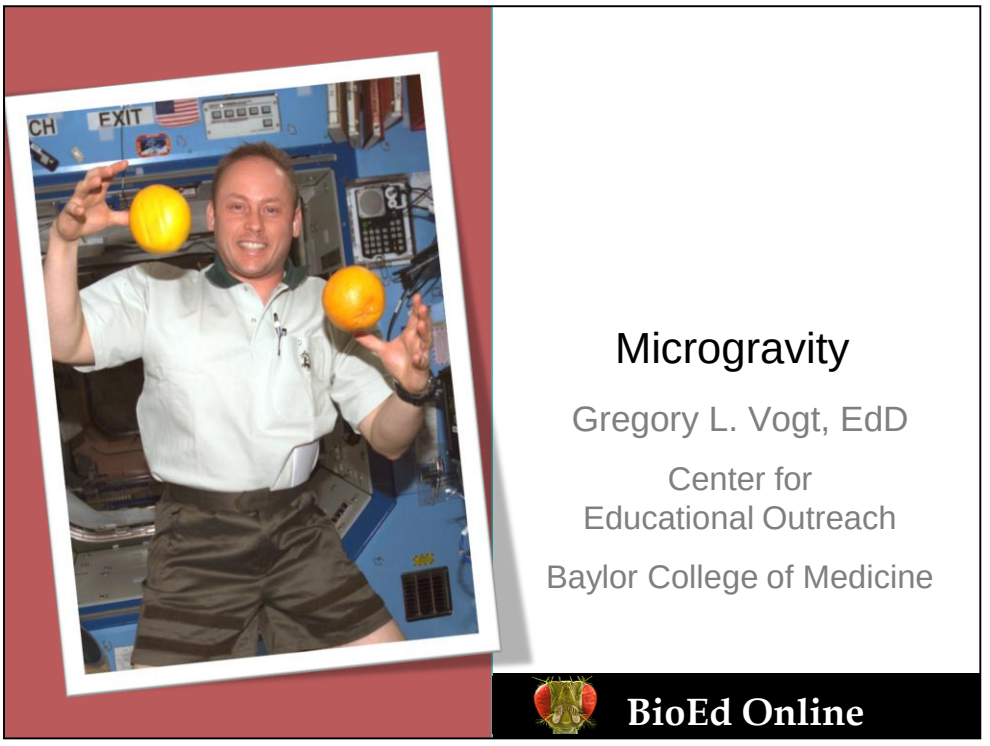
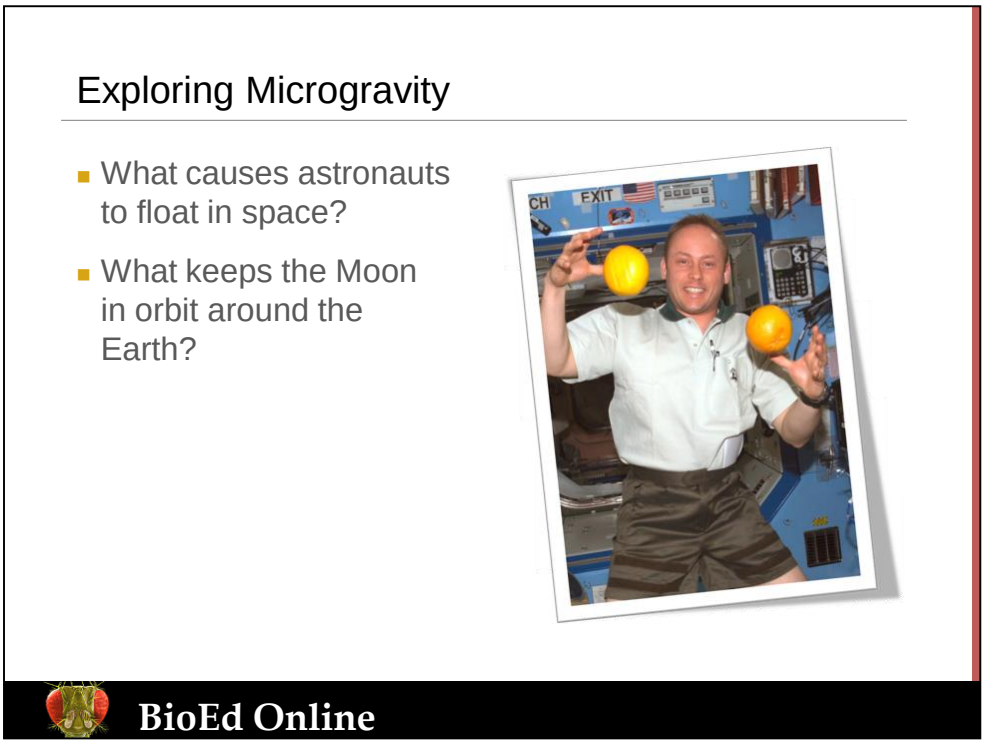


Microgravity

Microgravity is a an environment, created by freefall, in which gravity's effects are greatly reduced.

Image Reference

Astronaut Edward M. (Mike) Fincke, Expedition 9 NASA science officer and flight engineer aboard the International Space Station, juggles fresh fruit in the Destiny laboratory. Photo courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/image_feature_175_astronaut_juggling.html/.

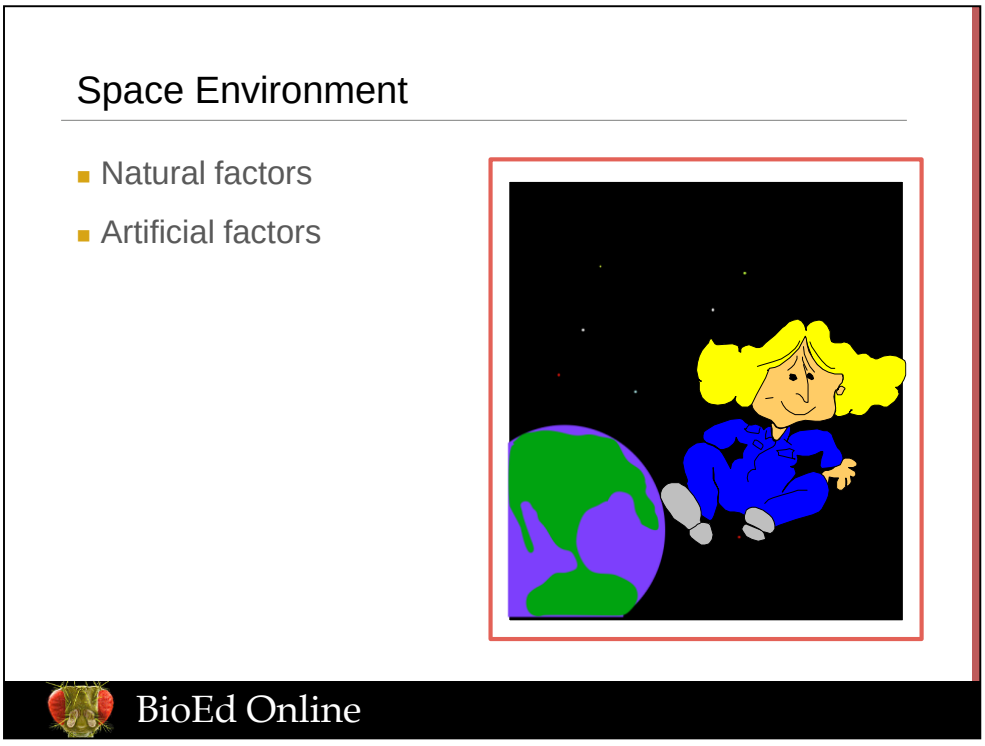


Exploring Microgravity

In answer to the first question, many students would say that astronauts float in space due to the absence of gravity. They also might answer that gravity keeps the moon in orbit around Earth. But these answers present a contradiction. In fact, astronauts appear to float in orbit, and the moon orbits the Earth because of gravity.

Image Reference

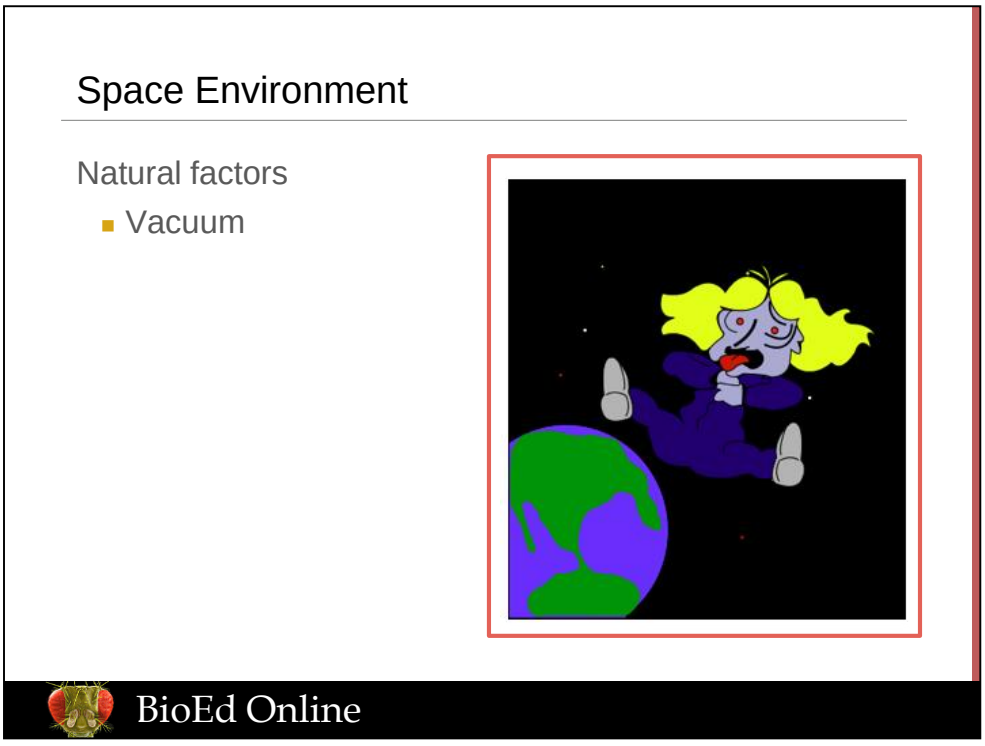
Astronaut Edward M. (Mike) Fincke, Expedition 9 NASA science officer and flight engineer aboard the International Space Station, juggles fresh fruit in the Destiny laboratory. Photo courtesy of NASA. Retrieved 1-13-10. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/image_feature_175_astronaut_juggling.html/.



Space Environment

The space environment includes both natural factors and artificial (man-made) ones.

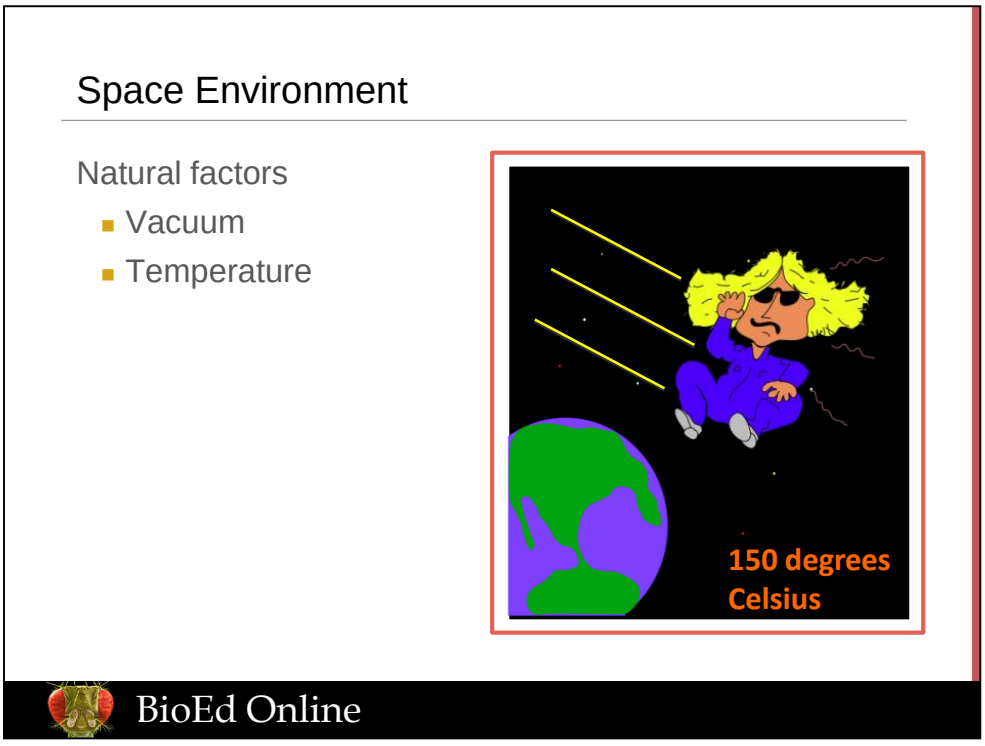
Image Reference



Space Environment

Space is a natural vacuum in which there is no air to breathe. Due to the lack of pressure in the space environment, gas bubbles begin to form in body fluids, causing the body to expand.

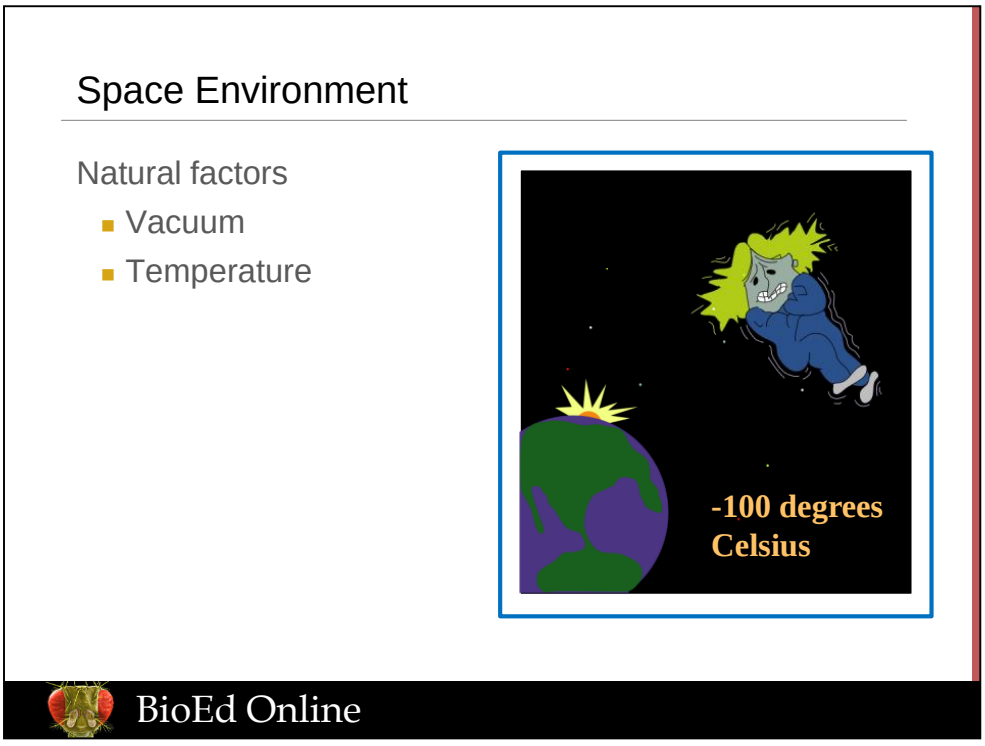
Image Reference



Space Environment

In sunlight, the temperature is very hot, reaching up to 150 degrees Celsius.

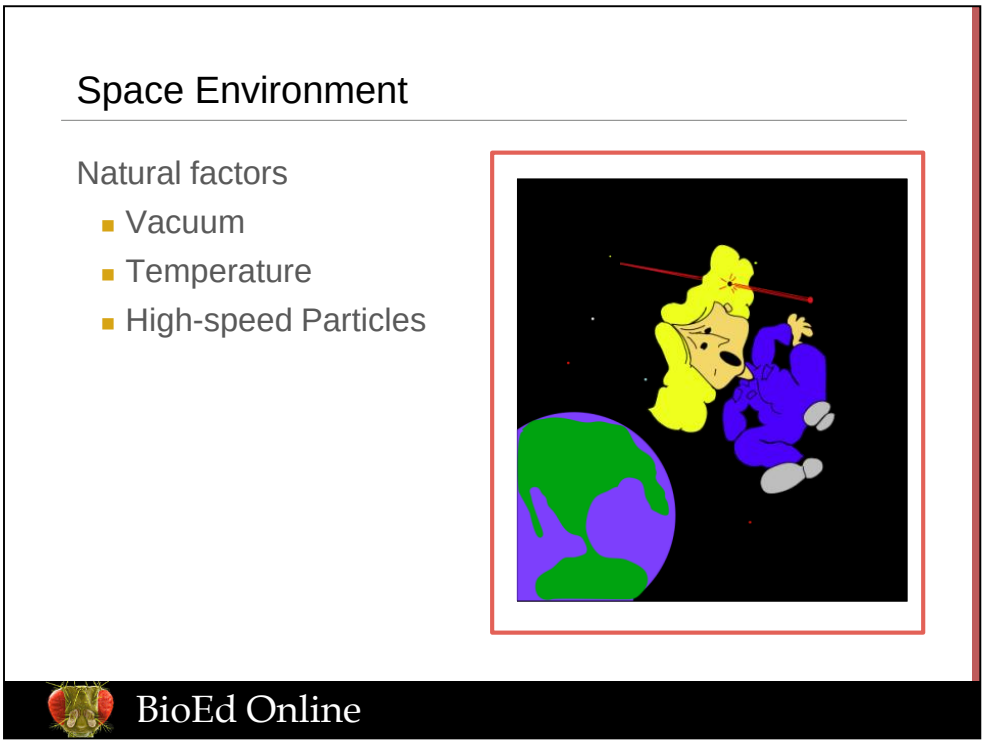
Image Reference



Space Environment

In shade, temperatures can drop to -100 degrees Celsius. The wide temperature range in space requires an active cooling and heating system in spacesuits.

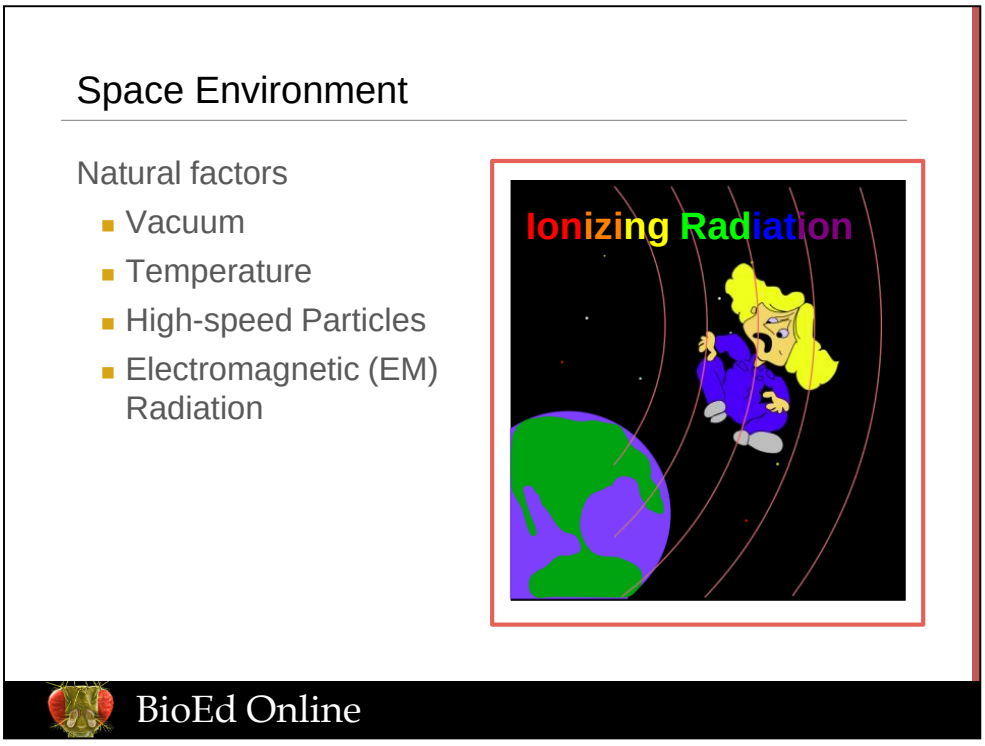
Image Reference



Space Environment

High speed particles and solar system debris, like micrometeroids, can be harmful to people and machinery.

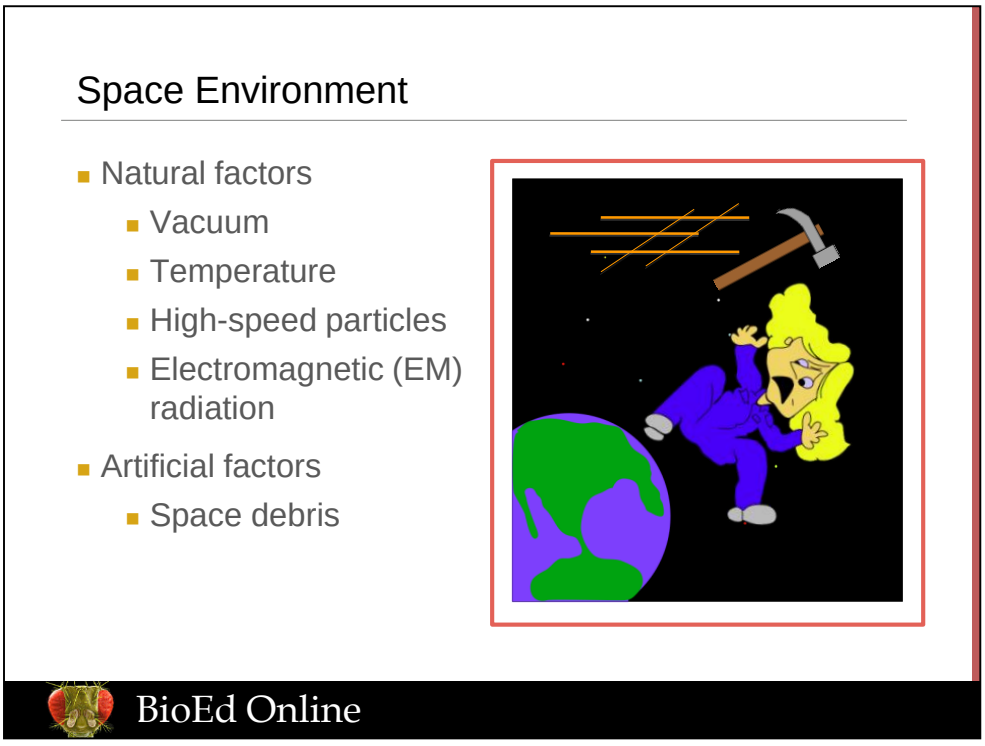
Image Reference



Space Environment

Electromagnetic radiation, also known as ionizing radiation, can damage cells and DNA.

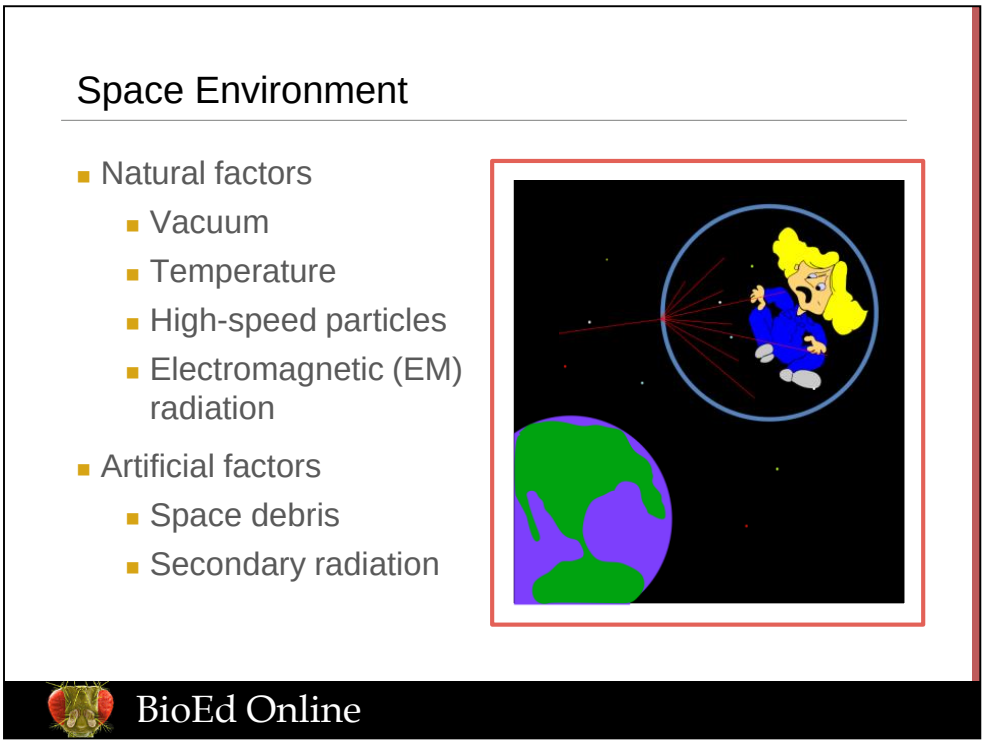
Image Reference



Space Environment

Space debris—objects lost by astronauts on space walks, and small pieces of spacecrafts—are artificial factors in the space environment.

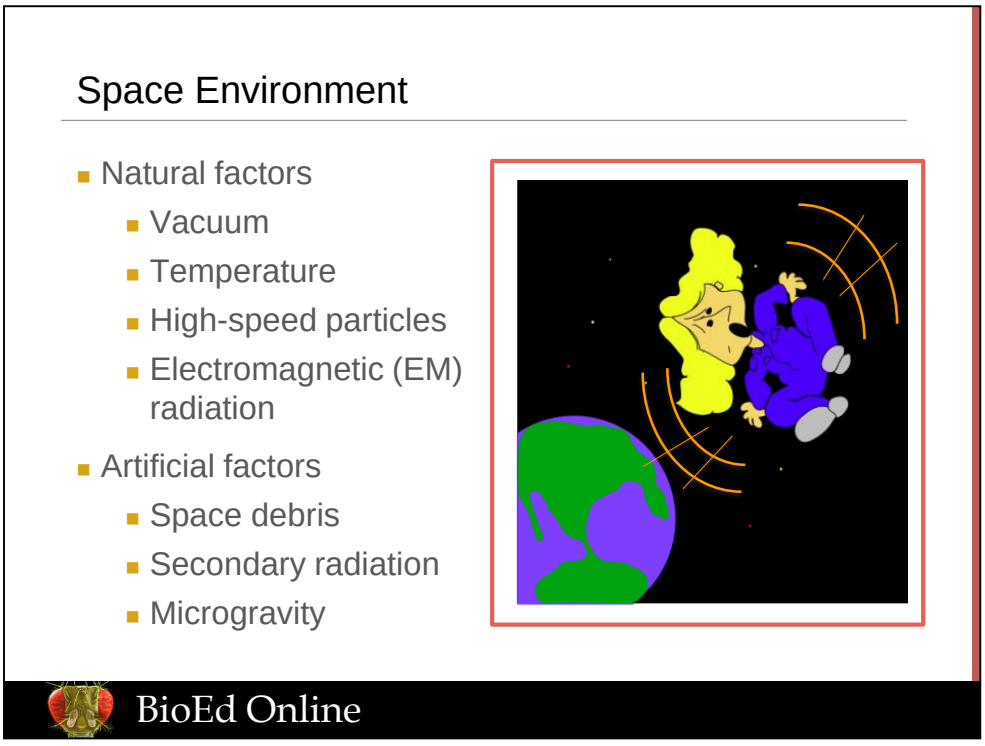
Image Reference



Space Environment

Secondary radiation is produced when a large atomic particle, such as the nucleus of iron, hits the spacecraft walls. Such collisions can cause a shower of smaller atomic particles that spray the astronaut.

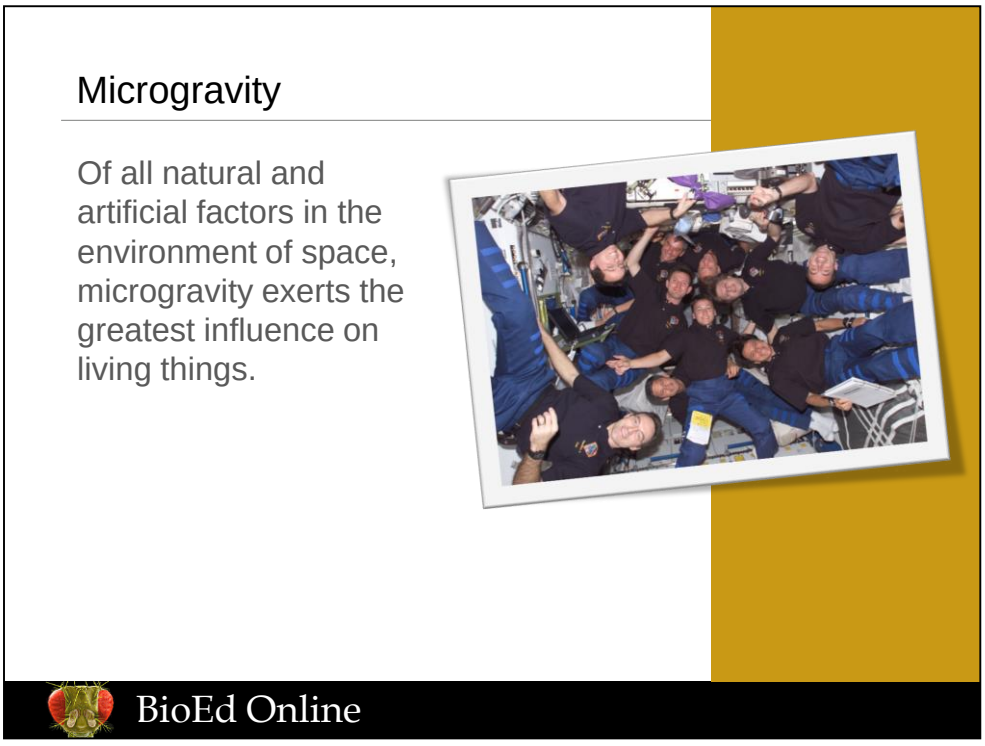
Image Reference



Space Environment

Microgravity is an artificial factor created by the presence of individuals. It is not always present.

Image Reference



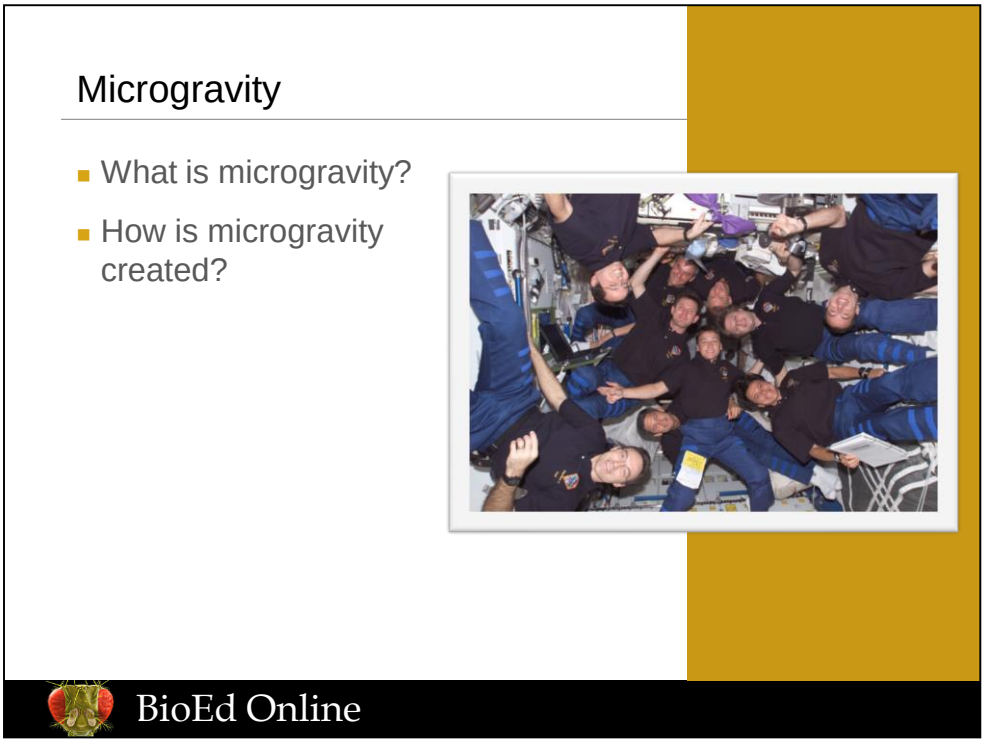
Microgravity

Microgravity is the most influential of all environmental space factors on humans and other living organisms.

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.



Microgravity

What is microgravity? How is microgravity created?

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.

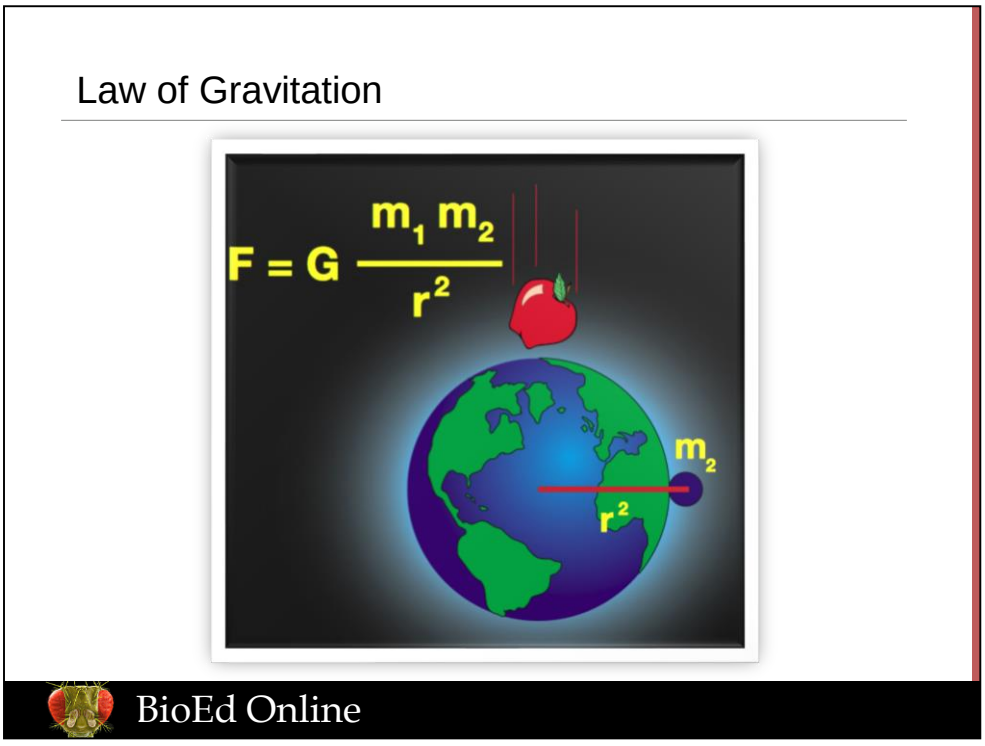
Is This a True Zero Gravity Environment?

"Zero gravity" implies that gravity has gone away. However, gravity is always present. The zero-g effect is created by freefall.

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

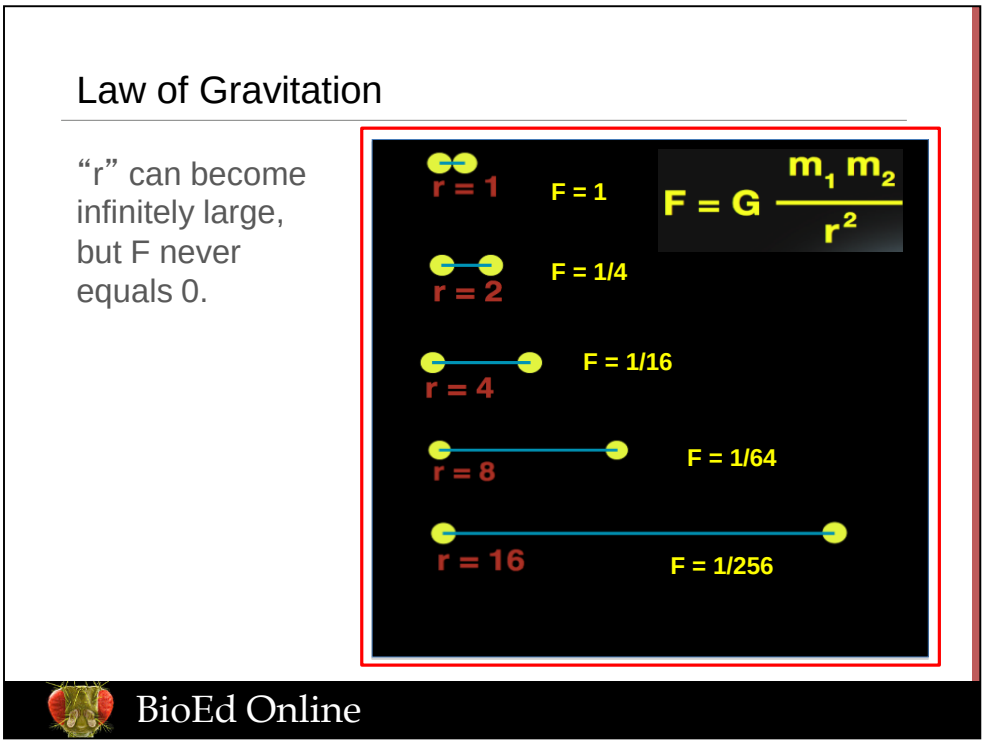
Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.



Law of Gravitation

In the example shown above, "G" is a gravitational constant; m_1 is the mass of Earth, and m_2 is the mass of a second object (in this case, a ball on Earth's surface). The term "r^2" refers to the radius between the center of the Earth and the center or the second object, squared. Force is increased if either or both masses in the equation are increased.

Image Reference



Law of Gravitation

As the distance between objects increases, the force of gravity is reduced by the inverse square of the distance. The "r," or radius between two objects can become very large, but the force of gravity can never equal zero.

Image Reference

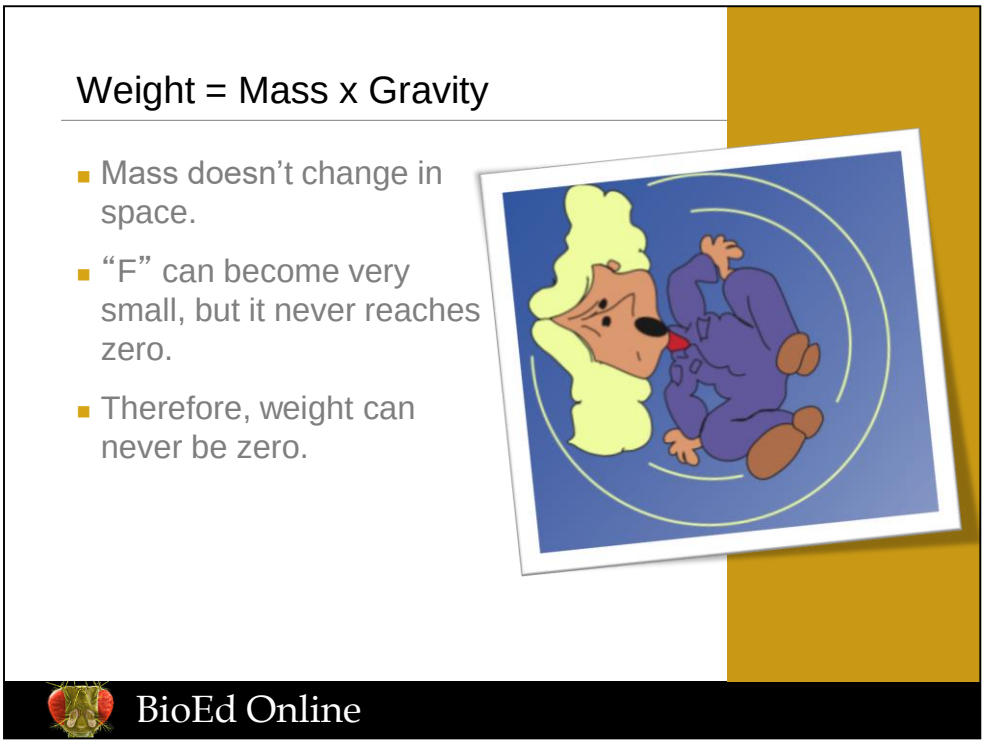
Is This True Weightlessness?

Although one may experience the feeling of weightlessness, a person's weight can never equal zero. Because there are no scales that work in orbit, weight cannot be measured in the usual manner.

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

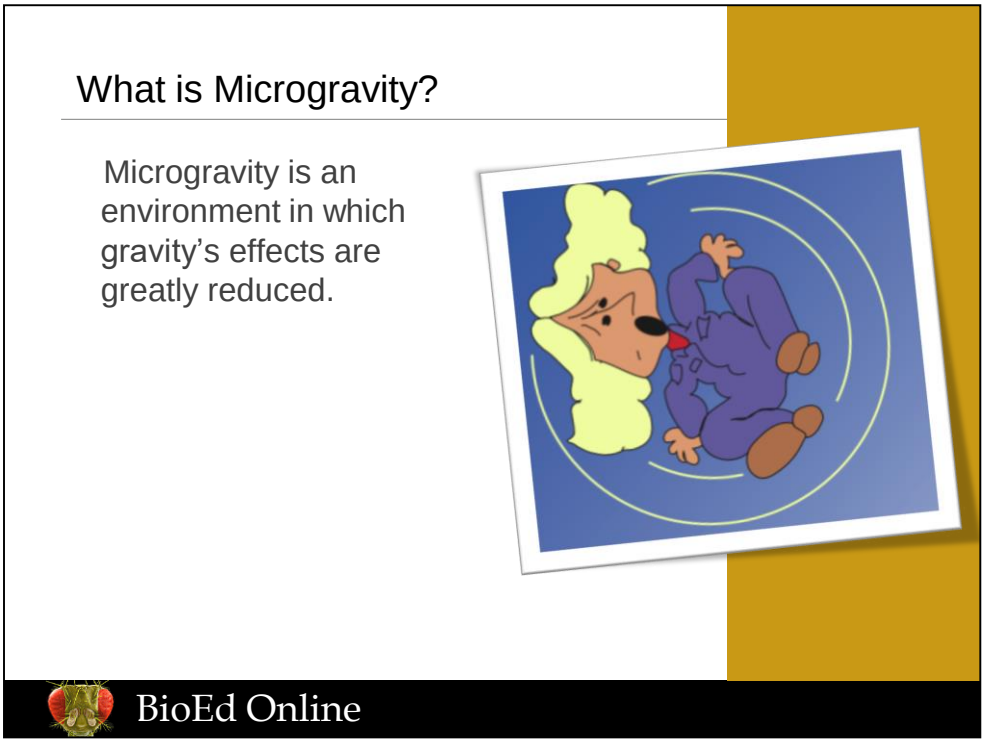
Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.



Weight = Mass x Gravity

Because gravity can never reach zero and mass does not change is space, their product (weight) can never equal zero.

Image Reference



What is Microgravity?

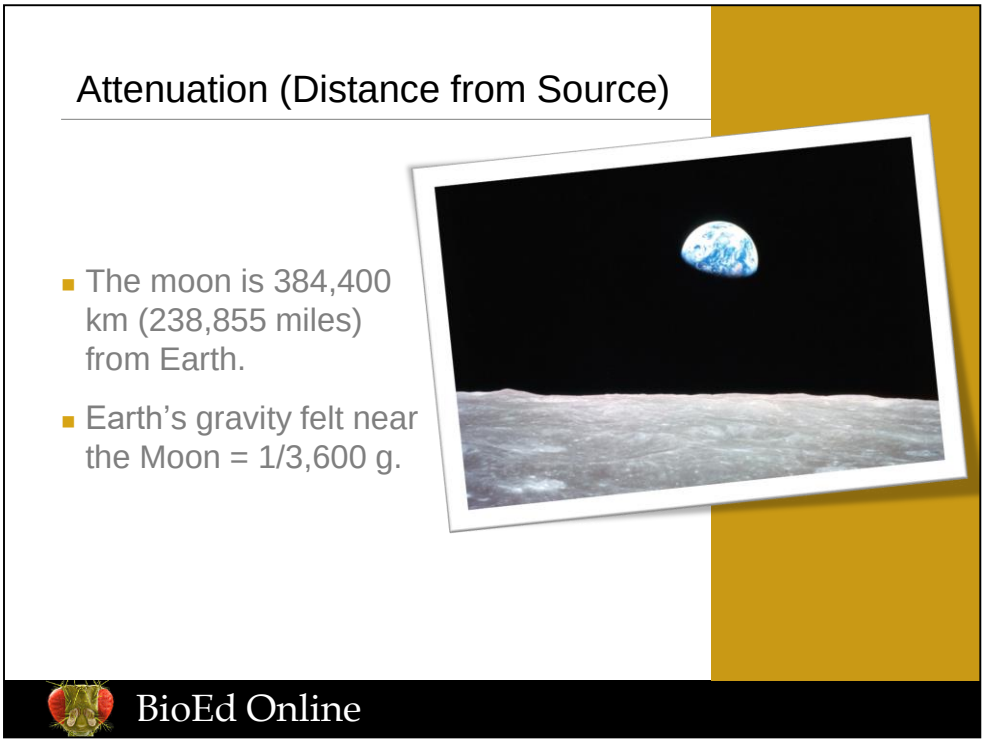
In a microgravity environment, the effects of gravity are greatly reduced.

Image Reference

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.

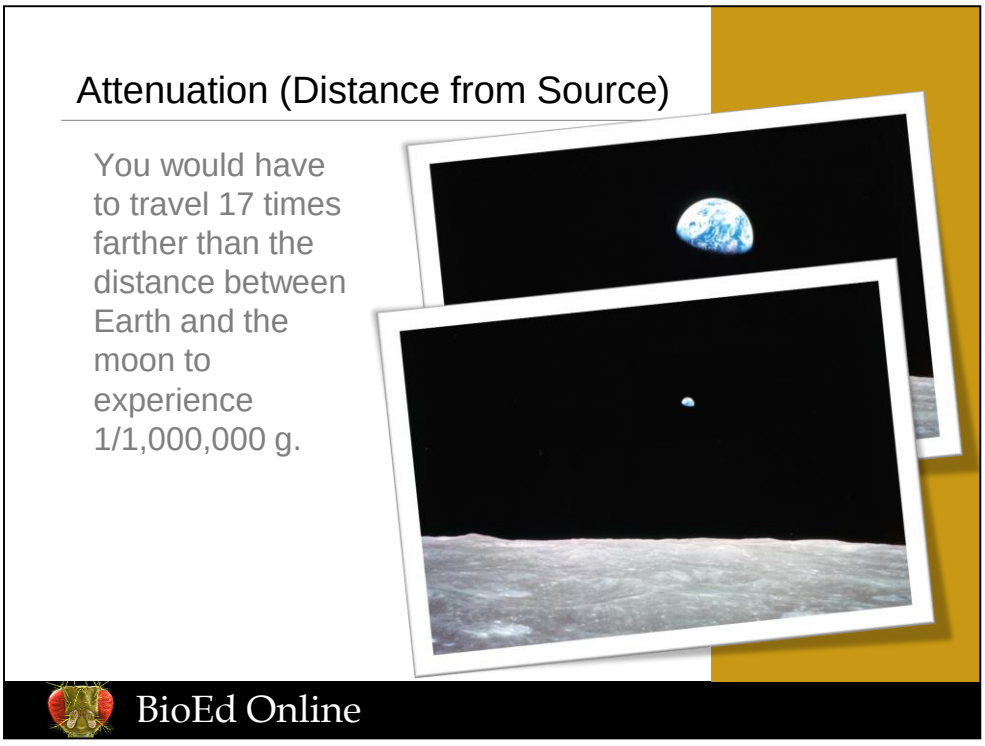


Attenuation (Distance from Source)

Distance from the source of gravity, otherwise known as attenuation, affects the magnitude of gravity felt. The father away you travel from the source (Earth), the less gravity you feel. Due to attenuation, an astronaut approaching the moon feels much less gravity than he or she does while standing on Earth.

Image Reference

Courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/index.html/.



Attenuation (Distance from Source)

Even after traveling 17 times farther than the distance between Earth and the moon, one would still experience slight gravity (1/1,000,000 g).

Image References

Courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/index.html/.

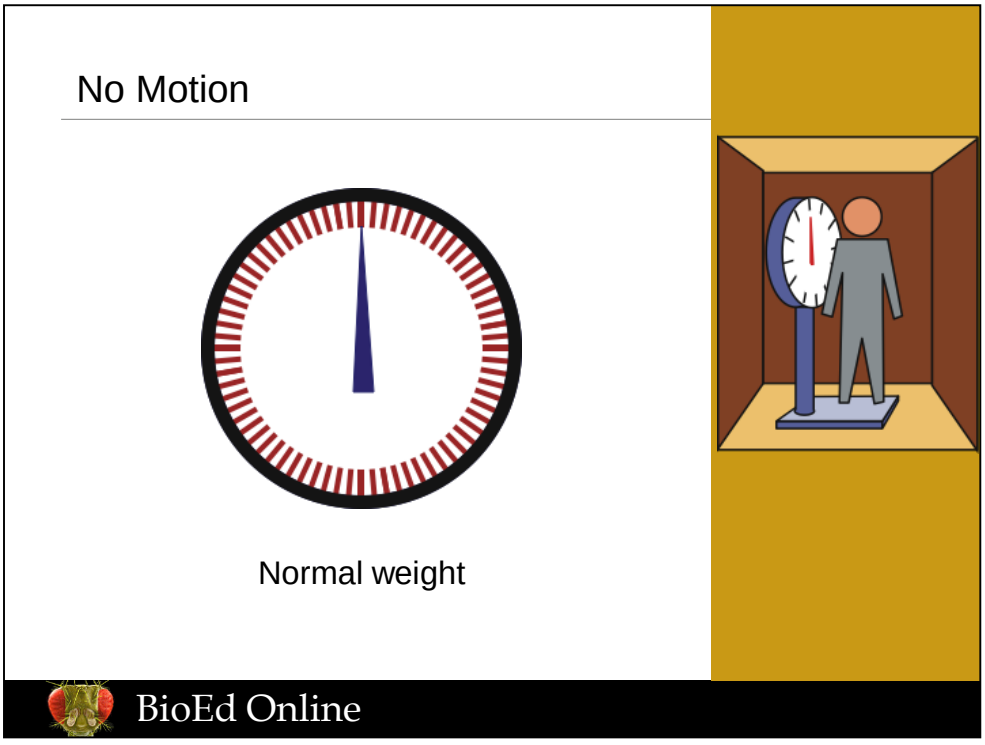
Falling

Free-fall reduces gravity's effects.

Image Reference

SS005-E-05022 (15 June 2002) --- The Expedition Four, STS-111, and Expedition Five crews assemble for a group photo in the Unity node on the International Space Station (ISS).

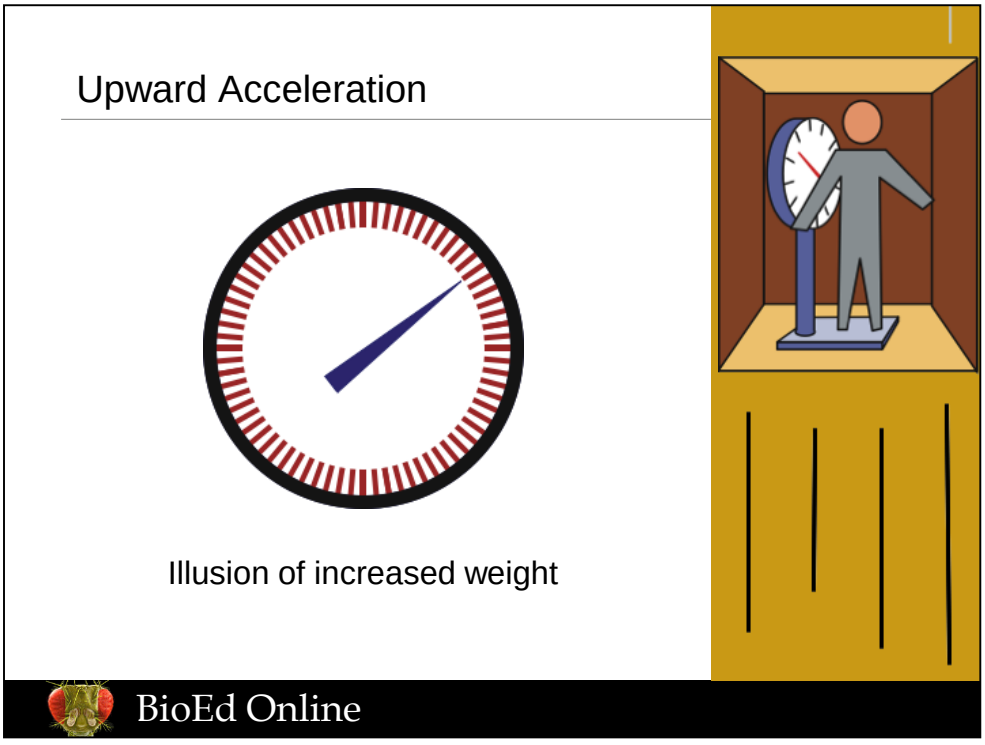
Courtesy of NASA. Retrieved 1-13-10. http://spaceflight.nasa.gov/gallery/images/station/crew-5/hires/iss005e05022.jpg/.



No Motion

When an individual stands on a scale in a motionless elevator, the scale reads the individual's normal weight.

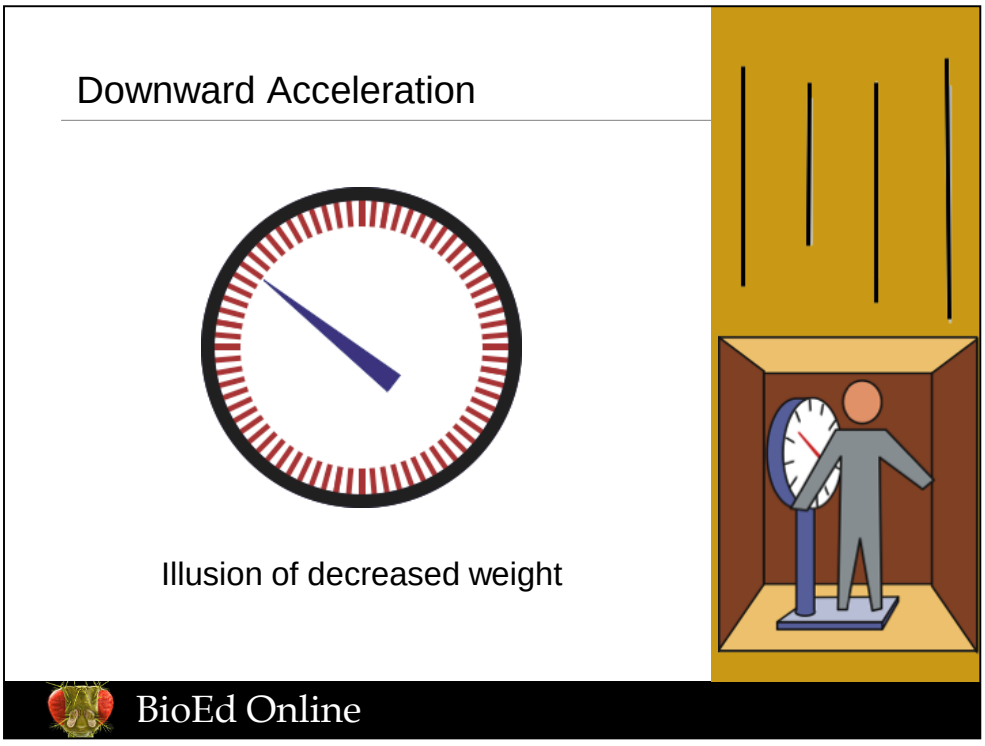
Image Reference



Upward Acceleration

If the elevator moves upward, inertia will cause the individual's body to push down on the scale, thereby producing a momentary increase in the weight measured.

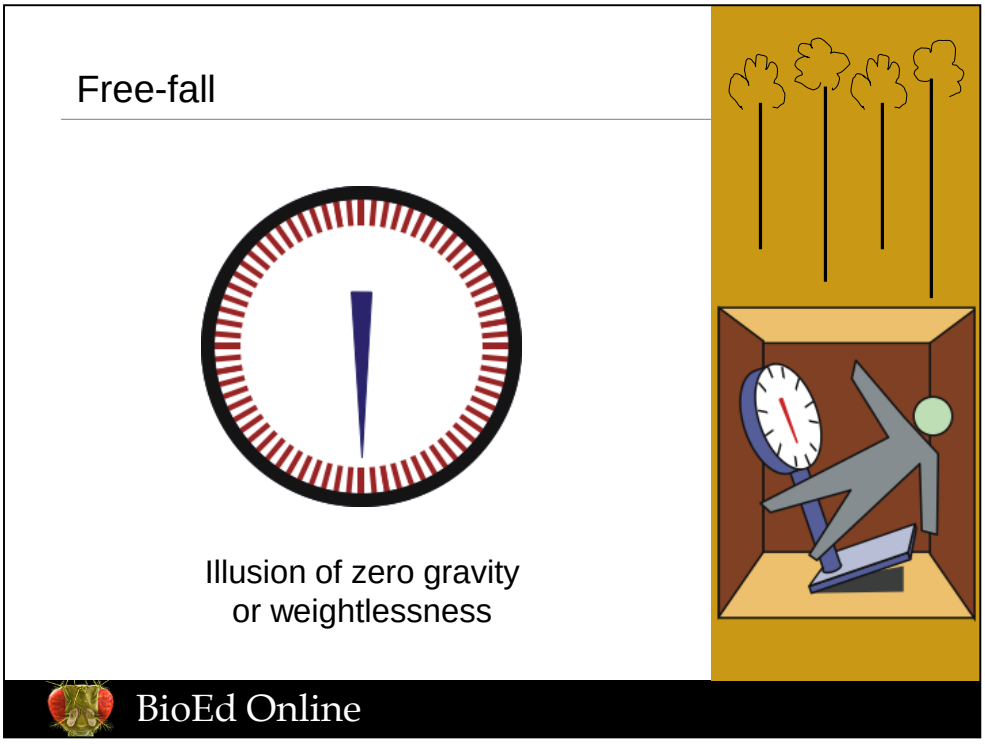
Image Reference



Downward Acceleration

If the elevator moves downward, inertia will cause the individual to remain in place momentarily, thus decreasing the pressure on the scale and creating the illusion of lowered body weight.

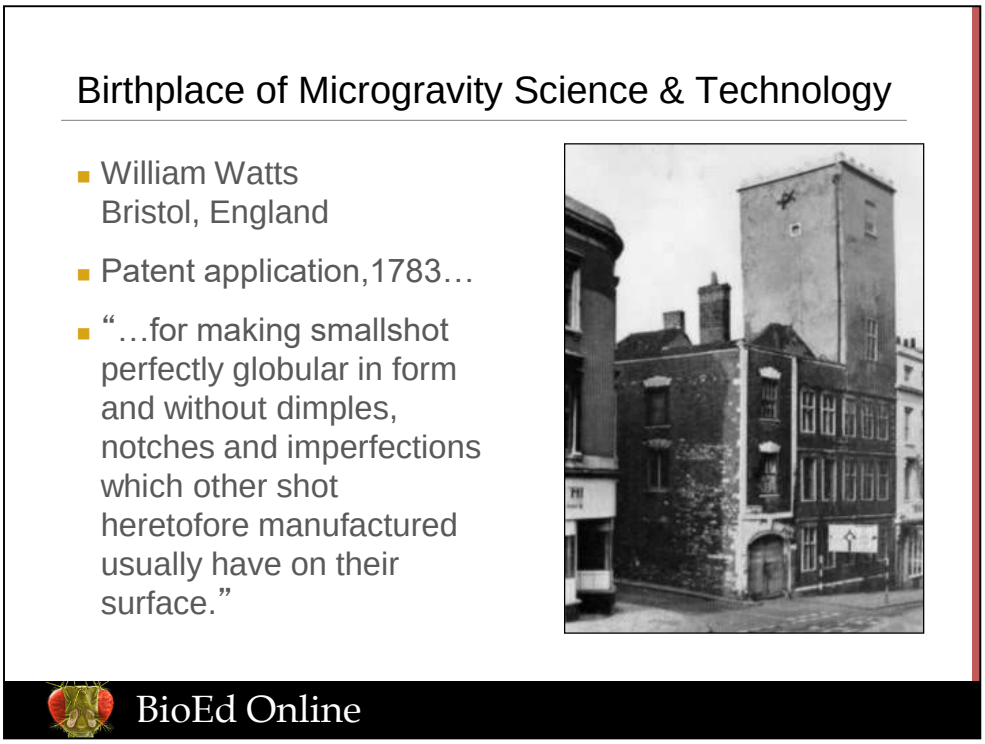
Image Reference



Free-fall

If the elevator's cable were to break, the individual would begin to freefall within the elevator car. At this moment, he or she would experience the illusion of zero gravity, or weightlessness.

Image Reference



Birthplace of Microgravity Science & Technology

William Watts made "perfect" smallshot by dropping melted lead through a sieve. This process reduced the effects of gravity, allowing for a more uniform and globular smallshot to be produced.

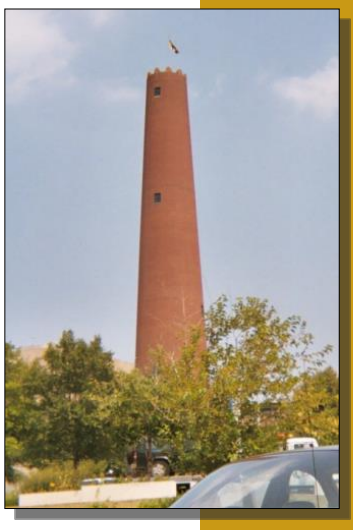
The world's first shot tower, built by Watts, took place in 1782.

Image Reference

Public domain. http://www.pssatrap.org/shot-towers-2/shot-towers-photographs-6.htm.

Historic Shot Towers

- Phoenix Shot Tower in Baltimore, MD, is 71 meters tall. It was built in 1828 by J. Wolfe.
- The shot tower in Hobart, Tasmania, was built in 1870, and is 48 meters tall.



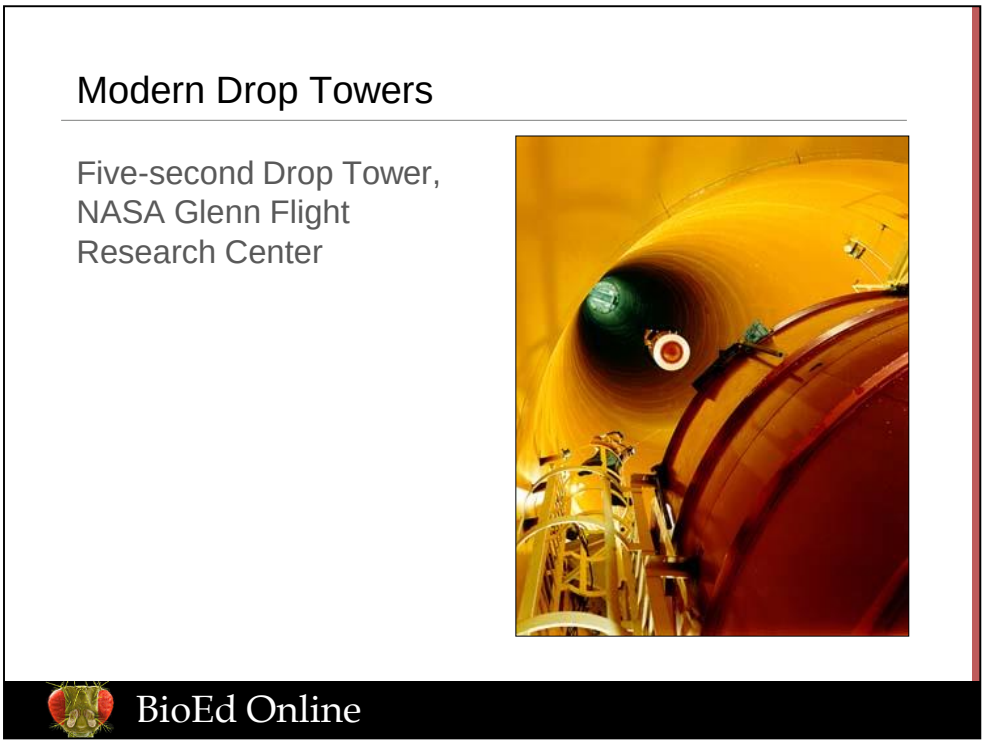
BioEd Online

Historic Shot Towers

Towers in which to create smallshot freefall conditions have been built in many locations worldwide.

Image Reference

http://en.wikipedia.org/wiki/Phoenix_Shot_Tower/.

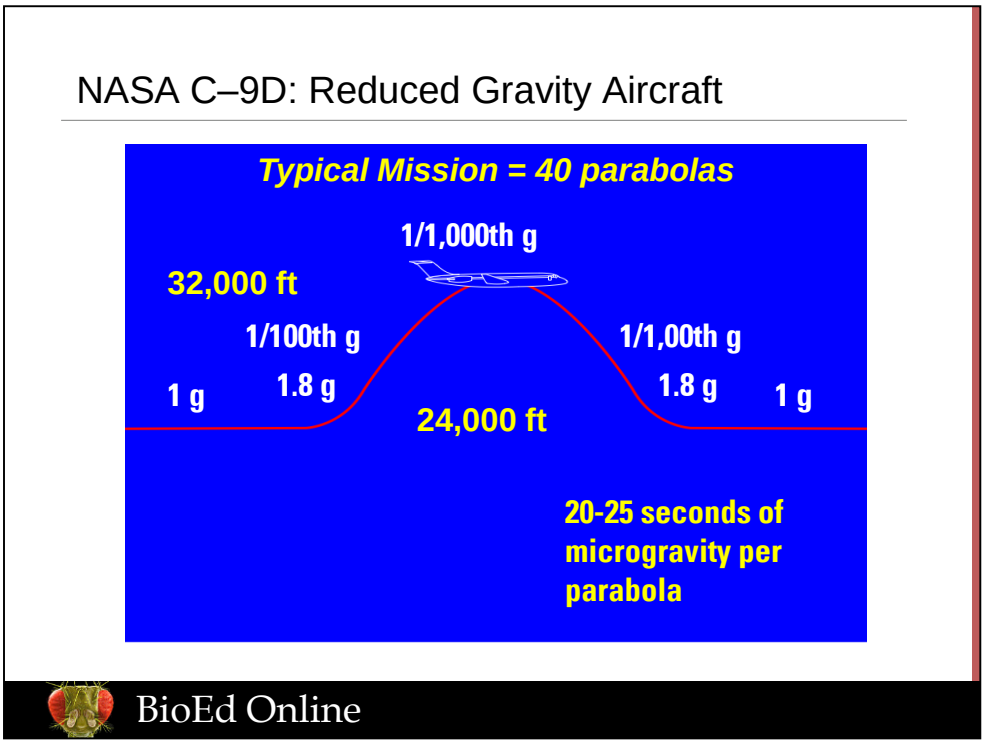


Modern Drop Towers

Inside of a 500-foot drop tower at NASA Glenn Flight Research Center, objects are released from the top to a target at the bottom.

Image Reference

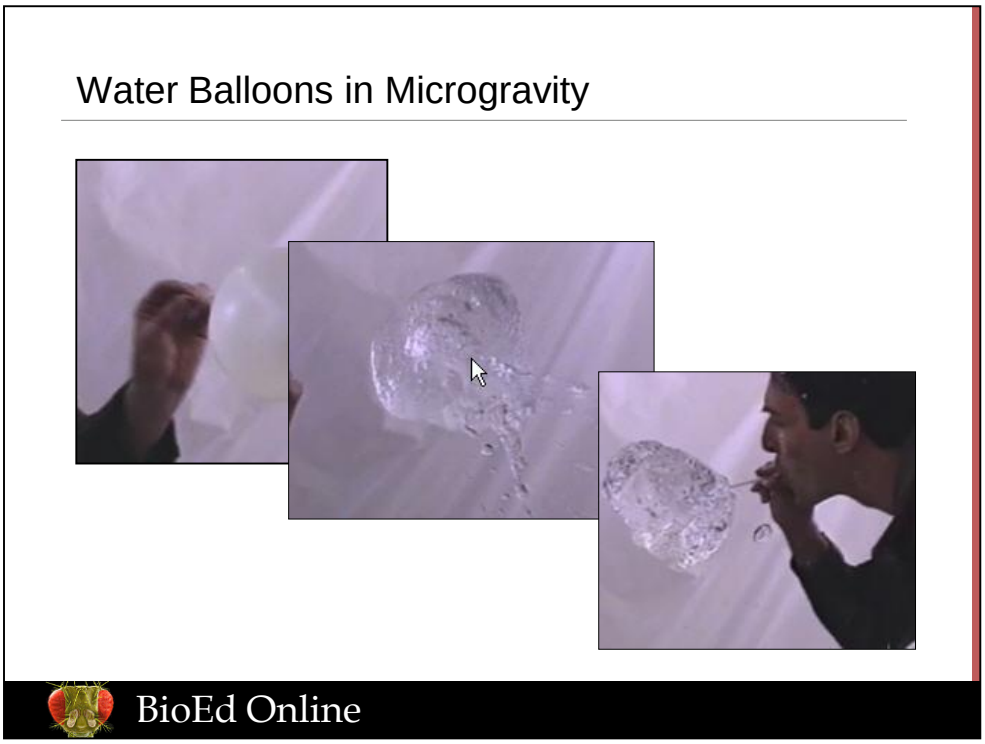
View of free-fall in the vacuum chamber. Courtesy of NASA. Retrieved 1-13-10. https://rt.grc.nasa.gov/main/rlc/zero-gravity-research-facility/.



NASA C–9D: Reduced Gravity Aircraft

The maneuvers of a reduced gravity aircraft can briefly simulate of microgravity for those seeking to conduct research in space or about the affects of spaceflight.

Image Reference

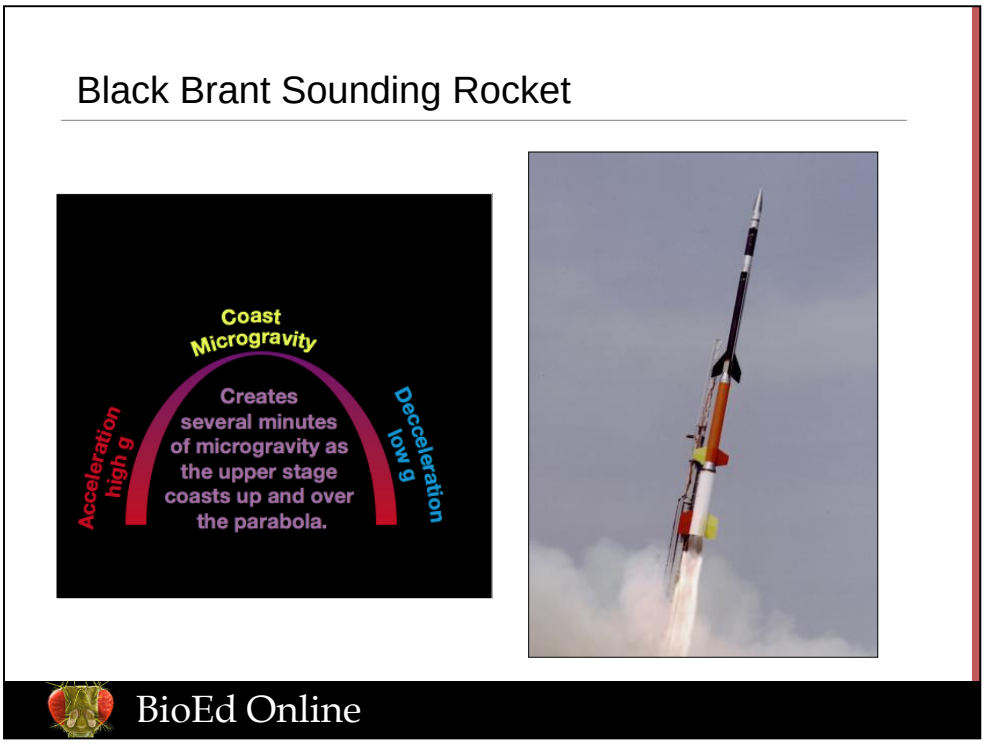


Water Balloons in Microgravity

The behavior of the water in the photos above makes it appear that there is no gravity. In fact, the astronaut, water, and spacecraft all are being impacted by the force of gravity, and they are falling together. This is why the water is able to retain its spherical formation.

Image Reference

Experimenter blows large air bubble into the free floating blob using a straw aboard a NASA airplane (screen shots from video). Courtesy of NASA. Retrieved 1-13-10. From video at http://spaceflightsystems.grc.nasa.gov/WaterBalloon/#AIRPLANE/.



Black Brant Sounding Rocket

A sounding rocket creates high “g” force at liftoff and provides several minutes of microgravity during its “coast” phase.

Image References

A Black Brant XII sounding rocket launching from NASA Wallops Flight Facility.

Courtesy of NASA/Wallops. Retrieved 1-13-10. http://en.wikipedia.org/wiki/File:Black_Brant.jpg.

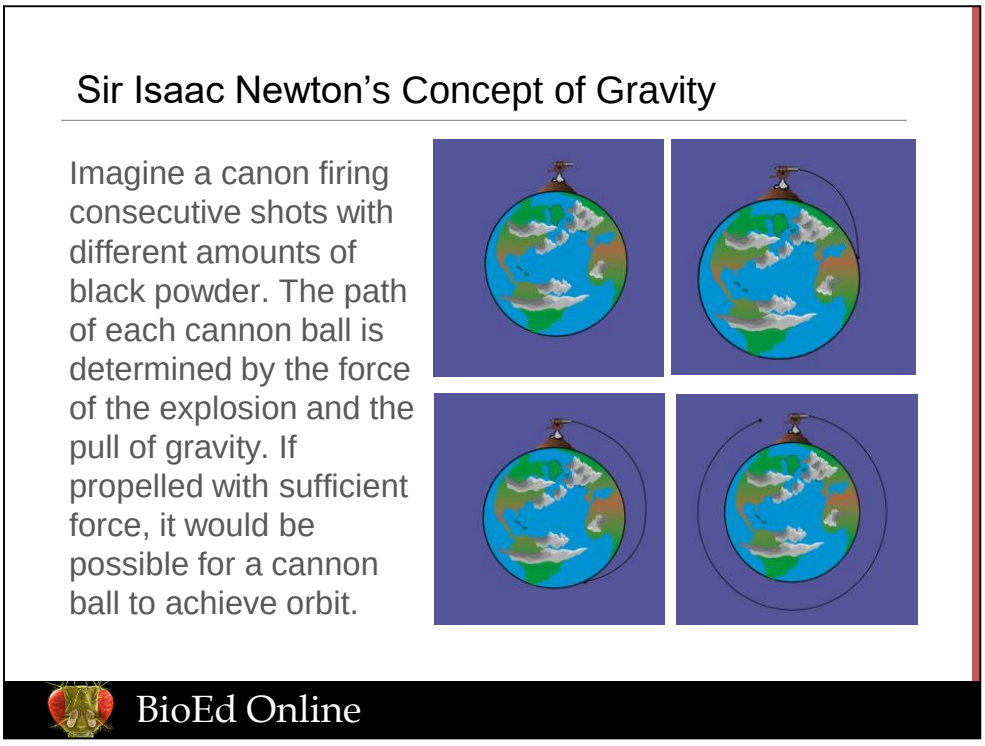


Image Reference

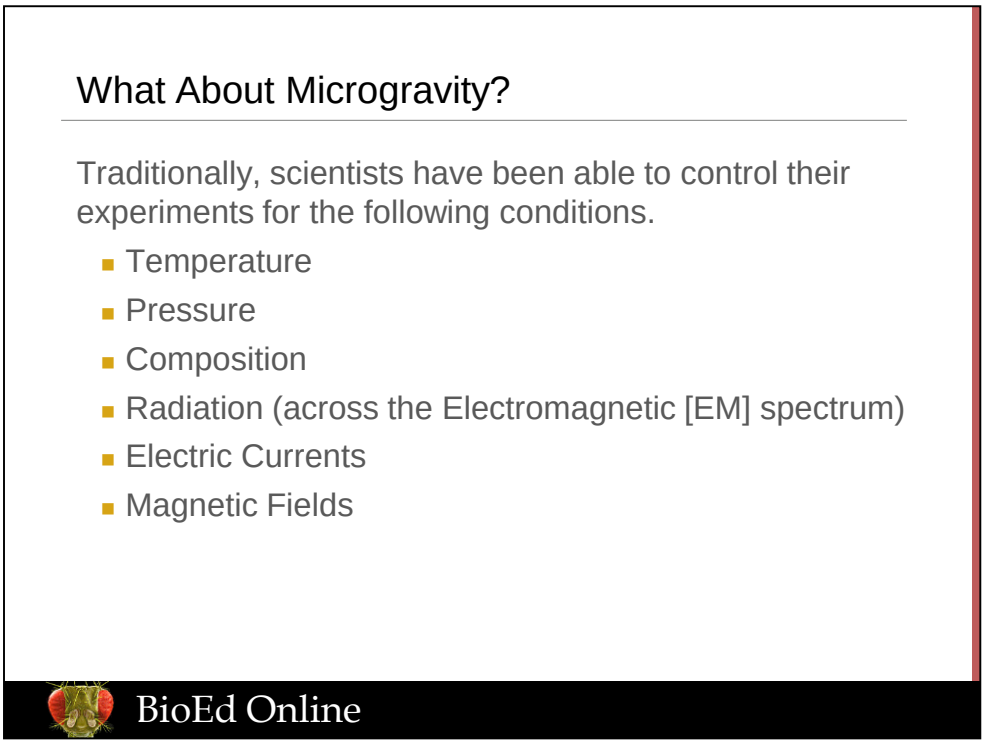
Illustration compilations @ G.L. Vogt.

Microgravity: Why Should I Care?

Microgravity creates an ideal environment in which to conduct many forms of research.

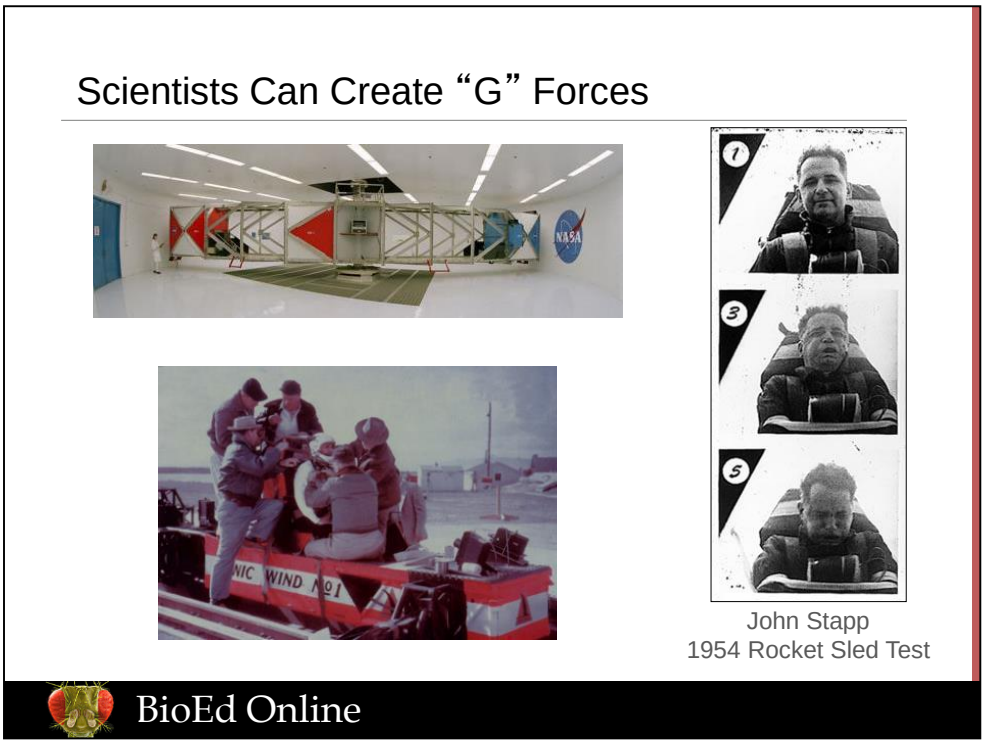
Image Reference

ISS005-E-21040 (21 November 2002) --- Astronaut Peggy A. Whitson, Expedition Five NASA ISS science officer, floats in the Destiny laboratory on the International Space Station (ISS). Courtesy of NASA. http://spaceflight.nasa.gov/gallery/images/station/crew-5/html/iss005e21040.html/.



What About Microgravity?

It is important to control variables when conducting an experiment. However, microgravity is one important factor that past scientists have not been able to recreate or manage.



Scientists Can Create “G” Forces

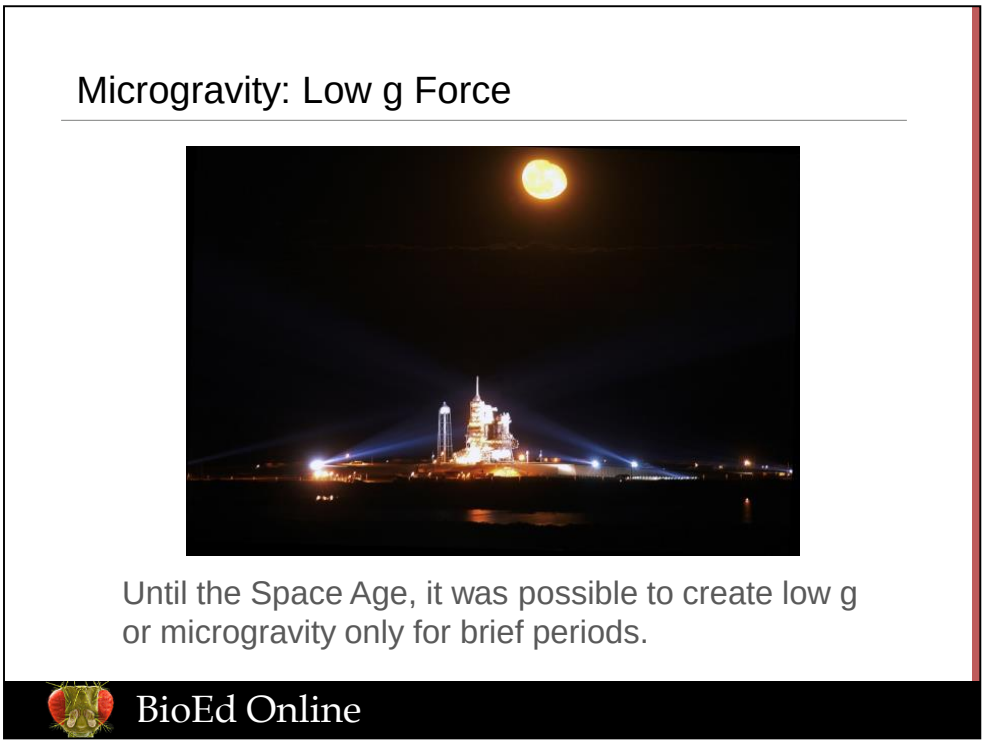
John Stapp was an investigator who rode a rocket sled, named Sonic Wind, that allowed him to experience forces up to 35g.

Image References

NASA’s 20 g-force centrifuge and cab. Courtesy of NASA\Ames. Retrieved 1-13-10. http://www.nasa.gov/centers/ames/multimedia/images/2006/20gcentrifuge.html/.

Stapp strapping into Sonic Wind. Note the lack of windscreen for this test. Courtesy EAFB History Office. http://www.ejectionsite.com/stapp/16.jpg/.

Time-sequence photos show Col. John P. Stapp on the rocket sled “Sonic Wind I” during a 421 mph-run in March 1954. Public domain. http://en.wikipedia.org/wiki/File:StappSled.jpg

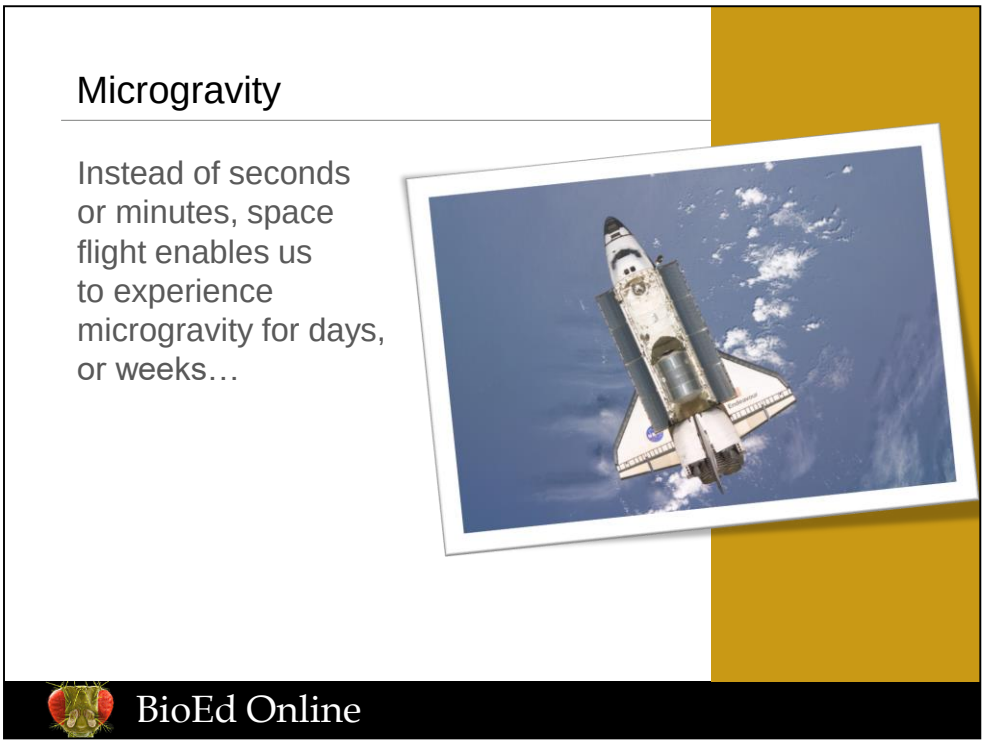


Microgravity: Low g Force

Recent technology has allowed scientists to sustain microgravity conditions for longer periods than was previously possible.

Image Reference

Courtesy of NASA. Retrieved 1-13-10.
http://www.nasa.gov/multimedia/imagegallery/index.html.

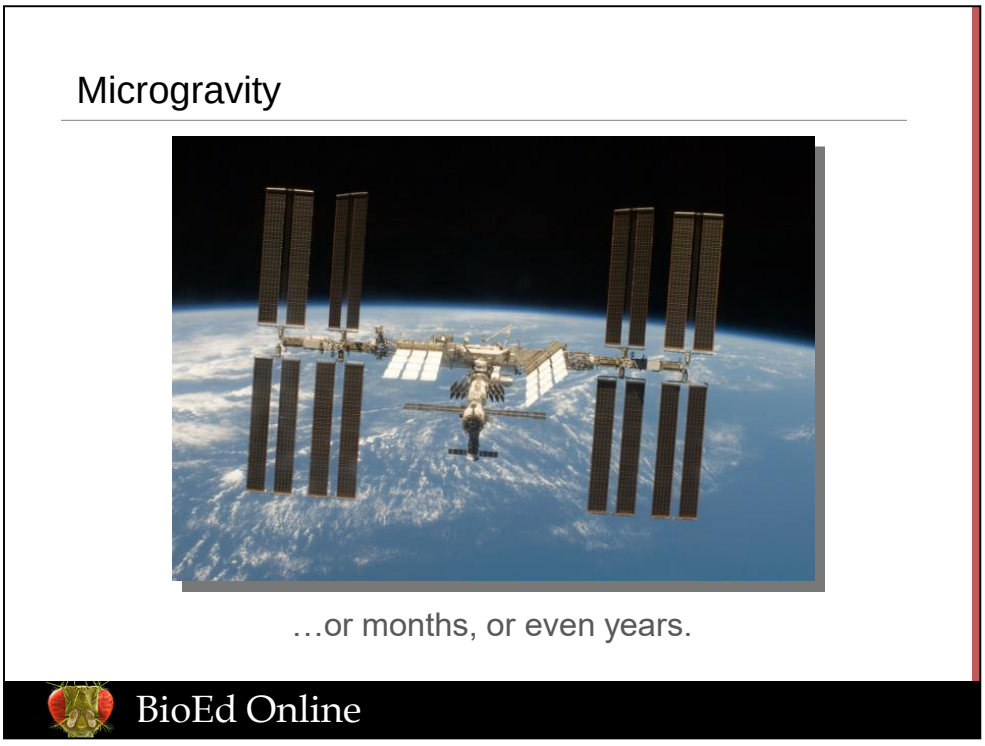


Microgravity

The space shuttle and other developments in space travel, have allowed humans to experience and study microgravity for weeks at a time.

Image Reference

Courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/index.html.

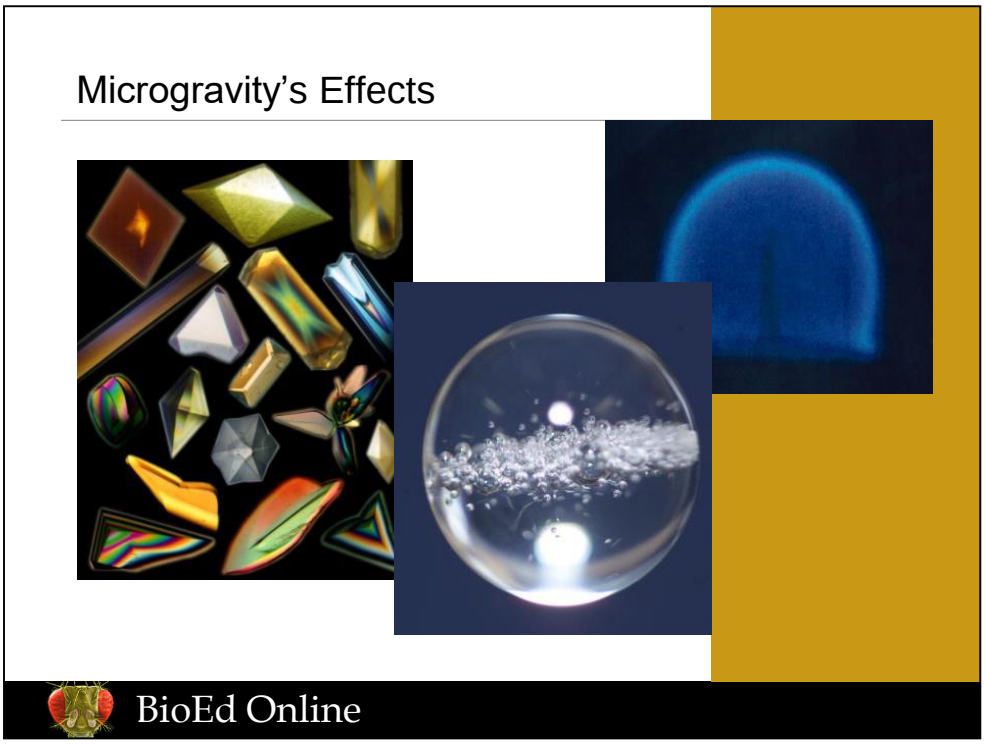


Microgravity

The International Space Station provides an environment for even longer stays in microgravity, up to months or years.

Image Reference

Courtesy of NASA. Retrieved 1-13-10.
http://www.nasa.gov/multimedia/imagegallery/index.html.

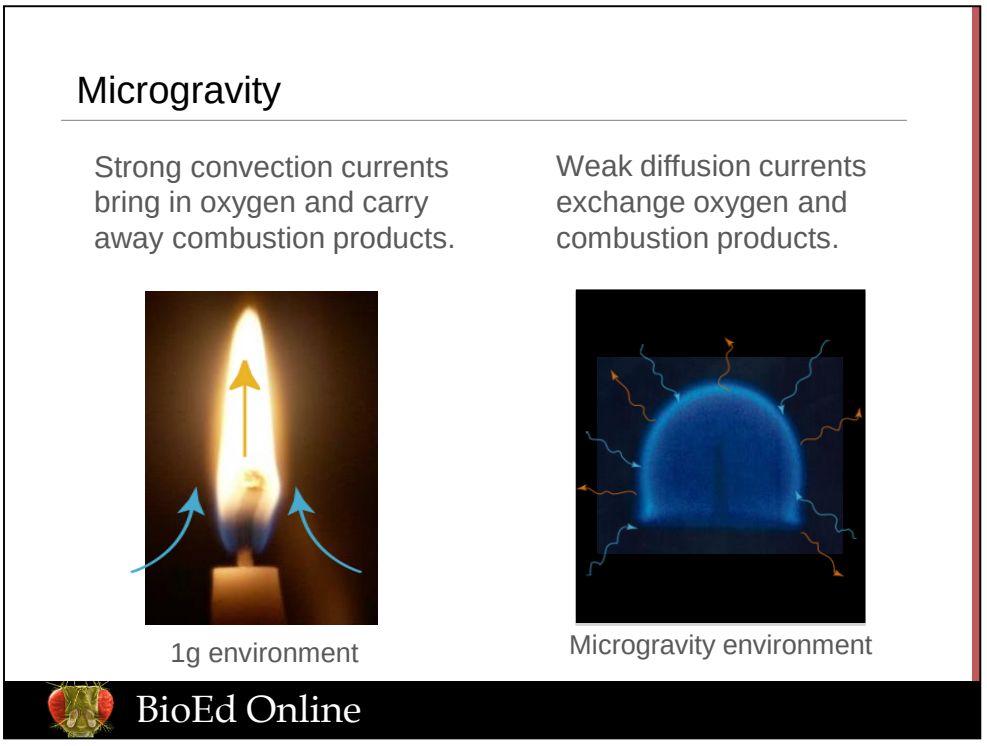


Microgravity's Effects

Experiments that use microgravity as a variable can be conducted on the ground or in space.

Image References

Courtesy of NASA. Retrieved 1-13-10.
http://www.nasa.gov/multimedia/imagegallery/index.html.

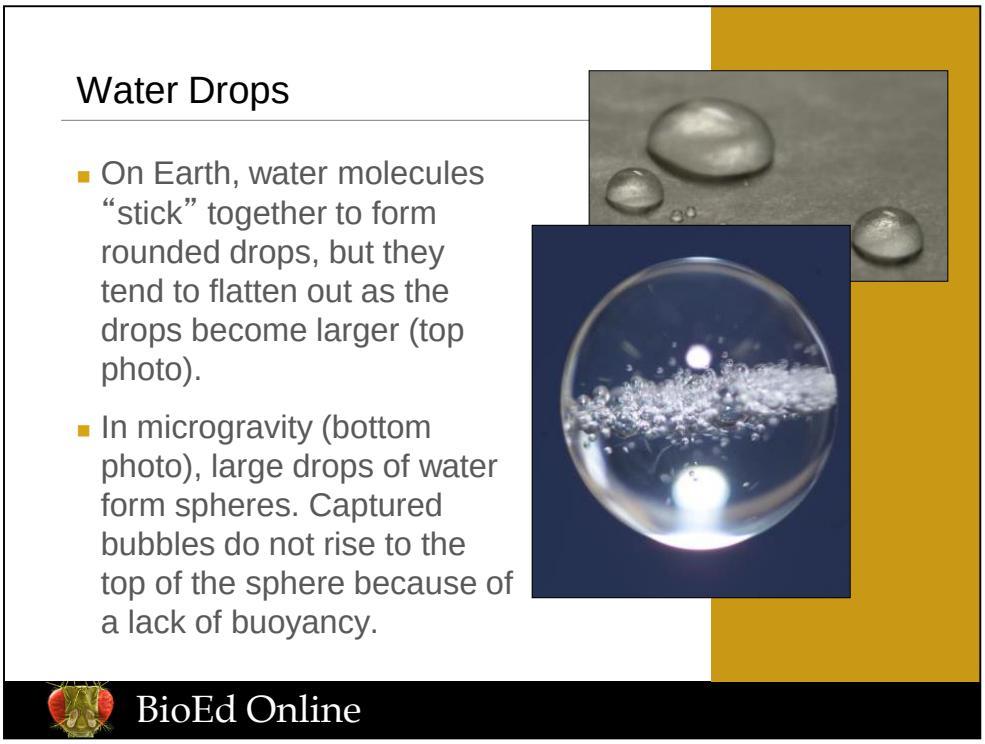


Microgravity

A candle flame on Earth receives fresh oxygen from rising hot air currents. In microgravity, there are no convection currents. Diffusion brings fresh oxygen to the flame, but it is an inefficient transport mechanism.

Image References

Courtesy of NASA. Retrieved 1-13-10, http://www.nasa.gov/multimedia/imagegallery/index.html.



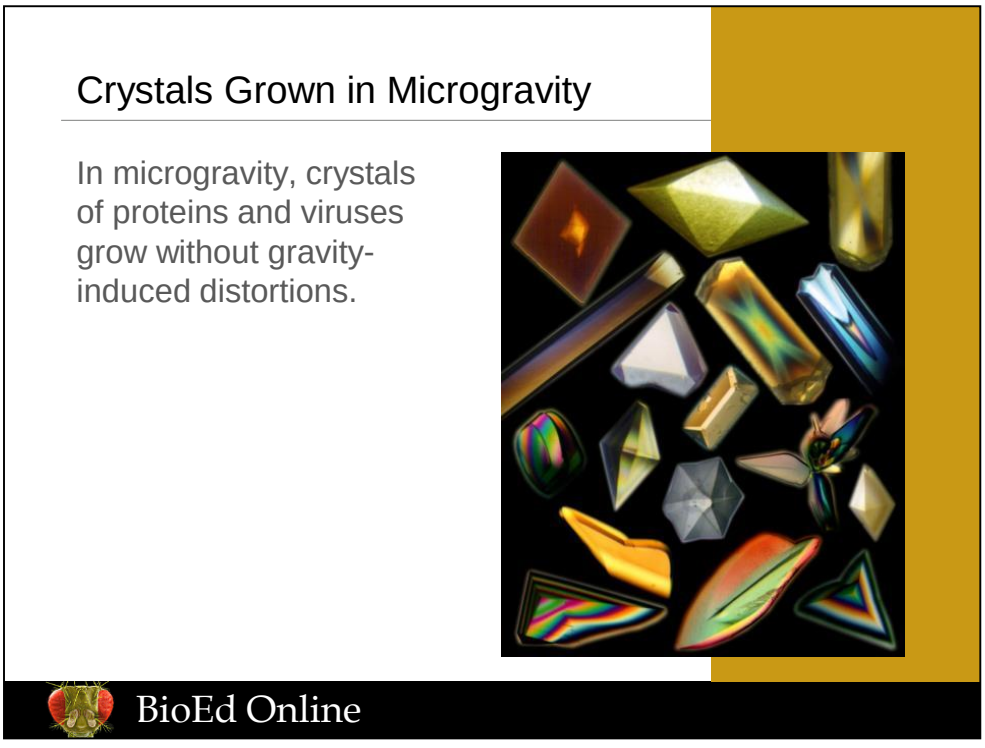
Water Drops

On Earth, water droplets eventually are flattened by gravity. In microgravity, drops of water remain spherical.

Because there is no buoyancy or sedimentation in microgravity, substances will remain in place until mixed, and heavier objects may rest on top of lighter ones.

Image References

Courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/multimedia/imagegallery/index.html/.

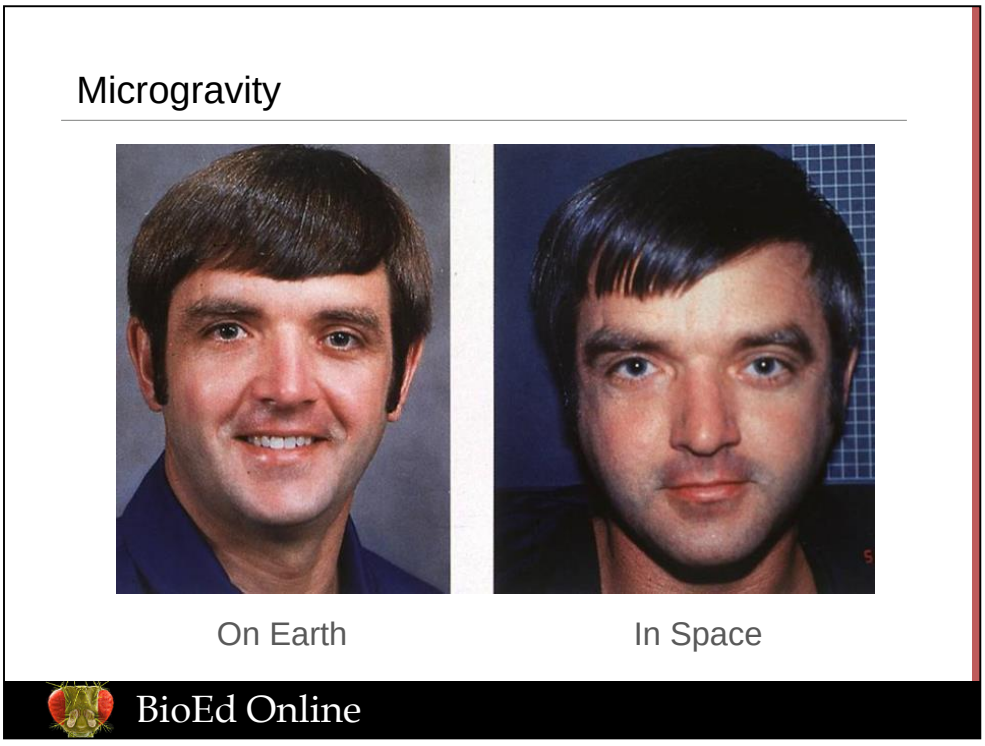


Crystals Grown in Microgravity

Crystals of protein and viruses grown on Earth can be distorted by gravity. Microgravity allows the growth of more perfect crystals, the study of which may lead to improved medicines.

Image Reference

Courtesy of NASA. Retrieved 1-13-10, http://www.nasa.gov/multimedia/imagegallery/index.html/.

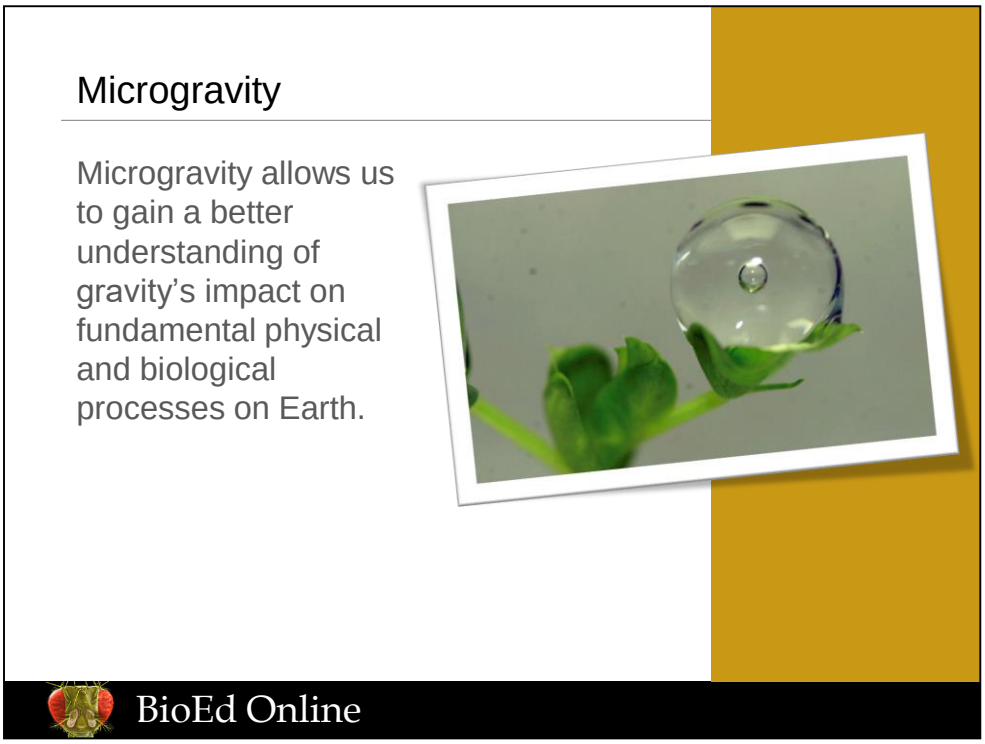


Microgravity

Microgravity causes an upward shift of fluid within the body. This redistribution of fluid can lead to a thinning of the legs and swelling of the face. Eventually, the body's baroreceptors detect the imbalance and convert some blood into urine to reduce swelling. As a result, when astronauts return to Earth, they have less blood than needed. Some require recovery time to regain their strength and rebuild their fluid levels.

Image Reference

Courtesy of NASA. Retrieved 1-13-10.
http://www.nasa.gov/multimedia/imagegallery/index.html/.



Microgravity

Plants can grow in space, but may grow haphazardly without a light source to provide direction. Also, roots may grow up if there is insufficient moisture at the bottom of the soil or growth media.

Image Reference

Courtesy of NASA. Retrieved 1-13-10. http://www.nasa.gov/audience/forstudents/5-8/features/space_gardens_feature.html/.