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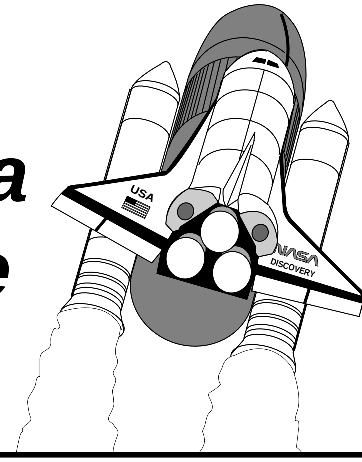
Liftoff to Learning



From Undersea to Outer Space

Video Resource Guide

VRG-009-11/94

Topic: Microgravity's effects on living things.
Video Length: 15:00
Description: This program describes a life science experiment using jellyfish. Because of their small size and rapid growth cycle, results of the experiment have provided scientists with a unique window into the process of living things adaptating to microgravity.

Shuttle Mission Facts

Orbital scenes were taken during the STS-40 mission.
Orbiter: *Columbia*
Mission Dates: June 5-14, 1991
Commander: Bryan D. O'Connor, Col., USMC
Pilot: Sidney M. Gutierrez, Lt. Col., USAF
Payload Commander: M. Rhea Seddon, MD
Mission Specialist: James P. Bagian, MD
Mission Specialist: Tamara E. Jernigan, PhD
Payload Specialist: F. Andrew Gaffney, MD
Payload Specialist: Millie Hughes-Fulford, PhD
Mission Duration: 9 days, 2 hours, 14 minutes
Distance Traveled: 6,085,703 km
Orbit Inclination: 39 degrees
Number of Orbits: 146
Orbital Altitude: 296 by 277 km
Payloads and Experiments:
Spacelab medical experiments in seven disciplines:

- cardiovascular/cardiopulmonary systems
- hematology
- muscles
- bones
- vestibular function
- immunology
- renal-endocrine systems

12 Getaway Specials
Orbiter Experiments Program (7 experiments)

Background

With its June 5, 1991 liftoff, the STS-40 crew of the Space Shuttle *Columbia* began an exciting mission to understand how living things function in the microgravity environment of Earth orbit. Microgravity is the floating effect that occurs on an orbiting space vehicle where objects seem to be weightless because they, and the vehicle they are riding on, are in freefall. *Columbia*'s principle payload was the first Spacelab mission devoted to life sciences research—Spacelab Life Sciences 1 (SLS-1). It consisted of the Spacelab long module mounted in *Columbia*'s payload bay. The pressurized, cylindrical module was 7 meters long and 5 meters in diameter. It was packed with experimental apparatus and medical instrumentation for use by the mission's seven-member crew.

Medical and life science experiments, flown on many Space Shuttle and Skylab missions, have provided tantalizing clues to how the human body adapts to microgravity in Earth orbit and what changes take place in the body. But often missing from past studies were data on the interrelationships of different body systems in microgravity. The Spacelab Life Sciences 1 mission sought to extend the understanding of the human body in microgravity by conducting studies on seven major body systems. These systems were: cardiovascular/cardiopulmonary, hematological, muscular, skeletal, vestibular, immune, and renal-endocrine.

An important part of the SLS-1 mission included 2,478 jellyfish polyps encased in flasks and bags filled with artificial seawater. They were the subjects in an experiment entitled, "The Effects of Microgravity-Induced Weightlessness on *Aurelia* Ephyra Differentiation and Statolith Synthesis."

The principle investigator of the experiment was Dr. Dorothy B. Spangenberg of the Eastern Virginia Medical School (EVMS) in Norfolk, VA. Dr. Spangenberg wanted to learn how microgravity influences the development of tiny jellyfish ephyrae and their gravity-receptors as well as the function of the gravity-receptors. Gravity-receptors enable jellyfish to sense up and down. The sensors have statoliths within them that are analogous to the otoconia found in the inner ears of humans and other mammals. The jellyfish used in Dr. Spangenberg's experiment were of the *Aurelia aurita* variety.

Early in the mission, crew members injected thyroxine or iodine into the containers to induce the polyps to metamorphose into free-swimming ephyrae. The tiny ephyrae were videotaped to observe their swimming motions for later comparison with control groups on the ground. Upon their return to Earth, scientists began studying the jellyfish to determine if any differences occurred in jellyfish gravity receptors (sensors) that developed in space from those that developed on Earth. (Note: The experiment was followed with a second experiment on the International Microgravity Laboratory mission that orbited Earth from July 8-23, 1994.)

Dr. Spangenberg and her team discovered that ephyrae developed during the flight and were able to pulse and swim in space. Statoliths formed in normal numbers in space-developed ephyrae but ephyrae from Earth lost statoliths in greater numbers after nine days in space than did their Earth-maintained controls. Ephyrae from Earth pulsed faster in space and tended to circle or loop when swimming.

Experiment Facts

<u>Title of Project:</u> Effects of Weightlessness on *Aurelia* Ephyrae Differentiation and Statolith Synthesis.

<u>Principal Investigator:</u> Dorothy B. Spangenberg, Ph.D., research professor, department of pathology, Eastern Virginia Medical School.

<u>Number of jellyfish launched:</u> 2,478

<u>Number grown for mission:</u> 60,000

<u>Description of Jellyfish:</u> Jellyfish have special structures which enable them to swim and orient. These are called gravity receptors and they resemble microscopic fingers. These structures have calcium crystals at their tips called statoliths, which move when the animals and the gravity receptors move. These sensitive structures provide positional information to the animal based on the direction of gravity and whether the jellyfish are tilted up or down. It is especially important to know whether statolith crystals form normally in space, since humans have similar calcium-containing crystals (otoconia) in their inner ears which help them maintain balance. In humans, the crystals are not accessible for study during or following space flight.

<u>Why Send Jellyfish into Space?</u> Very few studies have been made of developing organisms in space. Jellyfish complete their development at a warm temperature in six days. Many of the developing structures of jellyfish resemble structures of humans, although they are less complicated. Therefore, jellyfish may be used to predict events which may occur in embryos of more complex life forms during space flight.

<u>Purpose of Experiment:</u> To determine the effects of microgravity on the developing jellyfish in order to help us understand and prevent the adverse effects of microgravity on biological organisms, including humans. The experiment has also helped us understand how gravity influences development and behavior on

Earth. Studies made to determine whether microgravity causes a decrease in the calcium content of the jellyfish and their statolith crystals may help predict a similar calcium deficiency in astronauts. Otoconia crystals are found in the inner ears of humans, but the effect of microgravity on the crystals in humans has not been studied previously.

Procedure: Tiny, baby jellyfish were flown on the Space Shuttle in plastic bags in an incubator. The jellyfish were induced before and during flight to make tiny pulsing and swimming ephyrae from small, slow-moving polyps. During flight, ephyrae developed on Earth (control group) and some which developed in space (experiment group) were videotaped to learn whether they pulsed or swam normally. Following landing, researchers compared the flight and control groups to each other. They studied the development of jellyfish structures, including statoliths; grew new jellyfish through budding; and observed swimming or pulsing movements of ephyrae. (Note: For detailed information on the results of the experiment, refer to the journal articles listed in the reference section of this guide.)

The EVMS Jellyfish Experiment Team:
Dorothy Spangenberg, Ph.D.,
Principal investigator
Robert McCombs, Ph.D.,
Executive associate dean, EVMS
James Shaeffer, Ph.D.,
Professor, Department of Radiation Oncology and Biophysics, EVMS
James Slusser
Director, Electron Microscope Laboratory, EVMS
Mike Prokopchak
Biology teacher, Lake Taylor High School, Norfolk, VA
Brian Lowe
Mark Sampson
Cora Ramiro
Deborah Leete
Anna Shore
Technicians, EVMS
Thomas G. Shelton
Manisha Trivedi
Laboratory aides, EVMS
Mike McCombs
Mark Hughes
Alison Barnes
Volunteers
Experiment Hardware:
NASA Ames Research Center developed the chemical delivery and videotaping systems.
NASA grant #NAG-2343 funded the research.

Terms

Aurelia aurita - Genus and species names of the jellyfish studied in the experiment featured in this video.

Control Group - An experimental group done in exactly the same way as a second experimental group but without the variable being tested.

Experiment Group - An experimental group done in exactly the same way as a second experimental group but with the variable being tested.

Ephyra - Early free-swimming stage of jellyfish.

Gravity Receptors - Structures within many animal forms that enable them to sense the direction of gravity.

Life Science - The science of living things.

Medusa - The adult free-swimming stage of jellyfish.

Microgravity - An environment in which gravity's local effects are greatly reduced through freefall.

Neuron - Nerve cell.

Osteroporosis - A bone calcium deficiency disease that affects older adults.

Polyp - An early jellyfish life cycle (non-swimming) stage which develops into ephyra.

Statoliths-Calcium crystals found in gravity-receptors of jellyfish.

Otoconia-Calcium crystals found in the inner ear of humans and mammals.

Classroom Activities

The following activities can be used to demonstrate some of the concepts presented in this videotape.

Designing For Space Flight

<u>Materials</u>

Paper and pencils

<u>Procedure</u>

Challenge students to design a future Space Shuttle experiment using living things as subjects. What animals or plants would the experiment attempt to study? What would the experiment's hypothesis and research procedures be? What would the experiment apparatus look like and how would it function? How would the living things be cared for on the Space Shuttle? Students should submit sketches and descriptions of their apparatus. If time is available, students can construct working models.

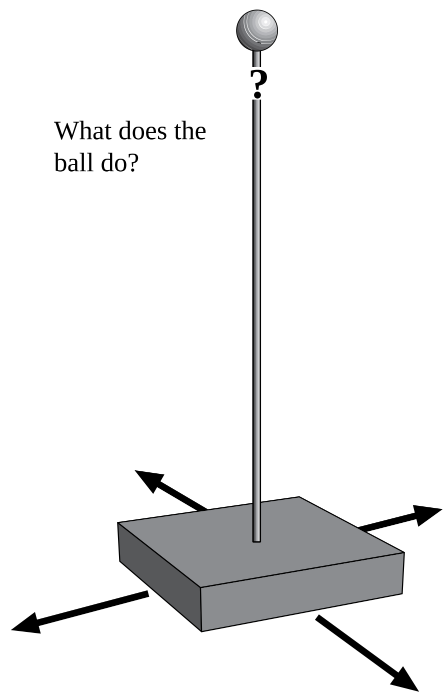
Otolith Motion Sensor Model

<u>Materials</u>

Wood block (approximately 6" x 6" X 1")
1/8"x 36" Dowel
Small solid ball
Drill and 1/8" bit
Glue

<u>Procedure</u>

Drill a hole in the ball and in the center of the wood block. Glue and assemble the model as shown in the picture. Slide the block across a smooth surface. What happens to the ball and why? How does this relate to gravity receptors in jellyfish and in humans? What can you do to the device to make it work vertically?



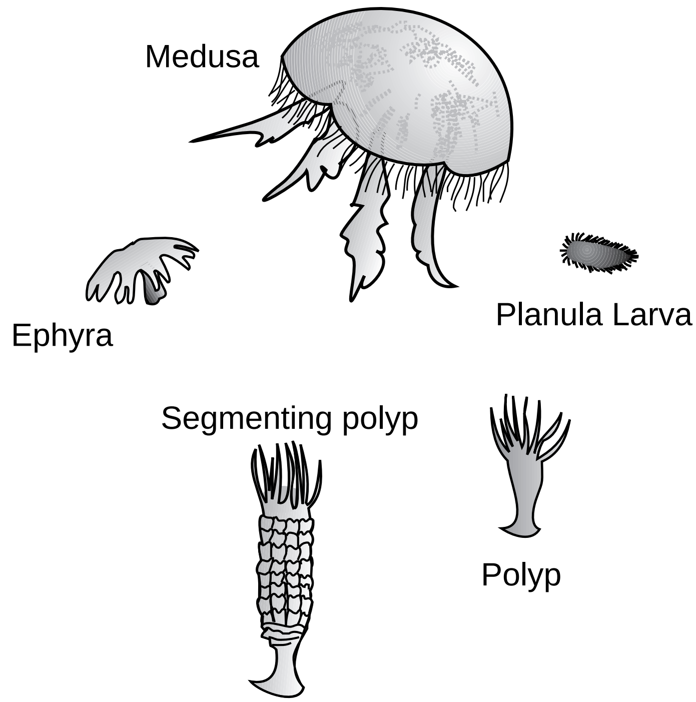
Jellyfish Life Stages

<u>Materials</u>

Modeling clay or paper maché
Poster board
Glue
Paints (if using paper maché)

<u>Procedure</u>

Construct 3-D models of the metamorphosis of *Aurelia aurita* jellyfish from larvae to medusa. Refer to the reference section for information on these stages or obtain a jellyfish life cycle chart from a science supply catalog.



Note: Several science supply catalogs offer jellyfish for dissection and mounted specimens for study. Live jellyfish may also be available for salt water aquariums. If you do not find a section in the index for jellyfish, look up *Aurelia*.

References

Journal Articles:

Spangenberg, D., Jernigan, T., Philput, C., & Lowe, B., (1994), "Graviceptor Development In Space And On Earth," Advanced Space Research, V14N8, pp. (8)317-325.

Spangenberg, D., Jernigan, T., McCombs, R., Lowe, B., Sampson, M., & Slusser, J. (1994), "Development Studies of Aurelia (Jellyfish) Ephyrae Which Developed During The SLS-1 Mission," Advanced Space Research, V14N8, pp. (8)239-247.

____(1994), Jellyfish Launch EVMS Scientist On A Space Odyssey, EVMS Now (Eastern Virginia Medical School alumni magazine), V1N4, pp10-14.

Videotapes:

"Space Basics," (1991) *Liftoff To Leaning* videotape series. This videotape helps students understand how orbiting spacecraft create a microgravity research environment.

"All Systems Go!," (1992), *Liftoff To Learning* videotape series. This videotape explains selected medical studies conducted on the Spacelab Life Sciences 1 mission on where the jellyfish experiment was carried.

• Information on culturing live jellyfish in the classroom is available by writing to:

Dr. Dorothy Spangenberg
Department of Pathology, Box 1980
Eastern Virginia Medical School
Norfolk, Virginia 23501

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Principle Investigator Biography

Dr. Dorothy B. Spangenberg (Ph. D.):
Dorothy Spangenberg, Ph.D., principal investigator for the study of the effects of microgravity on the development and behavior of jellyfish, is research professor in the department of pathology at Eastern Virginia Medical School in Norfolk, Virginia. Dr. Spangenberg received her bachelor's and master's degrees in zoology from the University of Texas, and her Ph.D. in developmental biology from the same institution. Throughout her 31 year career as a developmental biologist, Spangenberg has studied various aspects of jellyfish structure and development. From 1962 to 1965 Spangenberg was a research associate in pathology at the University of Arkansas, and from 1965 to 1966 she was an associate professor at Little Rock University, Arkansas. Spangenberg was a research scholar at Indiana University from 1966 to 1969 and from 1969 to 1972, she conducted jellyfish experiments at the University of Louisville School of Dentistry, Kentucky. Spangenberg was a visiting associate professor in the department of molecular, cellular and developmental biology at the University of Colorado, Boulder from 1972 to 1977. In 1977, Spangenberg joined the faculty at Eastern Virginia Medical School. Since that time her research has been funded by the National Institute of Health, the National Institute for Dental Research and Child Health and Human Development, the Department of Energy, and NASA. She is a nationally renowned expert on jellyfish and has published many articles on the development of the organism.

STS-40 Crew Biographies

Commander: Bryan D. O'Connor (Col., USMC). Bryan O'Connor, from Twentynine Palms, California, received a bachelor of science degree in engineering from the U.S. Naval Academy and a master of science degree in aeronautical systems from the University of West Florida. He is a Marine Corps test pilot and served as the pilot of the STS-61B mission.

Pilot: Sidney M. Gutierrez (Lt. Col., USAF). Sidney Gutierrez comes from Albuquerque, New Mexico. He earned a bachelor of science degree from the U.S. Air Force Academy. Gutierrez is an Air Force test pilot and a master parachutist. This was his first space flight.

Payload Commander: Margaret Rhea Seddon (MD). Rhea Seddon is from Murfreesboro, Tennessee. She received a bachelor of arts degree in physiology from the University of California-Berkeley and a doctorate in medicine from the University of Tennessee College of Medicine. Seddon served as a mission specialist on the STS-52D flight.

Mission Specialist: James P. Bagian (MD). James Bagian is from Philadelphia, Pennsylvania, and earned a bachelor of science degree in mechanical engineering from Drexel University and a doctorate in medicine from Thomas Jefferson University. He has worked as a mechanical engineer with the Navy and as a flight surgeon at NASA. Bagian served as a mission specialist on the STS-29 mission.

Mission Specialist: Tamara E. Jernigan (PhD). Tamara Jernigan comes from Santa Fe Springs, California. She earned a bachelor of science degree in physics and a master of science degree in engineering science from Stanford University. She also earned a master of science degree in astronomy from the University of California-Berkeley and a doctorate in space physics and astronomy from Rice University. This was her first space flight.

Payload Specialist: F. Andrew (Drew) Gaffney (MD). Drew Gaffney comes from Carlsbad, New Mexico, and earned a bachelor of arts degree from the University of California- Berkeley and a doctorate in medicine from the University of New Mexico. He received a fellowship in cardiology at the University of Texas and was the assistant director of echocardiography at Parkland Memorial Hospital, Dallas, Texas. Gaffney is an associate professor of medicine at Southwestern Medical Center in Dallas. This was his first space flight.

Payload Specialist: Millie Hughes-Fulford (PhD). Millie Hughes-Fulford is from Mineral Wells, Texas. She earned a bachelor of science degree in chemistry from Tarleton State University and a doctorate in chemistry from Texas Woman's University. She conducts research at the University of California and the Veterans Administration Medical Center on cholesterol metabolism, cell differentiation, DNA synthesis, and cell growth. This was her first space flight.

From Undersea to Outer Space

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