GENERAL SCIENCE

Challenge of Space Age

The space age has brought together physics, astronomy and the earth sciences to form an area of research of its own. The greatest achievement will depend on future scientists.

By. DR. ROBERT JASTROW

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An address given at the awards banquet of the 12th National Science Fair-International in Kansas City, Mo., May 12.

➤ IT IS AN HONOR to speak at the 12th National Science Fair-International, and to address the young men and women who have earned the privilege as winners in state and regional science fairs of displaying their science projects in this national competition. We wish to congratulate the SCIENCE SERVICE also, and the Science Clubs of America, who have made this outstanding National Science Fair possible.

I know you shared with me and all Americans a strong feeling of pride and excitement on May 5, when we sent the first American astronaut into space and back safely to earth. That was a great achievement, the first major step in our program for the manned exploration of the planets, and the harbinger of important events to come.

These are remarkable times, both for us already engaged in research, and for you who are now discovering the basic structure of science. There has been an explosion of energy in the new field of space research, a field which came into existence only three years ago, but has already brought together large areas of physics, astronomy, and the earth sciences to form an area of research with a character and integrity of its own. The rate of growth in this new discipline has been phenomenal. In 1958, a single scientific monthly, the Journal of Geophysical Research, published a half dozen papers in space science. In 1959 this same monthly published approximately 60 articles in the field, and in 1960, no less than 120 articles.

Scientists Respond to Challenge

This volume of activity represents the response of scientists to the opportunity and the challenge provided by rockets and spacecraft which can carry apparatus weighing several hundred pounds into orbit above the atmosphere and out into interplanetary space.

These spacecraft permit us to obtain information which we could not get on the ground. They open up new avenues of attack on some of the most important scientific problems to occupy the mind of man—problems related to the manner in which the sun controls the atmosphere of the earth; to the properties of the moon and the planets, to the origin and the history of the solar system; and to the structure of the universe in its most distant regions.

Our government and our scientists, in collaboration with the scientists of the United Kingdom and other countries, are responding to these opportunities with a remarkable display of energy and imagination. In a series of 19 elaborately instrumented scientific satellites and space probes launched during the last three years, we have examined the properties of the upper atmosphere and its extension into the interplanetary medium, and unraveled the complex and significant history of the relation between atmospheric properties and the solar outbursts; we have taken photographs of the earth from above, which reveal patterns of organization in the cloud cover over areas hundreds of thousands of square miles at one time and are rapidly advancing our ability to forecast the weather; we have charted the deviations of satellite orbits from their expected paths, determining thereby the irregularities in the gravitational field of the earth, and acquiring an understanding of the structure of our planet in its deep interior which could not be gained by surface means and most recently we have launched a gamma-ray telescope into orbit, designed to reveal the sources of energetic radiation in the sky, previously hidden from us by the blanketing effect of the earth's atmosphere.

Contribute to Astrophysics

Among these many projects in the National Aeronautics and Space Administration science program, astrophysics is an area to which we can make a unique contribution. All the information we have about the stars and galaxies in the distant regions of the universe comes to us in the form of starlight reaching the surface of the earth. This light is collected by large telescopes, dispersed into a spectrum, and photographed to tell us the composition, the temperature, the speed of motion, and other basic characteristics of the stars and interstellar gas and dust between them. That is how we obtain the knowledge we now possess regarding the universe around us.

This information which can be collected on the ground is pitifully meager because the atmosphere of the earth is an absorbing curtain, which screens out most of the starlight reaching us, permitting only a small band in the visible region and a certain amount of the radio region to arrive at the ground. We can study the full spectrum of incident starlight and thereby immeasurably increase the understanding of the entire universe, if we can mount a telescope in a satellite and place it in orbit above the earth's atmosphere.

For the first time in the history of science we now have the ability to do precisely that, and the development of the satellite telescope, called the Orbiting Astronomical Observatory, is one of the major projects of the NASA science program. It will take several years to perfect the techniques of guidance and control for pointing the telescope accurately from its satellite mount, and other problems that must be solved for the orbiting telescope, but when they are surmounted, the satellite observatory will be one of the most important contributions that the space program can make to science.

The coming NASA investigations of the moon and the planets are both scientifically important, and perhaps the most exciting of all to the general public, because they involve the direct physical exploration of virgin territory, in the spirit of the voyages of discovery and exploration in the sixteenth and seventeenth centuries by which we came to know our own planet.

Moon Explored First

The first extraterrestrial body to be explored will undoubtedly be the moon, which is the earth's nearest celestial neighbor. Mars and Venus are 100 times more distant, and a rocket that could reach the moon in a day or two could take months to arrive in the vicinity of one of these planets. An instrument station on the moon could also communicate with the earth more easily than one on Mars or Venus. The moon is a way-station en route to the planets, and a testing ground for the development of rocket technology and scientific apparatus required for the exploration of the planets.

The moon is a body whose surface has probably preserved the record of its history remarkably well, and better in fact than either Mars or Venus. For this reason, the moon is a particularly interesting object to the scientist, quite apart from its role in the technological development of the space program. It is a Rosetta Stone of the solar system, whose surface holds a key to the history and development of planetary bodies. The exploration of the moon will provide otherwise unobtainable clues to the manner of formation of the solar system, some four and a half billion years ago, and to its subsequent history.

In the first decade of the lunar exploration we will rely on unmanned spacecraft. The first major flight in the unmanned program is expected to take place in less than a year, when a spacecraft known as the Ranger is launched toward the moon on a trajectory which will carry it to an impact in the vicinity of the craters of Copernicus and Kepler. Ranger is now under development in the Jet Propulsion Laboratory of the California Institute of Technology. On approach to the moon's

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surface, it will obtain a series of TV images and relay them to the earth by radio. The last of these photographs should have a resolution of details on the surface hundreds of times better than obtainable on earth.

It will contain other instruments, including a seismometer designed to survive the shock of impact and to transmit back to earth data on the level of earthquake activity within the moon's interior, which can be analyzed to determine the moon's internal structure. Later and more advanced spacecraft, to be launched with rockets of greater thrust, will be able to deposit instruments gently on the surface of the moon for sophisticated physical and chemical tests of its surface.

Manned Flight to Moon

When manned flights to the moon become possible, we will reach the culminating and most rewarding phase of the lunar exploration. An extended period of engineering and scientific development will be necessary before we can achieve manned flights into space. The first step towards that goal is represented by the Mercury project which has as its objective the orbiting of an astronaut around the earth, and his safe return. The Mercury project involves the training of astronauts; research and development on life support and safety systems; recovery of the space capsule; and the critical problem of re-entry of the space capsule into the atmosphere after the orbiting of the earth.

Orbiting of the Mercury space capsule, now that we have successfully achieved a sub-orbital flight test, will be our next big step forward. Then subsequent to the orbiting of the manned spacecraft around the earth, there is planned a manned spacecraft known as Apollo, which will carry crews of two or more astronauts; weigh 15,000 to 20,000 pounds; provide living quarters with limited freedom to move about and carry out scientific observations in the capsule and assure sufficient flight duration and maneuverability for missions varying from earth orbiting, to moon orbiting, and return.

These are the achievements and potentialities of the space program in basic science; in addition, in the course of several years, earth satellites will make extremely important contributions to applied science, in the fields of communications and weather forecasting, with direct and immediate gains for the economy of this country and of the world.

Satellites for Radio and TV

Today the capacities of international teleradio and cable systems are burdened by present needs and will be exceeded by tomorrow's demands. Conventional terrestrial television signals cannot be transmitted directly more than 200 or 300 miles. Even though ground-based microwave relay links and coaxial cables overcome range limitations, they are impracticable, unreliable, or prohibitively expensive for overseas communications.

Such programs as NASA's project Echo (the "passive" or non-instrumented balloon satellite many of you have seen passing overhead) have demonstrated that satellites can be used to reflect teleradio and TV signals.

NASA's planned project Relay will involve the launching of "active repeater" satellites into space, which, with their electronic instruments, will relay messages from the earth to other active repeater communication satellites and back down to the earth at the desired terminal point.

NASA's successful meteorological satellites, Tiros satellites I and II, have already observed and transmitted more than 44,000 television pictures of the earth's cloud patterns and taken infrared measurements of the heat of the earth and its atmosphere. These meteorological satellites are the first steps in aiding us to understand better the atmospheric processes which produce our weather and climatic changes.

Weather Research

At present our meteorological observations from the ground and from balloons only can provide us with a 20 to 30 percent coverage of weather phenomena, mostly from the Northern Hemisphere and the underside of the atmosphere. Extensive areas are not yet covered by weather observations, and constitute regions in which storms can be generated and grow without detection, before they move over inhabited areas. These gaps will be filled by a weather satellite system.

The significance of these projects is sometimes lost in the international competition over rocket thrust, but it must be remembered that it is the scientific achievements, in both manned and unmanned flights, which deepen our understanding of the nature of the universe and the causes of natural events, and which are the enduring contributions of space research to society. It is this progress in our understanding of the world around us which you, who are embarking on careers in science, must always keep before you as your principal goal.

Future Rewards in Space Science

The discoveries in science which you achieve will have an enormous effect on our lives in the future. We have entered a period of rapid scientific progress, in which the rewards can be very great, but the responsibilities are very heavy. The scientists of my generation have already made a start towards the realization of the potential benefits of space research. But we are working with very crude tools in the Model T era of the space age.

Our greatest achievements are still ahead of us, and our success will depend entirely on the scientific and engineering talent of your generation. These are great opportunities and a great challenge, both for you and for the schools and universities from which you will obtain your training. I congratulate you again as regional and national winners, and I wish you every success in your future efforts.

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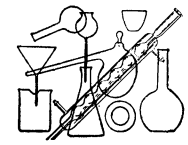

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