SUGGESTED REFERENCES

- "*Why go to Mars*" , Glenn Zorpette, **Scientific American**, November 2004. The first of a series of five articles in this magazine discussing the reasons for going to Mars and how it might be accomplished.
- **Space Station: Base Camp to the Stars**. Roger Launius, Smithsonian Books (June 1, 2003)
- *Living in space teachers guide from the National Space Biology Research Institute* http://www.nsbri.org/HumanPhysSpace/indexb.html
- *Mission to mars, a study in chemical equilibrium* http://www.sasked.gov.sk.ca/docs/chemistry/mission2mars/index.html

NATIONAL SCIENCE EDUCATION STANDARDS

5 - 8

Earth and Space Science
Earth in the Solar System

Science and Technology
Understandings About Science and Technology

9 - 12

Science as Inquiry
Understandings about Scientific Inquiry

**Source: National Science Education Standards, 1996, National Academy Press*

CREDITS

The producers thank Electric Sky for materials used in this program.

EDUCATOR ADVISORY PANEL

PRODUCTION CREDITS

WRITER/PRODUCER:	John A. Murnan III, M.S.
ASSOCIATE PRODUCER:	Patricia Norman
EDITOR:	Jon Glassman
NARRATOR:	J.J. Wilson

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VOLUME 35 ISSUE 3

COLONIZING SPACE

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SYNOPSIS

This program describes how humans have begun to colonize space. Just a few decades after we sent the first humans into space, we now have the first permanent human station in space. Plans are in the works for sending a manned mission to Mars. Our attempts to colonize another planet will require the development of equipment and materials that may have been imagined before only by science fiction writers.

Students will see how astronauts live on the space station. They will see how astronauts train for life in space. They will also be able to go inside Biosphere 2, an attempt to mimic the interacting systems that keep our own earth alive. Finally, they will see some of the work going into the development of regenerative systems that will allow astronauts in space to become less dependent on earth for supplies such as air and water.

CURRICULUM UNITS

- BIOLOGY
- CHEMISTRY
- COMPUTER ENGINEERING
- ENGINEERING
- INTEGRATED SCIENCE
- PHYSICAL SCIENCE
- PHYSICS

RUNNING TIME

16:57

BACKGROUND

The first humans made use of natural shelters such as caves. Now, we build incredibly complex structures in which to live. Some of these structures can house thousands of people. We have also built structures to survive the most extreme environments found on earth. As we consider colonizing Mars, we will have to develop different and probably even more complex structures.

One of the biggest limiting factors for humans in space and living on other planets is the cost of transporting materials there to keep the astronauts alive. The cost of transporting materials can be reduced by taking two measures, decreasing the cost of transporting each kilogram of material and reducing the number of kilograms of materials that have to be brought into space.

Unmanned rockets are helping to reduce the cost of transporting materials into space. Although space shuttles provide maximum flexibility for performing many different types of missions, they are not the most cost efficient transport vehicles. The International Space Station (ISS) depends on both manned space shuttle flights and unmanned rockets.

If the ISS and manned missions to the moon and Mars can make their own oxygen and water, then these materials do not have to be brought to them from earth. This would greatly decrease the cost of space missions. Scientists and engineers are exploring the development of regenerative systems, basically equipment that will recycle waste materials into the water and oxygen the astronauts need to survive.

Scientists tried to create a self-contained system that recreates the earth's systems. The project, called Biosphere 2, attempted to use only sunlight to drive its systems, just like the earth. Scientists living in the Biopshere tried for several years to get the system to work correctly, but the project was too large and too complex. In every ecosystem in the Biosphere, scientists found that helpful organisms were out competed by invasive organisms. In the end, the project taught us that we don't know very much about how our systems interact to keep the earth alive. We have had greater success with smaller regenerative systems such as the Sabatier reactor. This reactor takes carbon dioxide and recycles it into oxygen and methane. The program describes how this process works and it can be an excellent chemistry or physical science demonstration.

The effects of living in space on the human body are also explored. Most of the changes that occur to astronauts in space are the result of low gravity. Muscle atrophy and bone weakening are the most serious changes that occur. When astronauts return home from space, they may also suffer from disorientation as they re-adapt to gravity on earth. Astronauts living on the ISS and on longer missions to Mars will need to be monitored constantly for changes in body physiology. In addition, scientists will have to develop techniques to reduce the effects of living in zero gravity environments.

The program explores the challenges and possibilities of living on Mars. We have been mapping Mars since the 1960's, but beginning in the late 1990's the number of missions to Mars increased greatly. Recent evidence supports the likelihood that there was once liquid water on the surface of Mars. Although scientists have ruled out the possibility that multi-cellular life existed on Mars, it is still possible that single celled organisms may have lived there. Further research is ongoing.

When humans do colonize Mars, it will be with equipment that has proven successful over fifty years of space flight. It will also require the development of new equipment and new technologies that have been imagined in the past only by science fiction writers.

ADVANCED ORGANIZERS

Prior to showing this video, students should have some understanding of the following benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 3: The Nature of Technology

Section A - Technology and Science
Know by Grade 8

- Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.

- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. But they usually have to take human values and limitations into account as well.

ADVANCED ORGANIZERS (continued)

Know by Grade 12

- Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.

- Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.

Section B - Design and Systems
Know by Grade 8

- Design usually requires taking constraints into account. Some constraints, such as gravity or the prop erties of the materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones, limit choices.

Know by Grade 12

- Complex systems have layers of controls. Some controls operate particular parts of the system and some control other controls. Even fully automatic systems require human control at some point.

Benchmark 4: The Physical Setting

Section A - The Universe
Know by Grade 8

- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris.

**Benchmarks can be found at www.project2061.org/tools/benchol/bolintro.htm*

CRITICAL THINKING EXERCISES

1. Compare the environment of Mars to Earth.
2. Explain how living on Mars might be different than living on Earth based on the differences in the environment of each planet.
3. Explain what effects living in space has on the human body.
4. Describe how engineers might make equipment that stimulates the creativity of humans living in space.
5. Design a living space for the first astronauts who are going to live on Mars.
6. Compare living in the International Space Station to living on the moon; living on Mars.

VOCABULARY

Atrophy
Bioreactor
Biosphere 2
Buoyancy
Colony
Meteorite
Regenerative system
Sabatier Reactor
Sensors
Weightlessness
"Zero G" flight

CAREER POSSIBILITIES

- ASTRONAUT
- ASTROBIOLOGIST
- ARCHITECT
- COMPUTER ENGINEER
- PHYSICIST