clude that the scientific community bears a serious responsibility for helping to solve these problems, and have suggested a program that might accomplish this aim.

Such a program does not yet exist, and it would be appropriate for the AAAS to help bring it into being. The task is not an easy one. It will add to the scientist's burden of work; it will require from the citizen more attention to public affairs; it will demand new social inventions. But we believe that a society capable of producing the enormous new powers of science ought to be capable of finding the means of comprehending their effects on the social order. And we are confident that with such understanding, science—as an expression of the creative gifts of the human mind—will flourish, and the power which it endows will be turned more fully to the promotion of human welfare.

References and Notes

1. *Science* **125**, 143 (1957).
2. Premises quoted from the report of the Interim Committee [*Science* **125**, 147 (1957)].

Some Vistas of Astronomical Discovery

New developments in instrumentation have opened up new possibilities in optical astronomy.

W. W. Morgan

As is the case with all epochs, the present one has its own characteristics, both in its political and its scientific aspects. The science of 1960 is not the science of 1920, and, most emphatically, the astronomy of 1960 is not the astronomy of 1920.

The differences are not entirely differences in instrumentation and in techniques; even if the instruments of the 1950's had been identical with those of 1920, we would have been doing different things with them, because our thinking has matured and our approximation to reality in the astronomical field has improved through the investigations of the intervening years.

But the appearance of the new fields of radio astronomy and space science, with the accompanying revolution in instrumentation, is certainly the most spectacular astronomical development of the past 30 years, and the implications for the future in these fields lie beyond the range of the imagination.

However, the field of optical astronomy has also its charms for the future —even for earth-bound astronomers and telescopes, and I should like to describe some of these possibilities as they appear to a simple observer. The omission of further reference to radio astronomy, and to space, does not mean that I consider these fields unimportant but is, rather, a confession of inadequacy on my part to discuss them.

Continuities in 19th-Century Science

A perceptive observer, Jerome S. Bruner, emphasized a basic development in 19th-century science—the recognition of continuities—and he has pointed out the two giant figures in this development, Charles Darwin and Sigmund Freud. The former removed, dispelled, the concept of discrete categories for living forms and showed that organic connections, relationships, exist everywhere, and that man himself could no longer be considered a completely detached phenomenon.

Freud showed that in the case of the mind itself such absolutes as conscious-unconscious and sane-insane have to be abandoned, and that, in the case of these apparent opposites, a continuous sequence of phenomena has to be considered. In addition, developed and archaic qualities exist simultaneously in the same human mind.

Continuities in Astronomy

The development toward a concept of continuities has been a major feature of 20th-century astronomy. The idea of some uniqueness in the location of the earth, or the solar system, received three destroying blows in this century: (i) the demonstration by Shapley that the solar system is located far indeed from the central region of what Kapteyn had called "The Sidereal System"; (ii) the demonstration by Heber Curtis and by Hubble that our own stellar system is by no means unique, and that, on the contrary, multitudes of such systems exist; and (iii) the revision of the scale of distances by Baade, with its accompanying conclusion that our own stellar system is not unique in size. And, as we pass through the mid-century period, we find that more detailed study of astronomical problems brings us inevitably to a broader and broader concept of continuities in this field.

The "either-or" approach grows progressively more inadequate to describe the newly discovered shadings and relationships between phenomena. The concept of "giant" and "dwarf" stars, with its great importance in the historical development of stellar astronomy, has had to be modified successively by the introduction of subdividing categories—subgiants, supergiants, subdwarfs—and, finally, by the recognition of continuities.

The picture that developed out of Baade's brilliant discovery of the two stellar populations has had to be successively modified, first by recognition of an increasing number of subdivisions and now by development of the concept of a continuity of populations lying

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all along the range between Baade's extreme population I and extreme population II.

In the field of star clusters, an equally drastic change in point of view is taking place; the two historical categories of globular clusters and open clusters are becoming indistinct, and in their places comes the realization that the star-clustering phenomenon is probably a continuous one—from the extreme examples of halo globular clusters to the clusterings of stars in dense clouds of hydrogen. There can be no doubt that this progression toward recognition of continuities will develop further in the future.

Some Characteristics of the Present

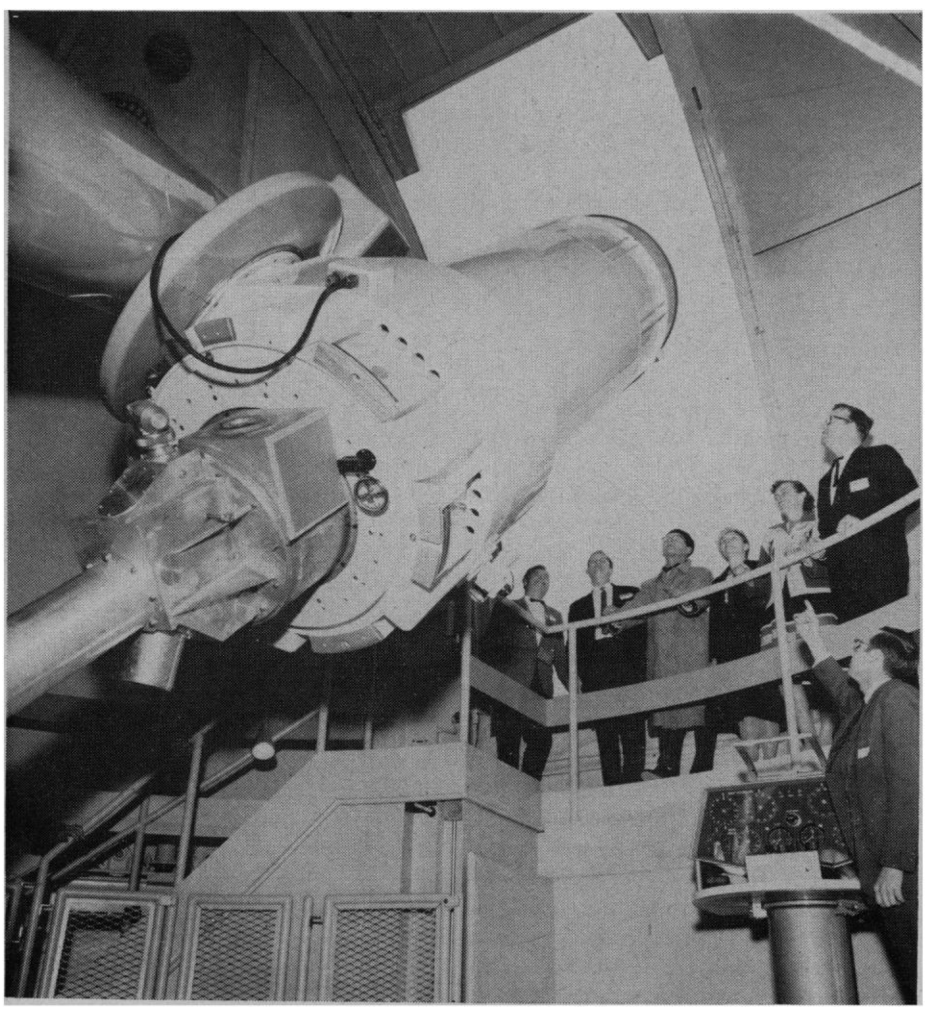
If we limit ourselves to optical astronomy from the earth's surface, certain tendencies seem to be clearly visible. The first of these is the revolution in instrumentation.

At the present time, to my knowledge, there are no firm plans in the Western countries for the construction of optical telescopes larger than the giants at the Palomar and the Lick observatories; but a great improvement in quality and applicability is taking place in the design and construction of telescopes of intermediate size, and (again to the best of my knowledge) the most significant developments in this direction are those going on at the newest of American observatories, Kitt Peak National Observatory.

Overshadowing all other instrumental development is that of image intensification. The real breakthrough in this field has already occurred, and it seems certain that within a very few years the image intensification technique will be in use throughout the astronomical world. This development is, by itself, causing a complete re-examination of the types of telescopes that are most suitable for the problems of the present and future.

The requirement of high aperture for the photographing of faint stars now is being reconsidered, and the advantages of the longer focal lengths in combination with image intensification techniques are becoming clear. One result of this change in emphasis is that certain telescopes now considered to be in the twilight of their careers of prime usefulness may have a recrudescence of life. The 40-inch refractor of the Yerkes Observatory is an interesting example. After a long and honorable career in the forefront of world astronomical research, it has seen the great reflectors take over the commanding role in almost all branches of modern astronomy. For the brighter stars, the great optical stability of the 40-inch has given it a continuing pre-eminence for the precise determination of relative positions of stars; however, this is almost the only field in contemporary astronomical research where the great reflectors have not superseded it in importance. Now, with the imminent introduction of light-amplification methods into astronomy, the speed and efficiency of the 40-inch refractor can be increased to such a degree that it may again have a wide area of usefulness in astronomy.

Of course, if another breakthrough were to take place in increasing the speed of photographic materials, the gain in usefulness of long-focus refractors would also be very great; if photographic emulsions could be increased in speed by a factor of 20, the Yerkes 40-inch telescope would have prime usefulness in the fields of galaxies, star clusters, and other basic areas of research of the mid-20th century.



Visitors to Kitt Peak National Observatory on dedication day inspect the 36-inch telescope.

Vistas of the Future

In site surveys for new observatories, one of the most important factors is the quality of the seeing—or the atmospheric steadiness of the star images. However, there have also been other requirements, such as proximity to roads and other factors affecting living conditions. In the future it may well be that factors other than seeing and transparency of the sky can be minimized in importance in favor of obtaining viewing conditions of absolutely highest quality. The observatory on Pic du Midi in France has seeing of superlative quality; access to this observatory is difficult, and living conditions are satisfactory only because of great preparatory efforts; however, in these days of major technological advances a very great range of sites becomes available, and comfortable living conditions can be provided almost anywhere.

Because of these developments, surveys can now be carried out that have as their purpose the location of the finest possible observatory sites, with much less attention given to accessibility than in the past. Then the problem of installing the best possible instruments on these sites and arranging for satisfactory living conditions becomes a technological one. It seems quite possible that this approach may furnish sites for future observatories far superior to any now in use on the earth's surface, and intermediate in quality between the best of existing observatory sites and those contemplated for future establishment on vehicles outside the earth's atmosphere.

And now, let us look for a few moments at some of the vistas in astronomical research itself. The safest predictions for the future are those in areas where breakthroughs in method have occurred recently—methods which have not yet been utilized, except in a preliminary fashion. I shall refer briefly to several instances of this kind.

1) A few years ago, Bengt Strömgren developed a method whereby, from precise measurements of a star's radiation within certain narrow, specially selected spectral regions, he was able not only to determine the true luminosity, or candle power, of a star but also to derive the stage in evolution of the star—and therefore, in principle, its age. This method of Strömgren's, as used by himself and by his pupil D. L. Crawford, now makes possible the determination of distances and ages of hundreds of thousands of stars, and this with the use of telescopes no larger than the completed 36-inch reflector of the Kitt Peak National Observatory.

And what problems can be solved by this kind of observation? Problems concerning the precise nature and location of the spiral arms of our galaxy and the arrangement in space of stars of varying ages and physical characteristics, and there is even the possibility —with the giant telescopes of Palomar and Mount Hamilton—of investigating the physical similarities and differences of stars in the galaxies nearest to our own.

2) One of the most active fields in present-day astronomy is the study of galaxies, or great clusterings of stars similar to the Milky Way system in which our sun and planets are located. Investigation by means of the spectroscope shows that some galaxies are composed principally of hot, blue stars and gas, while others are composed principally of cooler yellow and red stars, there being little evidence of large quantities of gas; intermediate between these two categories are galaxies having mixed characteristics, of hot and cooler stars together and intermediate amounts of gas.

Now a relationship exists between the forms of the galaxies and the stellar populations just described. The galaxies that contain the greatest proportion of extremely hot stars and gas turn out to be irregular in shape, with little concentration of their light toward their centers. On the other hand, galaxies composed principally of the cooler yellow-red stars are found to possess extremely luminous central regions and a generally symmetrical appearance. From an extension of these conclusions it becomes possible to make an approximate determination of the stellar and gaseous characteristics of galaxies from a simple inspection of their forms. And so, a method is furnished whereby the average stellar-population characteristics of galaxies can be determined over extended regions of the universe.

I could describe many other instances of exciting possibilities for astronomical research in the future; however, we must content ourselves here with the statement that at no time in the history of modern astronomy have there been so many golden pathways toward the expansion of our basic knowledge of the universe; never has there been such a rich range of possibilities for fruitful investigation by those now working, or by those expecting to enter the field of astronomical research.

Science in the News

Basic Research in the Defense Department: The Department's View

Final agreement on the $40 billion Defense budget was reached last week just before the congressional recess began. The appropriations include over $4 billion for RDT & E—research, development, test, and evaluation. A small proportion, roughly 3 percent, of this will be spent on basic research, but a small proportion of this huge sum makes up a very significant portion of the total amount of money the government spends for basic research.

The official budget lists $136 million, but together with other sums that properly should be considered basic research, the Defense Department will probably spend $150 million during the 1961 fiscal year, which began 1 July. This will be about one quarter of the total federal investment in basic research, and compares with a little over $100 million to be spent by the National Science Foundation, the government agency specifically created to support basic research.

Because Defense has a fairly good idea of where it wants to spend its money, its mechanism for giving grants is quite different from that of the NSF. The foundation picks out what seem to be the most promising proposals submitted. Defense identifies certain areas it wants to support and then uses a sort of talent-scout system to seek out people in the universities and foundations who can do some work in the area. Here are a few samples of the areas singled out by an advisory panel last year: physics—work with high magnetic fields; meteorology—wind fluctuations in the upper atmosphere; mechanics—theory of elasticity; mathematics—theory of numbers; geography—exploration and mapping of the polar regions; chemistry—preparation and properties