used to the exclusion of the recessive lethal amorphs, the cistron cannot be clearly identified. It is suggested that the gene product of the Notch locus ultimately complexes with other products to form two or more different structural proteins or enzymes. Since two different mutant varieties of the same Notch protein (derived from two different hypomorphic mutants) need not affect the same enzyme system of the two or more systems to which the protein contributes, the trans heterozygotes may have a normal phenotype.

Cytogenetic comparisons based upon Notch as a cistron and bithorax as an operon suggest that a single salivary band corresponds to a functional gene. However, it is the association of the genetic complexity at bithorax with multiple bands and the affinity of Notch with a single band that is of central importance, for, even if genetic interpretations change in time, the cytological difference must retain some meaning in its new context.

References and Notes

1. J. D. Watson and F. H. C. Crick, *Nature* **171**, 737 (1953); *ibid.*, p. 964.
2. O. L. Mohr, *Genetics* **4**, 275 (1919); ———, *Z. Verebungslehre* **33**, 108 (1923); M. Demerec, *Proc. Intern. Congr. Genet. 7th, Edinburgh* (1939), p. 99; H. Slizynska, *Genetics* **23**, 291 (1938).
3. T. H. Morgan, J. Schultz, V. Curry, *Carnegie Inst. Wash. Year Book* **40**, 283 (1941).
4. G. Lefevre, Jr., *Drosophila Inform. Serv.* **26**, 66 (1952).
5. This treatment evades a discussion of dosage compensation—Why does a male deficient for an entire X chromosome not suffer from the loss? For a discussion of dosage compensation see C. Stern, *Can. J. Genet. Cytol.* **2**, 105 (1960).
6. H. Bauer, *Z. Vererbungslehre* **81**, 374 (1943).
7. H. J. Muller, *Proc. Intern. Congr. Genet., 6th, New York* **1**, 213 (1932). According to Muller's classification there are *amorphic, hypomorphic, hypermorphic, antimorphic*, and *neomorphic* mutants.
8. The mutant *spl* does not appear to be a hypomorph, but I will not try to classify it. The discussion of mutant types will be limited throughout to hypomorphs and amorphs, because they are relatively frequent and one is simply the extreme condition of the other. It should be understood that at Notch a relatively extreme hypomorph may be indistinguishable from an amorph.
9. W. J. Welshons, *Cold Spring Harbor Symp. Quant. Biol.* **23**, 171 (1958).
10. W. J. Welshons and E. S. Von Halle, *Genetics* **47**, 743 (1962).
11. This concentration of *N*'s is probably a consequence of using only radiation-induced and spontaneous mutants. The use of chemical mutagens might yield a different array of mutant sites.
12. E. B. Lewis, *Am. Zool.* **3**, 33 (1963).
13. S. Benzer, in *The Chemical Basis of Heredity*, W. D. McElroy and H. B. Glass, Eds. (Johns Hopkins Press, Baltimore, 1957), pp. 70–93.
14. M. Hayashi, M. N. Hayashi, S. Spiegelman, *Proc. Natl. Acad. Sci. U.S.* **50**, 664 (1963); M. H. Green, *ibid.* **52**, 1388 (1964).
15. M. W. Nirenberg, *Sci. Am.* **208**, 80 (March 1963).
16. C. Yanofsky, U. Henning, D. Helinski, B. Carlton, *Federation Proc.* **22**, 75 (1963).
17. F. H. C. Crick, *Science* **139**, 461 (1963).
18. M. E. Case and N. H. Giles, *Proc. Natl. Acad. Sci. U.S.* **46**, 659 (1960).
19. N. H. Giles, *Proc. Intern. Congr. Genet. 11th, The Hague* **2**, 17 (1963).
20. A. Chovnick, A. Schalet, R. P. Kernaghan, M. Krauss, *Genetics* **50**, 1245 (1964).
21. A. Schalet, R. P. Kernaghan, A. Chovnick, *ibid.*, p. 1261.
22. O. G. Fahmy and M. J. Fahmy, *Nature* **184**, 1927 (1959); M. M. Green, *Genetics* **34**, 242 (1963).
23. G. Lefevre, Jr., and M. D. Wilkins, *Genetics* **50**, 264 (1964).
24. E. A. Carlson, *ibid.* **44**, 347 (1958).
25. J. L. Southin and E. A. Carlson, *ibid.* **47**, 1017 (1962).
26. Courtesy of Dr. S. Abrahamson, University of Wisconsin.
27. These lethals, with the exception of *l (1) N*, could represent hypomorphic states intermediate between the recessive visibles and the amorphic or near amorphic *N*'s. They demonstrate the diversity of mutant types that can occur at this locus.
28. F. Jacob and J. Monod, *J. Mol. Biol.* **3**, 318 (1961).
29. F. Jacob, A. Ullman, J. Monod, *Compt. Rend.* **258**, 3125 (1964).
30. A. Ahmed, M. E. Case, N. H. Giles, *Brookhaven. Symp. Biol.* **17**, 53 (1964).
31. J. C. Loper, M. Grabnar, R. C. Stahl, Z. Hartman, P. E. Hartman, *ibid.*, p. 15.
32. E. B. Lewis, *Cold Spring Harbor Symp. Quant. Biol.* **16**, 159 (1961).
33. G. L. Dorn and A. B. Burdick, *Genetics* **47**, 503 (1962).
34. W. J. Welshons, E. S. Von Halle, B. J. Scandlyn, *Proc. Intern. Congr. Genet. 11th, The Hague* **1**, 1 (1963).
35. H. S. Rhinesmith, W. A. Schroeder, N. Martin, *J. Am. Chem. Soc.* **80**, 3358 (1958); V. M. Ingram, *Nature* **189**, 704 (1961); C. Baglioni, in *Molecular Genetics*, J. H. Taylor, Ed. (Academic Press, New York, 1963), vol. 1, p. 405.
36. M. Gans, *Bull. Biol. France Belg.* (Suppl.) **38**, 1 (1953); M. M. Green, *Heredity* **13**, 302 (1962).
37. B. H. Judd, *Genetics* **49**, 253 (1963).
38. W. D. McElroy, in *Cell Physiology and Biochemistry* (Prentice-Hall, Englewood Cliffs, N.J., ed. 2, 1964), p. 120.
39. Work performed in the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, operated by Union Carbide Corp. for the AEC.

The University and the Exploration of Space

The space program, continuing the expansion of knowledge, depends on and contributes to the universities.

Hugh L. Dryden

I wish to discuss the relation of science to space exploration, and the role of the university in the exploration of space in the context of its existing relationships with education, research, government, industry, and other elements of our social environment. Then I hope to become provocative in commenting on the role of the university in the next half century. The events of the past 7 years have had a profound effect on all human affairs throughout the world. Repercussions have been felt in science, industry, education, government, law, ethics, and religion. The toys of our children, the ambitions of our young men and women, the fortunes of industrialists, the careers of military officers, the pronouncements of high church officials—all have reflected the influence of the beginning steps in space exploration. No area of human activity or thought, no social institution, has escaped. The university can be no exception.

Those of us who are experiencing the first small steps cannot have the proper perspective to assess the full meaning to the history of man of the crossing of the space frontier. But I believe that its impact can only be compared to those great developments of past history such as the Copernican theory which placed the sun, rather than the earth, at the center of our solar system; to the work of Sir Isaac Newton in relating the fall of an apple to the motion of the moon around the earth through the universal law of

The author is deputy director of the National Aeronautics and Space Administration, Washington, D.C. This article was originally presented as an address at a symposium on Universities and Federal Science Policies held 11 October 1965, during the autumn meeting of the National Academy of Sciences, Seattle, Washington. Papers given at the symposium will be published in book form by the University of Washington Press.

gravitation; to the industrial revolution; or to other great landmarks in the history of man.

As is well known, scientists view the exploration of space with mixed emotions, but most now realize that it is not an enterprise undertaken by the nation as the next step in the evolutionary development of "big science." Most of our citizens instinctively accept the view stated by the late German space pioneer, Eugene Sänger, in the following terms:

> Space flight comes upon us as a natural event born in the deepest depths of the human soul, before which we can only stand humble or defiant; space travel comes upon us whether we love it or hate it or do not heed it at all, whether we believe in it or ridicule it, just as war and high flood tides and death come over us.

The exploration of space does involve what is now called "big science," a present aspect of the evolution of science which is resisted by many who wish to confine science to the traditions of the last century. The perspective of history shows that science has undergone a process of evolution, has changed, hopefully retaining the valuable characteristics of the past while adapting to a new social environment. To oversimplify, we have seen the birth of science centuries ago in the work of the natural philosophers. They were usually amateurs, wealthy in their own right or supported by patrons. They had an insatiable curiosity for knowledge. They could and did study and know all aspects of knowledge then available, the theoretical and the practical, about nature and about man in all his intellectual and spiritual activities. As knowledge expanded, specialization began, and the teacher and his disciples became a community of scholars, an association of specialists, a loose grouping of self-sufficient individuals. With further growth of knowledge and its permanent recording in books and libraries, the number of categories of specialists grew, institutions were built around broader objectives, universities and university departments were invented, and means of interaction between individuals and groups with generally similar interests were organized.

As science grew, the tools of the scientists became more complex and expensive but were at first operable by the scientist himself or by small groups which included a few technicians. We think of electron microscopes, infrared spectrometers, computers, and so on. The old traditions of individual freedom and complete control by the individual scientist were preserved. It merely cost more to support him with adequate equipment. Specialized industries evolved to design, manufacture, and sell the equipment. The days of glass, sealing wax, and wire assemblies by the scientist himself largely disappeared.

The Advent of "Big Science"

Then, with the airplane, the accelerators splitting the atom, and the rocket, came big science, involving massive engineering and industrial support, institutes, national laboratories, associations of universities, administration and management of large organizations, all of which were needed to match the more complex needs for further scientific advance as well as to meet the important social need of national defense.

On other occasions I have discussed the almost dominant role of the social environment in which the scientist and engineer work and which in most instances seems to be a prerequisite for the intensive development of the scientific concept itself (though not always its discovery) as well as of the ensuing technology. Thus James Maxwell in 1865 and 1873 described the propagation of electromagnetic waves theoretically. Shortly thereafter their existence was demonstrated by Hertz (1883), and limited development proceeded. But it was not until Marconi applied them to signaling in 1895 and succeeded in sending signals across the Atlantic in 1901 that greatly increased resources were applied, which were the foundation of very large industrial developments resulting in a very great social impact.

Today social needs have become much more complex—for example, war on poverty, and the abatement of air and water pollution—and go far beyond the material aspects of our life. The exploration of space may be interpreted as a modern social need which provides the environment to accelerate the growth of science and technology in many areas, not only to develop space capability but also to participate in that complex, dynamic interaction between science, technology, and the social need essential to all. To use an analogy from bacteriology, there has to be a nutrient solution (money and employment opportunities) as well as motivation to feed the scientific and technological effort. Then many latent efforts in science and technology begin to assert themselves and move forward.

NASA and Advancement of Science

One of the major goals of the National Aeronautics and Space Act of 1958 is fundamentally scientific, the expansion of human knowledge of the atmosphere and space; or, in the language of the President's Science Advisory Committee, the exploration of outer space in response to the compelling urge of man to explore and to discover. The sounding rocket, the satellite, and the space probe have made it possible to put instruments above the atmospheric curtain into outer space, near the earth, the moon, and the nearest planets, and probably in a few years to the outer reaches of the solar system for direct experimental measurements and for an unhampered view of the universe in all wavelengths from gamma rays to radio waves. Man himself has begun the exploration of nearby space and hopes to reach the moon in a few years. Without the full partnership of scientists, and in particular university scientists, the job would be impossible. In addition we must rely upon the universities for the basic research upon which to build a complex new technology and for ground-based experiments which contribute directly to understanding the results of observations in space; for assistance in the conception, design, development, and testing of instruments and spacecraft; for the exploratory and basic research necessary to guide the planning and evaluation of scientific missions and experiments in space; and for participation as experimenters in space flight missions. Finally, universities are the only knowledge-creating institutions that produce more trained people than they consume and hence are the primary producers of scientific manpower.

NASA early decided to rely on the National Academy of Sciences as its primary source of scientific advice through the Academy's Space Science Board under the leadership, first, of

Lloyd Berkner, and now of Harry Hess. These advisers have contributed immeasurably to whatever credit is due for making space science as excellent as possible under the restraints of "big science" in a team in which there are of necessity many more engineers than scientists. Profiting from this advice, NASA has adopted the policy of working within the university structure rather than fostering activities which pull the university researcher away from the teaching environment and of enlisting cooperation in a manner that will not only make it possible for NASA to accomplish its mission but that will also strengthen the university as an institution.

Space science offers completely new methods of attack on some of the oldest and most fundamental problems challenging science, including the structure of the universe, the abundance of the elements in the cosmos, the evolution of the stars and galaxies, the formation of the sun, and the origin of the earth. Extensive exploration has already been carried out in the near-earth region, the upper atmosphere, the ionosphere, and the magnetosphere. The investigations have been extended into the interplanetary medium beyond the influence of the earth's magnetic field. Extensive attention has been given to the sun, whose activity is responsible for many of the time-dependent phenomena observed in the space near the earth. Observations of the moon and nearer planets have begun. Finally, a beginning has been made on astronomical investigations above the blanketing influence of the earth's atmosphere.

In the missions undertaken primarily for scientific objectives, the choice of launch vehicle, trajectory and design of spacecraft are controlled by the scientific requirements, subject to the unavoidable restraints of available resources. The controlling priority is that of gaining fundamental scientific knowledge. Some science missions are flown to obtain specific information about the space environment in support of other missions. Although these missions, such as Ranger and Surveyor, do give scientific information, their primary motivation is to insure adequate engineering design of space vehicles. In the course of the past 7 years NASA and the universities have learned to adapt to each other's problems, to provide adequate forums and other mechanisms to make possible joint planning of scientific flight missions, and to establish policies which have enabled fruitful cooperation in space science. These have often been reviewed on other occasions and need not be repeated here.

Government Use of University Resources

For many years the government mission-oriented agencies have used the resources of the universities for research through the project method, a pattern originally developed in most effective form by the Office of Naval Research. A new form of contract, the research contract, was developed as a special tool for the support of research at universities, largely awarded on the basis of proposals originated by university scientists. This contract, differing markedly from the usual procurement contract, provides a mechanism for tapping the ideas of the entire academic community of scientists, both for the basic research of science and the applied sciences of engineering and medicine.

All the NASA flight missions are undergirded by a program of advanced research and technology, carried out in in-house laboratories of NASA and other government agencies, in universities, and in industry. The work ranges from basic research to applied research and advanced technological development, and there are literally thousands of projects. Among them are projects from the physical and biological sciences, engineering science, space propulsion technology, vehicle systems technology, space operations technology, tracking, data acquisition and processing, and even a few socio-economic studies.

Mission-oriented agencies support primarily projects relevant to their missions, although they participate, as I will indicate later, in the general support of basic research. Relevance has been broadly interpreted. For example, in the field of astronomy NASA has given some priority to supporting an expansion of ground-based astronomy relating to the Moon, Mars, and Venus, in order to contribute directly to understanding the results of the early missions to these celestial objects. It supports the development of instrumental techniques for measurements from space vehicles in parts of the spectrum not accessible to ground-based telescopes, and it supports, to a lesser degree, gap-filling projects in basic astronomy in coordination with the National Science Foundation and other governmental agencies.

In addition to direct project support, a more intimate association is necessary and desirable, as is now becoming generally realized by government and university leaders and by the Congress. Thus in the fiscal year 1962 NASA initiated a program of enlarged scope for utilizing more fully the present and potential abilities of our universities in the space program. This program included the encouragement of interdisciplinary groups for research in broad areas, adapted in each case to the interest of the university itself and the needs of NASA; the provision of research facilities in special cases where essential to the new activity; and the support of the training of people in fields relevant to space science and technology through research grants. These three components—research, facilities, and training—are complementary, and their relative magnitudes have been balanced in each case to ensure the most efficient use of the capabilities and resources provided.

Many of the problems encountered in the space program require an interdisciplinary approach demanding the concerted and cooperative efforts of biologists, geologists, physicists, chemists, electronic specialists, metallurgists, engineers, economists, sociologists, and many others. The universities are the only institutions in our society having the potential ability to bring to bear on our problems such a variety of skills. We have therefore given encouragement to the integration of related research projects into unified multidisciplinary activities, initiation of new investigations to fill existing gaps, and participation of promising new groups. Thus able scholars in diverse disciplines are enabled to work together on the broad problems whose solution resists piecemeal attack.

At many institutions these interdisciplinary activities are seriously impeded by lack of room, and as a consequence NASA has, in special cases in which new programs are being established and where all the circumstances warrant it, aided in the provision of additional facilities, including buildings or building additions to provide laboratory space. In many cases this assistance is provided in consultation and cooperation with other government agencies as a part of strengthening the scientific and technological capability of the university available to all governmental programs.

As a consequence of the report of the Gilliland Committee of the President's Science Advisory Committee, which called for doubling the production of Ph.D.'s in science and engineering by 1970, NASA participated in a government-wide program to attain this goal. Since NASA's appropriation in fiscal 1962, when the program was started, amounted to about one-quarter of the federal R&D dollars, NASA took as its ultimate goal the production of 1000 Ph.D.'s annually, which represented approximately one-quarter of the increase considered desirable. This program is now nearing the planned level—the entrance of 1350 new students annually, yielding, after normal attrition, about 1000 Ph.D.'s by the time they have completed the 3 years for which they may be supported.

Selection of the students and administration of the program are decentralized to the university, the individuals being selected by senior members of the faculty who know the capabilities of the students, who will probably supervise their research training, and who in many cases are directly engaged in research activities supported by NASA. In addition to stipends for the students, funds are made available to help defray the cost of the program to the university. However, these funds are not specifically tied to the students but are made available to the university with the stipulation that they be used to enhance graduate education in fields relevant to space science and technology. The university itself determines these fields, which include all the fields previously mentioned under the interdisciplinary program.

Over 130 universities participate in the training program. There is no commitment that the graduates will work for NASA or the federal government. It is hoped that many will remain at the university. The initial grants, which covered only 100 students, are just being completed. We have been extremely gratified by the results to date. As of 15 June 1965, we had been notified that Ph.D.'s had been awarded to 68 students. Information is available as to the initial career choice of 58 of these students: 44 have chosen to remain with the university, 33 in research and teaching and 11 on postdoctoral appointments on Fulbright fellowships; of the remaining 14, two entered employment in government laboratories and 12 were engaged by industry.

Universities in the Future

I turn now to a more debatable and even controversial matter, the evolution of the role of the university in the future. We see around us much evidence of the ferment of change in response to what Lloyd Berkner has called a social and economic revolution of a magnitude unprecedented in the history of society and whose roots are nourished by the power of today's science, from which is derived an equally powerful technology. It is evident in the invention of new tools of university organization, such as research institutes within the university but not under departmental control, and associated nonprofit corporations affiliated with a single university or with a group of universities on a regional and, more recently, on a national scale. It is evident in the experiments on the evolution of scientific and, particularly, of engineering curricula. It is evident in the demands on university leaders to bring the university's great resources to bear on the complex social and economic problems of the neighboring community, the region, the nation, the global community of nations. The university is the one existing social institution where the environment is conducive to scholarship, objective analysis and time for considered thought, and the interdisciplinary flux of many specialist points of view. No other institution has in one place men skilled in physical science and engineering, in the humanities, in medicine and the life sciences, in sociology and the behavioral sciences, in political science, in law, in theology.

It is not expected that the university will become the primary action agency for solving the economic and social problems of our society or for setting basic social objectives, but it must have a prominent voice and influence. The university should, I think, aspire to intellectual leadership, to observe and analyze, to apply the power of the human mind—that faculty which distinguishes man from animal—to establish a rational basis for policy and action. The direct attack must be undertaken by other institutions, mainly by political agencies. We are now witnessing the evolution of government agencies, particularly those of the federal government, to meet social needs by direct action in all fields from economics and public health to science and technology. A beginning is being made in the mobilization and integration of the total available resources to attack the most complex social problems.

It is interesting to note the experiments of the State of California in the use of the aerospace industry to survey some of the major problems of urbanization, such as those relating to water resources, sewage and waste disposal, air and water pollution, and transportation. Industry, too, has assembled resources of scientists and engineers and has developed new concepts such as systems analysis dealing with the integration and application of knowledge from many fields to complex problems. The aerospace industry has had much experience in adaptation to change and has proceeded somewhat farther in its evolution to meet new environments than has the university. In the short span of 60 years, again in an oversimplified view, it has passed through stages somewhat analogous to those traversed by the university over several centuries.

The aerospace industry began with the designer and his apprentices at a stage where one man knew all there was to be known about the design of airplanes and the underlying science and technology. This was followed by the development of small teams with specialization of effort in aerodynamics, structures, and propulsion. These specialized problems were at first separable, with little interaction between the work of the design specialists. Then aircraft speeds increased, the air flow deformed the structure, the deformation in turn modified the air loads, other interactions occurred, and new specialties such as vibration and flutter analysis came into the picture. The aerospace company grew in size and complexity. It became harder to identify a single individual as the designer of its product.

When electronics brought new types of equipment such as radar, design compromises became necessary between the diverse requirements of electronics, aerodynamics, structure, and propulsion. Companies with different technologies became associated. Individual companies were expanded into large corporations with several divisions specializing in the several fields. With the arrival of missiles, atomic weapons, and space vehicles, research groups were established within the aerospace corporation, first made up of engineers and applied scientists, later including basic research scientists in the life sciences as well as the physical sciences. The development task became one of dealing with many systems, subsystems, and components, integrating them with extension of the systems concept to include all aspects of design, construction, and use. Even field maintenance, training of operators, and consideration of the real objectives and values of the whole development enterprise became an activity of the corporation. As the scope and size of projects became very large, even corporations had to be associated to provide the required resources.

Formation of a Team

In the space program it has been necessary to go still farther, to assemble a combined team of industry, government, and university, comprising hundreds of thousands of persons contributing to a single objective. Relations between supplier and customer grew to an intimate partnership. New institutions such as the Communications Satellite Corporation have been invented. Others will undoubtedly follow.

The university must be equally flexible and adaptive to meet its responsibilities and opportunities in the next century. Where does this leave the dynamic quality of science, the traditional values of pursuit of excellence, freedom of inquiry, preservation of creativity, and the support of the unconventional new ideas, particularly those of young scientists? We must be concerned to preserve these essential freedoms which have led to progress of the university in the past.

Paradoxical as it may seem, I believe that these values may not only be preserved but may even be strengthened within the larger framework of increased scope which can provide a sounder human motivation, bring allocation of increased resources, provide the satisfaction of great accomplishment in terms of human goals, and a sense of a community of interest with all mankind. If you will take the time to discover what is now going on in the exploration of space, you will find a free association of individuals, each with complete freedom of individual choice, in the largest and most challenging venture of man, the search for knowledge of his environment and the application of this knowledge to his benefit. In this group of several hundred thousand people you will find innumerable examples of the pursuit of excellence from the renewed pride of the workman in his handicraft, to the intellectual effort of the scientist to analyze and observe. You will find mainly young men, unafraid of large problems or rapid change. You will find the unconventional idea being given attention. The university and the university scientist must and will adapt to the age of space exploration.

Parenthetically, in closing, the National Academy of Sciences, born of the university and bearing the marks of its parentage, must also adapt to the environment of science as it exists today and to the environment of its second centennial. I have been pleased to see the steps being taken by the Council under the leadership of President Seitz to play an appropriate role in the formulation of science policy and in giving advice to the government on the potential contributions of all science, whether government, university, or industry, and whether "big" or "small."

NEWS AND COMMENT

Oak Ridge National Laboratory: Aim Is Change along with Growth

Oak Ridge National Laboratory has a name that needs explaining. Although its facilities are government-owned, ORNL is not a federal laboratory staffed by civil servants but, rather, is operated under contract by a major industrial corporation. Furthermore, for more than two decades the laboratory has concentrated on research and development work relevant to the mission of its sponsoring agency, the Atomic Energy Commission. Increasingly, however, ORNL is going "national" in the sense of carrying out R & D activities aimed at solving problems beyond the boundaries of the AEC mission, as narrowly defined.

ORNL has a mixed academic-industrial ancestry. It grew from the original research facility—known as X-10—built in 1943 shortly after the Manhattan Engineer District settled on Oak Ridge as the site for major plants for separating uranium-235. The new X-10 was essentially a pilot plant designed to extract very small quantities of plutonium to prove the feasibility of big plutonium-producing reactors scheduled to be built at Hanford, Washington.

In inspiration and to some extent in staff, the facility was really an extension of the University of Chicago Metallurgical Laboratory. The University of Chicago was contractor, but engineers of the du Pont Company, which had been made contractor for the Hanford works, collaborated in the design of the graphite reactor and the radiochemical pilot plant which were X-10's main elements. Old hands recall that, because of du Pont experience and the unknowns involved in the project, X-10 was laid out like an explosives plant.

Shortly before the end of the war, the contract for operation of X-10 was transferred to the Monsanto Chemical Company. The name Clinton Labora-