The Knowledge Bank – 1971

Narrator: Today we have an incredibly sophisticated scientific laboratory in space. OSOs, OGOs, OAOs, IMPs, RAEs, and other scientific satellites carry the experiments of famous scientists from many nations. This achievement can only be understood by measuring it against generations of scientific endeavor. Let's step back to that rainy day in 1752, when a great American put a scientific deposit in the bank of knowledge. He identified lightning with electricity, though of course he had no way of understanding how to use its power. Over the next century, other deposits were made, until one day the discoveries poured in so fast that the sum of knowledge became enormous. Faraday discovered how to build a motor. Wilhelm Roentgen was experimenting with a strange force which he named X-rays. Almost at the same time, Thomas Edison cashed in on Ben Franklin's deposits in the knowledge bank as he discovered how to light a bulb, starting the age of electricity. Science continues this way.

The deposits may seem small, but the interest is enormous and the payoff is frequently beyond even the range of science fiction.

Today's Franklin stands in the shadows of a launch control room, watching his instruments roar aloft to gather knowledge for the bank. The tools of investigation have changed since Franklin's day, but the methods have not. His kite is a spacecraft, his key a cosmic ray detector or a miniaturized mass spectrometer, his string the stream of data linking the experiments with the ground station.

Space science is science done in space. The laboratory has become enormous. Space science began with the first balloon carrying photographic film to detect cosmic rays above the curtain of the atmosphere. These balloons investigated the first 35 miles up, the troposphere and stratosphere, as we call them. Beginning in 1945, scientific sounding rockets began mapping the ionosphere, that is, from about 35 miles up to about 1,000 miles. Sounding rockets do not orbit like satellites; instead they take an important vertical sample of the upper atmosphere and also make measurements at altitudes too low for satellites. It was experiments on sounding rockets that first discovered X-rays from the Sun and first observed the Earth's enormously complex cloak of charged particles, the ionosphere. In 1958, the Van Allen team, their experiments riding on the first satellite, Explorer 1, discovered great seas of intense radiation swirling about our fragile spacecraft Earth.

Since 1958, nearly 150 satellites, to say nothing of over 1500 sounding rockets, balloons, and high-flying aircraft, have mapped the Earth's environment in space in ever-increasing detail. High altitude satellites concentrated on what came to be known as the magnetosphere, a vibrant, turbulent teardrop shaped by the million mile per hour solar wind, tormented by severe turbulence on its shock front and buffeted into a streaming tail stretching millions of miles away from us, away from the Sun. This enormous sea of charged particles and magnetic fields is affected by every mood of the Sun. And when the Sun flares up, its energy interacts vigorously with the magnetosphere, the ionosphere, and the atmosphere in very noticeable ways.

Pilot: Good evening ladies and gentlemen, this is your captain speaking. If you look to the right-hand side you'll notice we're getting a very pronounced aurora over the entire sky. And further south…

Woman: I can hardly hear you, can you hear me? Mom? Mom? Can you hear me? Isn't this a terrible connection?

Newscaster: The long range forecaster said today that high radiation levels may force postponement of this important manned flight.

Narrator: From this research in space, the physicists can, for the first time, begin to understand the Earth-Sun relationship as a single system. And as they look beyond our star they begin to sense the presence of titanic forces as awesome as lightning was to primitive man. It has been a decade of unlocking secrets; of naming things and drawing maps, maps unlike any you have ever seen; a decade of making things work the first time; of continual battering against the frontiers of scientific knowledge; a decade of lofting instruments and telescopes above the distortion caused by the Earth's atmospheric blanket; of world-wide tracking networks and international cooperation. As Franklin identified lightning as electricity, we have identified new forces and phenomena which we now have to try to understand. That will be the role of the scientific satellites of the seventies. Building on deposits that previous generations left in the knowledge bank, our generation has left some remarkable deposits of its own. The benefits of this wealth of scientific knowledge for the future are certain to be astonishing.

One of the first areas of satellite exploration in the 1970s will be in what we call the transition region of the upper atmosphere, from 75 to 95 miles. In this region, harmful solar radiations are screened out. A new generation of atmosphere explorers will carry small rocket engines to help them overcome the drag of the very few air molecules in that region and to propel the spacecraft to different altitudes. Instruments that will count electrons, ions, and neutral atoms and take their temperatures will be carried aboard, as well as those for measuring the fluxes and energies of fast electrons, and instruments to measure the Sun's ultraviolet light, which affects these particles. The effect on the particles is something like what goes on in the kettle on your stove. If you look at molecules of boiling water under a microscope, you get an idea of how the Sun's energy stirs up the particles in the transition region of the atmosphere. We are interested in these reactions for the same reasons that James Watt was interested in boiling water before he invented the steam engine.

A small but important satellite of the seventies will be the SSS, which stands for Small Scientific Satellite. The mission of SSS-A will be to investigate in detail some of the phenomena discovered by the larger observatory satellites in the 1960s. The SSS can be launched by the Scout vehicle, a rocket which is readily transportable to any site in the world. SSS-A will be launched from the Italian San Marco range off the eastern African coast in order to concentrate on charged particles and magnetic ring currents around the equator.

While an economical spacecraft like the SSS is at work, an old established satellite will be continuing in business in the space between Earth and the Moon. These are the OGOs, the Orbiting Geophysical Observatories of the sixties. Six of these OGOs were flown, each with an expected lifetime of one year. Today, after nearly a decade of service, two of them are still going strong even though their original missions are accomplished. Now scientists from all over the world have been invited to plan new observations using the instruments onboard the OGOs. Because there is a long line of experiments waiting for a flight on new spacecraft, this further use on experienced satellites will be a valuable resource for space scientists in coming years.

To fly the increasingly sophisticated space instruments of the seventies, instruments which will analyze the discoveries of the sixties, NASA is planning the launch of three more Interplanetary Monitoring Platforms, nicknamed IMP. From 1963 to 1969, seven of these satellites have returned enormous quantities of data from vast areas of space. They have flown in a series of eccentric orbits, cigar-shaped rather than circular. These included the so-called Anchored IMP, which orbits the Moon. These spacecraft provided the first accurate measurements of the interplanetary magnetic field, the boundaries of the magnetosphere, and the shock front or bow wave set up by the shield of the magnetosphere against the solar wind. Without this shield, the Earth would be struck full blast.

Three new IMPs will seek the answers to the sources of energy in the particles trapped by our magnetosphere. They will also try to find out what it is that changes their speed. These super IMPs of the seventies have three times the size and ability of their ancestors. They will carry instruments, ranging from Geiger counter telescopes to a small computer, and will study a wide variety of phenomena: cosmic rays, gamma rays, solar protons, electric and magnetic fields, and the solar wind. Balloons, planes, sounding rockets, Atmospheric Explorer, the SSS, OGO, and IMP: this is the versatile bag of tools with which the astrophysicists of the seventies will examine the environment of Earth.

Every day the need to understand becomes greater. How can we properly design our communications and weather satellites if we don't understand the medium through which they must fly? How can we perfect a worldwide communications system without understanding how radio interference comes from magnetic storms? How can we put together a unified picture of the world's weather to the point where we could do something about it without understanding our entire environment, of which the lower atmosphere is only a fraction? These are questions which will sooner or later affect the lives of all of us. The space maps which are being made by the satellites of today will be to future explorers what the early maps of this continent were to those who opened the West. Day after day the space physicist continues to make important deposits in the bank of knowledge.

The space knowledge bank is a joint account between the physicist and the astronomer. Their instruments fly side by side, sometimes even in the same spacecraft. The physicist is an indoor man. He works in a very limited laboratory; it is only a billion miles wide. The astronomer, on the other hand, works outside that area. He is studying phenomena at distances which range to the very edges of the universe. However the physicist and the astronomer do have one thing in common: the Sun. This incredible furnace converts over 600 million tons of hydrogen into helium every second. Every square yard of its surface emits 70,000 horsepower into space as X-rays, ultraviolet, visible, and infrared rays, and as radio waves. To the physicist, study of the Sun is the key to the origin and survival of life on Earth. To the astronomer, the Sun is the only star near enough to be observed in any detail.

Since the telescope was invented in 1610, the astronomer's lens has been partially obscured by the Earth's atmosphere. He is continually plagued by the distorting qualities of air, to say nothing of pollution. He has also found that very little other than visible light and radio waves can penetrate it. Ultraviolet, infrared, X-rays, and gamma rays – in fact, over 90 percent of the electromagnetic spectrum – are all stopped by the atmosphere. As a result, the astronomer has always carried his telescopes as high as he could, but only in the last few years has he been able to rise completely above the heavy curtain between himself and the universe. Knowledge of the Sun and stars has expanded proportionately.

This is one of the Orbiting Solar Observatories, the seventh in its line and the first of four planned for the seventies. OSOs are easily recognized by their sail, the portion which locks onto the Sun, while the bottom wheel spins like a gyroscope to stabilize the spacecraft. Here under test at Cape Kennedy prior to launch, you can see how motors turn the sail to keep it steadily pointing at the Sun. OSO's sensors, in this case X-ray and ultraviolet spectrometers, scan the Sun in the same way as a TV camera, except very slowly, adding one line at a time to eventually return data which can be visualized like this, a solar map actually drawn by a computer.

Considering that the Sun's weight is 335,000 times that of Earth, you can imagine the length of time we have needed to complete our picture of its surface, its temperatures, and its thermonuclear behavior. That study will continue as astronomers and physicists prepare instruments that will be pointed even more carefully at the Sun by bigger, more sophisticated OSOs. How are solar cosmic rays generated? How are the charged particles in these rays accelerated to such astonishing energies? And how do they affect Earth's environment? It was through puzzling over star energies that scientists were led to the understanding of thermonuclear energy. No one can predict what new discoveries are awaiting withdrawal from the OSO deposits in the bank of solar knowledge.

During the decade of the seventies, NASA will place the manned orbiting Skylab into space. The Earth-circling space station will carry even more powerful solar telescopes to solve some of the puzzling mysteries surrounding our nearest star.

While the OSO satellites have been studying the Sun, king-sized satellites like this one have been studying the far reaches of the universe. This is OAO, the Orbiting Astronomical Observatory. Its size and weight, which is over two tons, are needed to accommodate as many as nine separate ultraviolet and X-ray telescopes, together with a maze of electronics for automated operation and great pointing accuracy. Three gyroscopes control the orientation of each of the spacecraft's three axes. The star trackers are gimbaled to find a target star, the coordinates of which are commanded from Earth. Once locked on, other trackers seek the fainter, distant stars which are to be studied. The entire procedure, and the storing of images and data for transmission, is automatic. So fantastic is its accuracy that from a distance of 50 miles OAO could observe one of your eyes, lock onto it, and hold that lock for an hour. Already the OAOs are cataloguing and measuring the brightness of stars and nebulae. During the seventies, OAO will be studying other heavenly mysteries: pulsars and quasars, white dwarfs, neutron stars, old novae, and hot young stars.

Cosmic radio noise led to the discovery of the pulsars by radioastronomy ground stations. Much radio noise, however, remains a mystery. At very low frequencies, such as seem to be controlled by some of the larger moons of Jupiter, these radio waves do not penetrate the atmosphere. They're even distorted by the magnetosphere. To study radio signals from the planets and stars, NASA will launch into lunar orbit RAE-B, its second Radio Astronomy Explorer. It will orbit the Moon, using the lunar disc as a shutter for accurate direction finding. The RAE satellite has antennas which unreel to the enormous span of 1500 feet, making it the world's longest satellite by far. The device by which these arms are extended after orbit is typical of the ingenuity of space engineers. This kind of technology can be applied to many industrial, medical, and community needs.

By contrast with the size of OAO and RAE, a new series of small and more versatile satellites is planned to bridge the gap between sounding rockets and astronomical observatories. This is SAS, the Small Astronomy Satellite. The SAS series concentrate on general surveys of X-rays and gamma rays over a broad area of the sky. The resulting large sky maps are being studied to select areas for closer investigation by other satellites.

At the frontier of space science, engineering, and technology for the seventies will be HEAO, the High Energy Astronomical Observatory. Still being designed, HEAO will carry six tons of instruments to find and measure cosmic rays, their energies, and their velocities. These naturally occurring particles have energies of perhaps 100,000 times those being generated artificially by the largest atomic accelerators on Earth. Somewhere in these phenomena are the secrets of incredible energies beside which nuclear power is like a small match struck in a dark room. HEAO will seek to learn the ways in which these energies are created.

Ten years of space science research have solved some mysteries and presented some profound new ones, mysteries which may be close to explaining man's role in the universe. Within the next ten years, many of these mysteries, complex as they are, will be well within the grasp of anyone with a curious and restless mind. Imagine a form of matter which the more you look at it, the less you can see, a star which is collapsing so fast that no light can escape from it, leaving a black hole in the sky. When scientific satellites look across the universe to the quasars, they may be looking billions of years into the past. When they look at a supernova, an exploding sun so bright as to actually cast shadows on Earth, they may be looking billions of years into our future. To a visitor from an equally curious planet, the Earth would have looked no different than this, that day in 1752 when Franklin established the relationship between lightning and electricity. On the cosmic scale, little time at all has elapsed since that event, although our scientific knowledge has exploded at a rate equal to what we imagine the explosive creation of the universe to have been 10 billion years ago. In that so recent tick of time, Benjamin Franklin deposited his findings by hand, by candlelight; today by electric light and into an electric ledger, the physicist and the astronomer enter their deposits of knowledge. Little by little they build a picture of nameless new forces beside which electricity is an infant. It makes one wonder by what light and into what ledger we will record the future, the future which space science has already placed in our hands.