pace than is expected here.

Graduate students

Our graduate student body continues its normal size and quality. We were pleased that 30 recipients of National Science Foundation Fellowships—selected on the basis of a national competition—chose to pursue their graduate work here. Only three or four of the largest and most renowned universities of the country attracted a greater number of these top students—an impressive compliment to the reputation of our faculty.

The need for a dormitory for graduate students continues as a high-priority item. We shall continue to hope that someone will see here an opportunity for a fine memorial.

The Air Force ROTC Unit

The Air Force Reserve Officers Training Corps Unit at Caltech ended its second year of operation and again showed up in competition as one of the outstanding ROTC units of southern California.

However, as the unit moved into its third year of operation with the prospects of a group of more than 100 students interested in proceeding with the advanced course, a distressing change in policy was announced by the U. S. Air Force. Because the prospective number of officers graduating from ROTC units all over the country was substantially in excess of officer needs, very restrictive quotas were established on the number of students who could be admitted to the advanced course.

This means that out of approximately 88 students at Caltech who were qualified and interested in proceeding with the advanced course, only 44 can actually be admitted. Only 18 nonflying candidates were allowed. There is still a possibility that an additional 14 might later be admitted but at least 30 students have had to be definitely rejected. In view of the assurances given these students two years ago by the Air Force, and thus through implication by the Institute, this situation represents a serious disappointment to many who had hoped through this program to qualify for officers' commissions in the Air Force.

It is true that no quotas have as yet been set on cadets who agree to undergo flight training, since the Air Force is still short of pilot officers. However, the need for technically trained nonflying officers has apparently been drastically reduced, so that very few can expect to be admitted to the advanced course and to officers' commissions in future years. There are as yet no limitations on the size of the freshman and sophomore ROTC classes.

The Institute undertook to install an ROTC unit at a time when the need of the national defense establishment for technically trained officers was very great. As far as the Air Force is concerned, this need has been reduced to such a low level (at least for the immediate future) that the question of the Institute's continuing the Air Force ROTC unit must now be considered.

Research Highlights

THE YEAR 1952-53 saw additional important advances in the Institute's research programs. Some 550 research papers were published. Obviously it is impossible to summarize such a mass of material, but a few highlights may be mentioned here.

Seismology. A conspicuous activity of the Institute's research program this year was the study by the Seismology Laboratory of the series of earthquakes which were set off by the Arvin quake of July 21, 1952. This earthquake, second in magnitude in the past 95 years only to the San Francisco shock of 1906, was the first of a series of several hundred shocks of lesser magnitude which have followed throughout the subsequent year—and which still continue, but with decreasing frequency.

This whole disturbance of the earth's crust might well have been made-to-order for Dr. Beno Gutenberg and the Caltech seismologists, because it enabled them to put the full resources of their laboratory at work to secure all possible data on this major series of fault slippages. More was learned from this series of near-by quakes than from all the previous recordings made during the 25 years of this laboratory's existence.

The Institute has asked a group of corporations (utilities, railroads, insurance companies, etc.) to assist financially in expanding the activities of the Seismology Laboratory. More knowledge about the nature and occurrence of earthquakes will assist in reducing the damage which they cause. Contributions and subscriptions have already been received exceeding $33,000 per year for this purpose. An additional $30,000 annually is needed; plus about $250,000 for a much-needed addition to the Laboratory.

Dr. G. W. Housner and his colleagues in civil engineering also obtained new data for their studies on earthquake-resistant structures. In analyzing their records of earth motion it was found that the seismic waves were of such a form that they could be regarded as produced by a series of pulses, as would result from a series of discrete slippages of a fault. This theory will aid in analyzing the effects of strong earth motion on buildings and other structures.

Astronomy. The interest of both the scientific and the lay public was attracted by the recent discovery that the universe is perhaps "twice as big" as had previously been supposed. The measurement of astronomical distances is, of course, an indirect process, based on measurements of relative apparent brightness of different objects which are presumed to be identical except for their distance from the earth.

If one object appears four times fainter than another object which is believed to be identical, it will be concluded that the fainter object is twice as far away. But if it is later found that the two objects are *not* identical after all, then this "distance scale" is destroyed.

That is essentially the discovery recently made by Dr. Walter Baade—that the groups of stars which previously had been used to establish the distance scale are of two types, one substantially brighter than the other. Since the brighter ones had (unknowingly) been used along with the dimmer ones in the distance estimates, the distances had been correspondingly underestimated.

Thus the most distant nebulae visible on plates taken with the 200-inch Hale telescope at Palomar may be as much as *two* billion light-years away, rather than previous estimates of one billion. It is as though a person who was accustomed to estimating a distance by "pacing it off" suddenly found that his paces instead of being two feet long were actually four feet long! All his distance estimates must now be doubled.

As is well known, the work of Drs. Humason and Hubble on the "red shift" in the spectra of distant nebulae some time ago suggested the idea of an expanding universe. By measuring the velocity of expansion, the time elapsed since the expansion "began" was computed. This turned out to be a little less than two billion years. But there are radioactive rocks on the earth which physicists can prove are nearly four billion years old. This dilemma was embarrassing indeed. Now it may have been resolved.

If the nebulae are twice as far away as was thought, it obviously took them twice as long to get there. So the universe appears, after all, to be nearly four billion years old.

There is still considerable uncertainty in the distance measurements, but the general nature of the revisions in estimates seem now to be understood. It should be emphasized, however, that the expansion idea is not at all fully accepted, nor if accepted is it agreed how the "age" of the universe may be computed. There are some who argue that the age is infinite. This question will not be resolved soon.

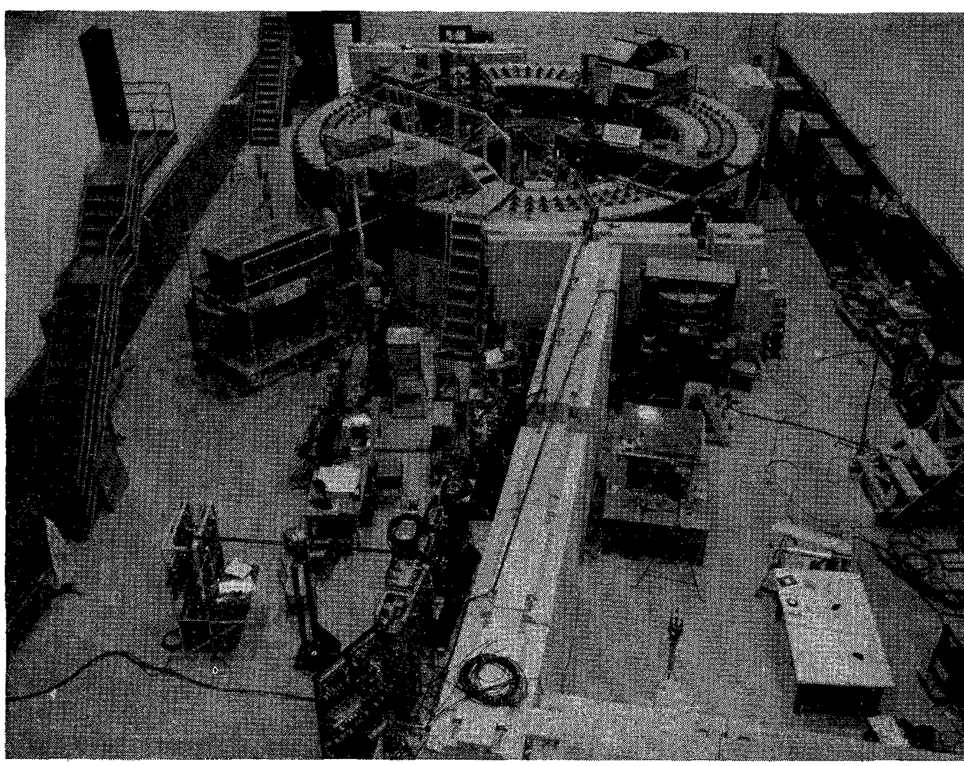
The astronomers and physicists have also been probing further into the age-old question of the source of energy within the sun and the other stars. It has been realized for many years that only some form of nuclear reaction could be responsible for the vast supply of energy continually radiated from the sun. About 15 years ago it was shown that the combination of hydrogen into helium through the so-called "carbon cycle" (the carbon serving as a sort of carrier or catalyst) offered a good quantitative explanation. However, new measurements in the Kellogg Laboratory at Caltech seem to complete the chain of evidence that carbon is not involved at all. Direct reactions between the various isotopes of hydrogen and helium can account for all of the sun's energy.

Thus, to put it grimly, the sun and other similar stars are nothing but continuously operating H-bombs. Each star is a vast mass of hydrogen which is being "fused" into helium through a colossal "thermonuclear" reaction.

Geochemistry. A significant new area of research at the Institute got into full swing this year under the guidance of Professor Harrison Brown—the field of geochemistry. A suite of rooms in the Mudd building has now been equipped with the most modern instruments for analysis of minute quantities of certain elements, for measurements of abundance of isotopes and of minute traces of radioactivity.

An unexpected problem arose when it was found that measurements on minute traces of lead in certain igneous rocks were thrown off by contamination from the air. Smog-laden air contains lead from the "ethyl" (lead tetraethyl) of antiknock gasoline. The normal air-conditioning equipment of the laboratories thus had to be supplemented with special "smog-removing" filters to keep the laboratory sufficiently lead-free. (The Earhart Plant Laboratory went through this filtering problem several years ago and the biologists were able to advise the geochemists on how to meet it.)

The problem of "dating" geological samples has moved substantially nearer to a complete solution—from very recent to very old material. The Gladwin tree-ring measurements, combined with isotopic ratio of carbon atoms of weight 12 and 13, and of radioactive carbon 14, give the ages for "youthful" specimens (under 20,000 years old). The measurements of traces of helium in rocks now give ages from 20,000 years upward, while the familiar lead-uranium ratio takes care of the upper scale to the 4-billion year "limit." All of these techniques are in use here with facilities which



X-rays from the Caltech synchrotron are the most energetic ever produced.

allow each to be pushed to the utmost in sensitivity and precision.

Physics. It was in the summer of 1952 that the new synchrotron went into operation, accelerating electrons to energies of over a half-billion electron volts. During the past year the operation of the machine has been steadily and very greatly improved, so that a large and reliable electron beam is now always available.

The X-rays from the machine are the most energetic ever produced and have been used to study the creation of mesons in hydrogen. As seems to happen so often in modern physics, this seemingly simple process turns out to be more complex, and hence more interesting, than had been predicted. The results will thus supply new information about the nature of the hydrogen nucleus—the proton—and also about the nature of gamma rays and of mesons.

In the new cosmic-ray laboratory Carl Anderson and his colleagues were dealing with energies which made the man-made synchrotron energies look puny indeed. At these cosmic-ray energies many kinds of subatomic particles are created which "live" only one-hundred-millionth of a second or less, and then decay into other particles.

These processes are most complex, but the Caltech group has been most productive in observing and interpreting them. The neutral V-particle is now quite well established as a particle which is heavier than a proton, but which decays into a proton plus a negative pi-meson.

Now Anderson and his colleagues find a *charged* particle which is heavier than a proton, decaying into a proton plus a neutral meson. There are also neutral V-mesons (which are lighter than protons), which decay into two pi-mesons, and there are tau-mesons which decay into *three* pi-mesons.

These complexities of the subatomic world are not at all understood from the point of view of nuclear theory. It seems likely that a radical new advance in theoretical physics will have to take place before understanding can come. But the theorists need still more experimental evidence before their new theories can be formulated. It is an exciting period in nuclear physics, with information accumulating more rapidly than comprehension.

Jet Propulsion. At Caltech there are two research units devoted to problems in jet propulsion. The Guggenheim Jet Propulsion Center is on the campus and is devoted to basic theoretical and experimental studies and to the training of students. It is financed by a continuing grant from the Daniel and Florence Guggenheim Foundation.

The Jet Propulsion Laboratory, located five miles off the campus, is financed principally through a contract with the Ordnance Corps of the U. S. Army. Part of the function of the laboratory is to develop and to engineer guided missiles needed by the Army. This work cannot be publicly discussed, of course, though it has been announced that the Army's huge "Corporal" rocket is a J.P.L. product. At the same time J.P.L. carries on a large program of fundamental research on fuels, thermodynamics, cooling, and combustion; electronic guidance and control; and other areas.

Of particular interest is the possibility of replacing liquid by solid propellants in guided rockets. It is evident that in continuously operating *aircraft* jet engines, a liquid fuel is the only practical type that can be handled. The air furnishes the oxidant. On the other hand, in a small artillery rocket a solid propellant is most practical. Here the thrust is needed for only a brief time to bring the missile up to speed.

For longer range *guided* missiles, however, liquid propellants again have been used because they can be more accurately controlled, *e.g.*, the fuel supply can be shut off promptly when the desired speed has been attained. The burning of a solid stick of fuel cannot be quenched. However, two large tanks of liquid fuel and oxidant with all the pipes and valves and pressure equipment involved provide a most complex array of apparatus to be installed in an expendable vehicle. This is a chief reason that long-range rockets are expensive. If solid fuels could be used, a major advance will have been made. Clearly this possibility is not an immediate one, but further research is of great importance.

Chemistry. The work of the Division of Chemistry and Chemical Engineering continued to be both extensive and productive—and hence impossible to summarize. More light has been shed on the nature and behavior of enzymes, of certain materials that induce cancer in animals, of others that cause hemorrhages in tumors, of still others that prevent malaria.

Further progress has been made in the study of various types of hemoglobin in human blood, especially types that cause several diseases of the anemia type. A promising substitute for blood plasma, oxypolygelatin, has been perfected to a point where extensive clinical tests may be made. A new theory of ferro-magnetism has been developed. Electron-diffraction studies have revealed data on the structure of many types of molecules; other studies revealed the crystal structures of complex alloys.

Steady progress was made in fixing the structure of certain protein molecules, following the major advances made last year by Drs. Pauling and Corey. And further measurements were made on the properties of the various constituents of petroleum under conditions of high pressure and temperature found in deep oil reservoirs. There is surely no more dynamic center of chemical research in the world.

Biology. Members of the Division of Biology engaged in a variety of research activities during the year. These included an extension of new tissue culture methods of virus study to poliomyelities; investigations of protein synthesis; probings into the inner workings of the nervous systems of animals; determinations of the biological effects of high energy radiation; and looking into the mechanisms by which plants grow, flower and fruit.