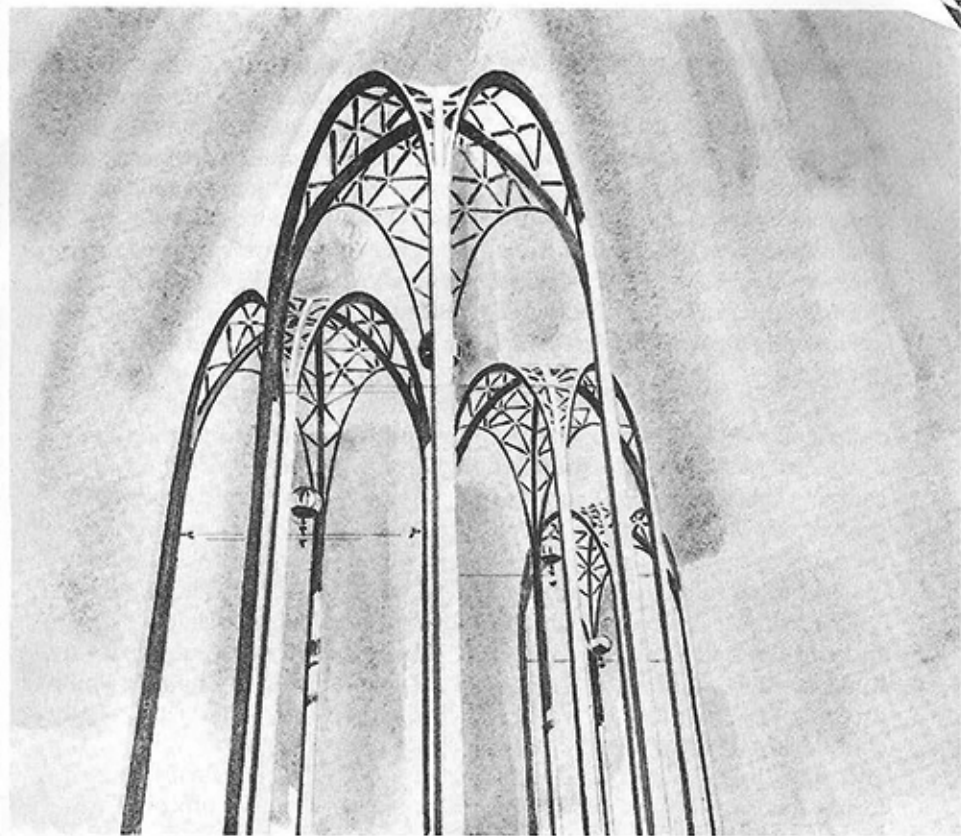




WORLD OF
SCIENCE



volved in nutrition (and growth) processes.

6) Transformation—a motion picture presentation of the transformation experiment in which a dead resistant strain of pneumococci and a live non-resistant strain are mixed together and injected into a mouse. Eventually, the tissues of the infected mouse have live resistant pneumococci.

7) Avery, MacLeod and McCarty—a graphic display of their identification of deoxyribonucleic acid (DNA) as the transforming principle in experiment six.

8) Watson and Crick—a display of their picture of a DNA molecule as a double helix and an explanation of the arrangement of the molecular series of the helices, demonstrated by a large three-dimensional model of a DNA molecule.

9) Summary panel—"Life is the control of increasing orders of complexity."

In Space:

1) Tycho Brahe—a replica of his armillary sphere to represent his precise measurement of planetary motions.

2) Development of the heliocentric idea of the solar system—three short animated motion pic-

tures on three adjoining screens discuss: Ptolemy (geocentric concept, circular orbits of planets and sun); Copernicus (sun is center, planetary orbits circular); Kepler (planetary laws based on Brahe's measurements, sun is center, planetary orbits ellipses).

3) Galileo—a display of the theory of falling bodies; an adaptation of his inclined plane experiment.

4) Newton—universal gravitation is shown in a three-dimensional presentation demonstrating that Newton brought together Kepler's laws of planetary motions and Galileo's study of falling bodies in the law of universal gravitation.

5) Einstein—a demonstration of the extension of Newton's law of universal gravitation in the general theory of relativity.

6) Einstein—the theory that motion is relative to some arbitrarily chosen frame of reference is demonstrated by twin simulated rocket ships traveling at different velocities.

7) Earth motion model—a sculptural presentation of the four dimensional path of Earth in space-time.

trip into space starts and ends in this circular, domed auditorium.

The imaginary 10-minute excursion to the outer galaxies simulates what in actuality would be a two-billion light year journey.

The passengers—up to 750 of them per trip—take their places behind curved hand railings mounted on the tiered floor. A voice identifying itself as "Spacearium central control" announces the time to takeoff. Background music and sound blend to create the impression of closing doors and escaping air. The lights dim and a narrator explains that to make the journey in the time allotted this "ship" travels at 10-trillion times the speed of light.

The theater fades into almost complete darkness, the music swells to a crashing climax and in the dome shutters open to reveal Earth in the late afternoon sunlight. The trip is begun.

After following Earth's curve for a short time, the ship sets on a lunar course and a full moon looms at eye-level dead ahead. The narrator explains: "One quarter of a million miles from Earth, our moon is a satellite world of desert flatlands and tumbled mountain ranges . . ." The ship turns slightly and the moon begins to pass over the dome. It fades to a quarter and to the rear as the constellations of Leo, Virgo, Libra and Scorpius come directly in view.

Another change of course and the sun rises on the left. The ship approaches nearer; the narrator speaks: "Our sun, our own star—a gigantic nuclear fission furnace—converts four-million tons of matter into energy each second."

Sun spots and solar prominences, great leaping flames millions of miles long, are clearly visible before the sun slowly recedes and casts rainbow colors across the sky.

Mars appears in the far distance as a tiny red speck. It grows bigger as it gets closer. "Fifty-million miles from Earth," the narrator explains, "orbits the red planet Mars, named for the mythical god of war. Though colder and only half as big as Earth, Mars may support some form of life."

In the empty vastness between Mars and Saturn, only an occasional asteroid disturbs the darkness.

"And 800-million miles from Earth, mighty Saturn rules," the voice of the narrator coincides with the rise of the ringed planet ahead. The ship passes between the colored rings as it roars outward past remote Pluto, the outermost planet in the solar system.

"Out from here extend vast intervals of space. On the course we are traveling, it is 60-million-million miles to the first neighboring

AREA 3—THE SPACEARIUM

Four times an hour, a 60-thousand-billion-billion-mile round

star," the narrator advises.

Rose 154, a white flare star, smaller, cooler and redder than the sun shows in the dark sky briefly. Then a double star, a giant red sun and a white dwarf, appears.

Further into space, clouds of light resolve into billions of separate stars which are the hub of the Milky Way, Earth's galaxy.

As the ship changes course again, Spacearium central control announces: "We're leaving the Milky Way Galaxy and setting course for Andromeda. Grasp hand rails, please."

Before Andromeda comes into sight a great globular star cluster appears overhead, but it and the other stars in the Milky Way retreat to the rear. Looking back, the whole of the Milky Way, one-billion-billion miles across, fills the lower half of the view. Forward, Andromeda grows larger.

"And now we approach Andromeda. Twin sister to our galaxy, this colossal complex—like the Milky Way—contains 100-billion stars, each reeling in immense orbit," the narrator says.

The ship swings in a giant curve and Andromeda shifts past to the left and all the other stars fall from view. There is momentary silence as the ship completes its 180-degree turn and galaxies rise at every quarter.

In a small spiral galaxy close by, a supernova begins to grow. A cosmic nuclear explosion, the supernova creates a brilliance greater than all of the other stars of its galaxy combined.

As these celestial fireworks fade, Spacearium control reports: "We are setting course for home." The trip back is only a matter of seconds, past Venus and Mercury. As it ends the shutters close over the dome and the theater lights go on.

The Boeing Company of Seattle conceived the idea for this space age planetarium and is joint sponsor of the project with the U. S. Department of Commerce. Cinerama, Inc., headed a group of subcontractors which supplied lens, projection equipment and screen, and Fine Arts Productions, Inc., made the film.

The Spacearium screen is an eight-ton aluminum dome 75-feet in diameter, 38-feet high, with a total viewing area of nearly 8,000 square feet.

The dome is suspended inside a rectangular shell and the floor is tilted slightly to provide a point of reference for the audience.

The projector, which has the world's largest wide angle lens, is in a housing in the middle of the audience area. The newly-designed 70-millimeter lens was used to shoot the film as well as

to project it on the dome, 360-degrees horizontally and 160-degrees vertically.

In producing the film, Fine Arts, Inc., built an imposing photographic library of space objects.

AREA 4—METHODS OF SCIENCE

To show the variety and ingenuity of present-day scientific methods, examples of the work being done by scientists on 25 diverse research projects are on display in this area, the largest in the United States Science Exhibit. The title of each of the exhibits is in the form of a question and they are arranged in six groups according to subject matter.

The first exhibits explore the nature of our surroundings. Counter-clockwise around the hall other groups treat: the sources of energy; the nature of behavior; how living organisms function; the structure of matter, and the molecular basis of life. In the center are a model cell exhibit and a modern laboratory in which members of the staff perform simple experiments in public view.

GROUP 1—THE NATURE OF OUR SURROUNDINGS

Title: Where are radio waves generated in the universe?

Experiment: A model radio-telescope installation shows how radio waves from outer space are

received and recorded. The length of the waves varies from 2.5 centimeters to 38 meters, depending on their point of origin in space.

Title: How can we see planets and stars more clearly?

Experiment: A stratoscope model and photographs show how astronomers loft telescopes by means of balloons to escape the earth's atmosphere and increase the effectiveness of the telescope.

Title: What are the electromagnetic forces around the earth?

Experiment: The earth's magnetic field captures charged particles from the sun that are associated with sun spot activity. Interactions of such particles with the earth's radiation belts and ring currents cause auroras and interfere with radio transmission. These phenomena are studied by rocket probes and simulated with models such as the stormertron, which is displayed here, and with films of the aurora and the sun's corona.

Title: How can we study the shape of the earth from the satellites?

Experiment: A model radio-telescope installation shows how radio waves from outer space are received and recorded. The length of the waves varies from 2.5 centimeters to 38 meters, depending on their point of origin in space.

Experiment: The TRANSIT system of satellites and ground plotting stations supplies accurate information about the earth.

Title: What is inside the earth?

Experiment: The Mohole project, in which scientists attempt to drill through the earth's crust, is described.

GROUP 2—THE SOURCES OF ENERGY

Title: How can we produce electricity more directly?

Experiment: There are many ways to convert heat energy into electrical energy mechanically. Science is searching for a more direct method.

Title: How can we control nuclear fission?

Experiment: Scientists' attempts to emulate the sun's burning processes are described.

GROUP 3—THE NATURE OF BEHAVIOR

Title: What can salmon see?

Experiment: To discover why salmon migrate and how they are able to travel thousands of miles to spawn in the place of their birth, science is investigating what and how salmon see. The evidence presented in this exhibit suggests that at a minimum they can discriminate colors.

Title: What controls early behavior in animals?

Experiment: Day-old chicks will follow any moving object and

once the response becomes "imprinted" the chicks follow the same object throughout their lives. In this experiment, chick reactions are studied under controlled conditions.

Title: What leads to mother-child affection?

Experiment: Groups of monkeys have been reared with real mothers and surrogate mothers. This experiment shows the monkeys' reaction to "mothers," made of steel wire, which feed them and "mothers," made of other material, which are soft and warm. Animals reared with surrogate mothers prefer them throughout life and choose the "mother" with the comfortable lap before the one with the food.

Title: How does heredity affect animal behavior?

Experiment: Scientists have developed strains of mice of peculiar habits. One kind prefers alcohol to water; another likes to eat inordinately and will grow excessively fat. This exhibit shows how scientists study such genetic effects and what they mean to humans.

Title: How do animals learn?

Experiment: Primitive man discovered that he could teach a dog tricks by rewarding him with bits of food. In recent years men have tried to find out, on a scientific basis, just how and when

rewards can best be given. They have found that animals can be taught some very subtle tricks. The pigeons in this experiment are taught to discriminate between shapes. Various methods for conditioning animals are under study.

Title: What are teaching machines?

Experiment: Science is investigating ways to improve and speed up the teaching process. Some mechanical means have shown great promise. Some of them are demonstrated here.

GROUP 4—HOW LIVING ORGANISMS FUNCTION

Title: How does a firefly produce light?

Experiment: The abdominal region of the firefly is dried and its various chemical components are isolated to determine which are necessary for light production. These are mixed to reproduce in a "test tube" the firefly's light. How this information has been utilized as an analytical tool is also demonstrated.

Title: How can we speed up nerve growth?

Experiment: Chemicals seem to determine the growth of certain nerve tissues. In this experiment the chemicals are isolated, and their origins found.

Title: How do muscles contract?

Experiment: An electron microscope takes pictures of muscles. Study of the results of transplanting the muscles from one individual into another reveals suppressed reaction.

Title: How is plant growth regulated?

Experiment: In an experimental garden, some of the plants grow under normal conditions, others have been treated with a growth retardant and some have been treated with Giberellin, which was discovered in Japan during World War II and is the subject of intensive study. The differences are marked.

Title: How does information come to us through our eyes?

Experiment: A large model of the human eye and its pathways to the brain, a closed-circuit television and a machine that slices tissues so thin that they are invisible to the naked eye are parts of this exhibit, which shows what science has learned about the workings of the visual system.

GROUP 5—THE STRUCTURE OF MATTER

Title: How do we see the structure of an atom?

Experiment: By scattering high energy particles supplied by electronic accelerators, science is able to study details of the atomic structure and construct models of the atom as displayed here.

Title: What is the shape of the atomic nucleus; what is its structure?

Experiment: Scientists at the Bureau of Standards at Stanford University have managed to trace the shape and structure of the atomic nuclei by scattering X-ray and electron particles.

Title: What are the basic constituents of the nucleus?

Experiment: Brookhaven National Laboratory scientists sighted strange particles within the atom. Their findings contributed to the modern picture of the atom on view in this display.

Title: Where do cosmic rays come from?

Experiment: Natural high energy particles from outer space are studied by means of counters, spark chambers and cloud chambers at observatories such as Volcano Ranch. Recent data reveal particles too energetic for origin in our own galaxy.

Title: How do we grow diamonds?

Experiment: The right combination of temperature, pressure and molecular forms of carbon will produce diamonds synthetically. The process is explained and enacted here.

GROUP 6—THE MOLECULAR

BASIS OF LIFE

Title: How are genes transmitted?

Experiment: By feeding radioactive thymidine to a plant and then tracing the radioactivity in its cells, science has been able to determine how chromosomes which contain the genes are made, when cells divide and what happens to them in the process of growth.

Title: Can genes be synthesized?

Experiment: Scientists in a laboratory have incubated a synthetic DNA (abbreviation for the chemical, deoxyribonucleic acid) that is markedly similar to natural DNA.

Title: How do viruses infect?

Experiment: The outer wall of the virus consists of protein. This, with the cell to be invaded, serves as a means of attachment and may contain substances that trigger the entry of viruses into the cell. The inner core of the virus usually consists of DNA and controls the production of many new identical virus particles inside the cell. The process is duplicated on film.

The model cell exhibit is close to and a part of the molecular life series of experiments. It consists

of movies, models and displays which explain and illustrate what science knows and conjectures about the cell, the basic unit of life—what it is, how it works, when it dies.

The biologist can look into one particular cell and learn things about all cells. The more he

AREA 5—THE HORIZONS OF SCIENCE

Up to this point in the story being told in the United States Science Exhibit, the accent has been on the functions of science. The scientific approach to the search for knowledge has been demonstrated.

Scientific knowledge inevitably leads to action. It enables man to harness nature's forces, to ease the burdens of living and lengthen the span of life. As it increases, man's ability to act, to mold and control his environment, will increase.

In Area 5, at the conclusion of the story of science, the implications of science are examined. There is a single monolithic exhibit here to reinforce a single dominant impression—that science and its resulting technology can be used by society to increase and enlarge its own horizons.

Four aspects of the implications of science are treated here:

learns, the closer he is to the explanation of the secret of life.

Adjacent to the cell exhibit in the center of the area is a model of the modern laboratory in which attendants conduct demonstration experiments in electrophysiology, histology, microbiology and biochemistry.

Science and the individual.

Control of man's physical surroundings.

Science and the problem of world population.

Man's concept of his place in an increasingly scientific and technological world.

are you a unitarian without knowing it?

Do you believe that religious truth cannot be contrary to truth from any other source?

Do you believe man is capable of self-improvement and is not condemned by "original sin"?

Do you believe that striving to live a wholesome life is more important than accepting religious creeds?

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The entry from Area 4 follows a curving corridor until it comes to a large turntable. As the turntable revolves slowly about a central structure, a narrator discusses the subjects listed above it. Images of scientific truths touched on in other areas appear in window-like openings in the

AREA 6—DOING SCIENCE

For young people between the ages of eight and 13, a laboratory in the arcade provides a rare opportunity to learn science by doing science. Demonstrations in which they participate and simple experiments they conduct explain as no words can some of the fundamental laws of science. A staff is on hand to guide and answer questions but there is no effort to instruct or lecture. The lessons are for the most part inherent in the demonstration experiments. For instance:

A frictionless vehicle which will not move when the driver squirms but will shoot forward when he throws a ball out behind is a highly practical demonstration of Newton's law of motion (every action has an equal and opposite reaction).

A giant gyroscope which keeps spinning in the same plane despite the efforts of the youthful visitor to alter it. It is this characteristic of the gyroscope which

wall. At the same time, related pictures of some actual or potential applications of the scientific truths are displayed in louvered apertures in the outer wall.

The turntable carries the audience through the exhibit and to the exit and the visit to the World of Science comes to an end.

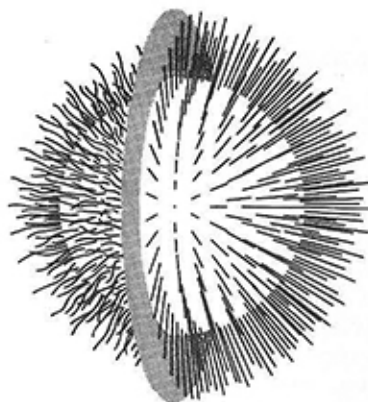
makes it a valuable navigational aid.

Youngsters move back and forth across the opening of a chamber containing star models. Some of the stars appear to change position. This is parallax and this is the way astronomers measure distances to remote stars.

Weight comparisons which give children an experience in the difference in weight of the same object on the earth, on the moon (lighter) and on Jupiter (much heavier).

A reflecting telescope which is an accurate model of the telescopes used in large observatories shows children how scientists study the stars.

Living one-cell animals are enlarged under a microscope and projected on a screen. A close-up of the growth of the frog from pre-birth through adolescence is shown under a microscope.



NERVE GROWTH

What it may mean to your future

This drawing of a model you can see in the U.S. Science Pavilion doesn't look exactly like your nerves. But it symbolizes some of the recent discoveries about one type of nerve—discoveries that may offer clues to the treatment of damaged or diseased nerves.

The left portion represents part of a normal cluster of nerve cells ("ganglion") from the sympathetic nervous system. The right portion symbolizes a similar ganglion treated with "nerve growth factor," a substance discovered recently in certain animals. Note how the nerve growth factor has caused the ganglion on the right to increase in size and has multiplied the number and length of nerve fibers.

Visit Exhibit 97 in the U.S. Science Pavilion, Area IV. See (with the aid of time-lapse motion pictures, models and microscopes) how this substance was discovered and how it is being studied today...to find ways toward better health tomorrow.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The peaceful exploration of space is described by the National Aeronautics and Space Administration Exhibit in the southwest corner of the International Plaza. The exhibit of rocketry is a segment of the World of Science.

It is NASA's first major attempt to tell graphically the story of the United States' space program. NASA, the contributing aerospace industries and the fair have invested over \$2 million in the presentation.

A tour of the exhibit, which acquaints the visitor with what has been and what is being done in space, takes about one-half hour. Fifteen trained guides are on hand to answer questions and provide information.

The introductory displays explain something of NASA's history and of what it is trying to do. Beyond is a section devoted to models and mock-ups of satellites successfully launched and orbited by the United States. Their names are familiar to most visitors: Explorer, Vanguard, Pioneer, Ranger, Mariner and Topside Sounder.

A pictorial display shows where NASA's tracking satellite stations are located and how they trace the progress of the man-

made moons around the earth. It also reveals some of the information the stations have been able to relay from the cruising satellites to scientists. The next section has three-dimensional visualizations of the fuel systems currently in use or under study: liquid, solid and atomic. On display are actual rockets or scaled-down replicas.

One of the exhibits in the next section is the space craft in which Commander Shepard made the first manned American space flight. The section deals with the whole United States' manned flight program, which has as its immediate goal the development of three-man space vehicles for orbital and moon flights. The equipment and hardware used in this program—including a half-size model of a proposed three-man space craft—are on display.

Near the entrance is a small theater which has continuous showings of films on space explorations, astronomy and rocketry. Some of them are being shown publicly for the first time. There are daily changes in the film schedule. Also, there are lectures and special demonstrations by experts in space research and technology.