Editor's Note:

The investigation of the Challenger space shuttle disaster in 1986 found the probable cause of the accident as the failure of an O-ring used to seal the joint between two sections of one of the solid rocket boosters. Temperatures on the ground were much colder than normal on the morning of the launch, changing the properties of the O-ring material so that it did not function as it should. The first hint that this material could have been the culprit came when Caltech physicist and Challenger Investigation Committee member Richard Feynman impulsively plunged a sample of the O-ring material into his glass of ice water and noticed that it became significantly less pliable.

In this activity, students can devise their own tests to find out how the properties of an ordinary material may change under extraordinary circumstances, which certainly describes the environment in outer space.

This activity can be very simple—and safe—for younger students. Older students who understand the potential hazards of even small amounts of materials such as paint thinner and gasoline, and whose teachers can procure dry ice or liquid nitrogen, can extend the experiment greatly.

Testing new technologies and new materials in space is the focus of NASA's New Millennium Program. It is important to validate new technologies before they are depended upon for critical space science missions. Find out more about the New Millennium Program at http://nmp.jpl.nasa.gov/ .

This activity and article were created by Diane Fisher and Enoch Kwok. Ms. Fisher is a science and technology writer at the Jet Propulsion Laboratory and developer of The Space Place (http://spaceplace.jpl.nasa.gov), a web site with fun and educational space-related activities for children. Mr. Kwok is a high-school teacher and consultant. The cartoons are by Alexander Novati and Liliana Novati. Thanks also to Nancy Leon, Education and Public Outreach Manager for a number of programs and projects at JPL.

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50 Ways to Torture a What?!

You may think there's a big difference in temperatures during summer and winter where you live. You may have noticed that things like garden hoses seem almost as if they're made of different stuff, depending on whether it is hot or cold outside. The material is soft and flexible when it's hot, and hard and stiff when it's cold.

But even the most extreme temperature variations here at home on the surface of Earth are nothing compared to what a spacecraft may encounter in space or in visiting other solar system bodies.

Materials going into space encounter extremely harsh conditions not normally encountered on Earth. Radiation is terrible. Depending on which side of a spacecraft is facing the sun, it may be either very hot or very cold. There's no air and very little gravity. Probes dropped into the atmosphere of a planet like Jupiter or Saturn's moon Titan may encounter tremendous pressures, temperatures, and corrosive gases. It's not friendly out there!

If we are going to learn about space and what other planets, moons, asteroids, and comets are like, we have to build our spacecraft out of very special and tough materials.

Stre-e-e-tch Your Imagination

In this experiment, you will take an ordinary material used to make a very ordinary, but useful object, and subject it to just about any punishment you can think of, to see how the material holds up.

The material you will be testing is the rubber used in making rubber bands. For the class, you will need at least two fat, identical rubber bands for each person or team doing an experiment. One rubber band is subjected to a test condition, and the other rubber band is not (it is the control). We suggest some ways to test your rubber band, but you are not limited to this list.

Some of these materials are hazardous, and, in addition, some are not very easy to find. The teacher will be the one to decide which materials to bring into the classroom.

You (or your team) will pick one test to do on your test rubber band.

Note the Starting Conditions

However, before subjecting it to any testing, observe and record the following properties of both the test and the control rubber bands:

Elasticity (you could hang a weight from the rubber band and measure how long it stretches out)
Brittleness (how stiff and breakable is it; just describe in words)
Strength (can you break it easily just by stretching it?)
Color
Light reflection (dull/shiny)
Texture (smooth, sticky, crumbly)
Odor

And Start the Test

Now, pick out one way to "torture" your test rubber band. The control rubber band just lays around and escapes punishment. Subject the rubber band to the test for anywhere from a few hours to a couple of weeks. Decide the duration of the test based on how harsh you think the hazard will be to the material.

When you have finished your torture test, compare the properties of the test rubber band with the control rubber band and report your findings.

> **Note:** For tests that involve soaking the rubber band in a liquid, we suggest using small glass jars with tight-fitting lids. Some of these liquids could dissolve or otherwise ruin plastic.

Simple tests, very safe for the tester:

Freeze it in the freezer.
Put it in a bowl of water and freeze the water (don't put a lid on the container), then thaw the ice.
Heat it over a candle or Bunsen burner flame (don't allow the rubber to burn or smoke!)
Keep it in a warm place (not over flame) for several days (like near a furnace or fireplace)
Put it in a glass jar with a tight lid and leave in a warm spot for a few days (check jar for any film deposited on inside).
Expose it to sunlight for a few days/weeks.
Expose it to lots of air pollution for a few days (such as near the exhaust pipe of a vehicle, but not where it will get too hot—if possible).
Soak it in water.
Boil it in water.
Soak it in vinegar.
Soak it in a bottle of cola soft drink.
Soak it in motor oil.
Soak it in cooking oil.
Soak it in isopropyl (rubbing) alcohol.
Soak it in liquid dishwashing detergent.
Soak it in a brine (salt) solution.

Stretch it out and keep it stretched for several days (hang a weight from it).
Find some way to stretch it over and over, hundreds of times. (For example, rig it to stretch every time a frequently used door is opened.)

More hazardous tests:

CAUTION! Please handle this stuff with care!

Freeze it with liquid nitrogen.
Freeze it by putting it between layers of dry ice.
Soak it in gasoline.
Soak it in acetone.
Soak it in nail polish remover.
Soak it in paint thinner.
Soak it in formaldehyde.
Soak it in a strong household cleaning solution.
Soak it in chlorine bleach.
Put it in a glass jar (tight lid) with some moth balls, Borax (or some other reactive dry substance).
Or expose it to any other environmental hazard you can think of.

Damage Report

Before checking for property changes, if the rubber band has been soaking in a liquid, rinse it with water (if a water soluble liquid) or dry it off with a paper towel (if a non-water-soluble liquid).

Again, check the "treated" rubber band for the same properties you checked at the beginning. Record your observations. Compare the treated with the untreated rubber band.

Can you draw any conclusions about the kinds of space environments where this material would or would not be suitable? Keep in mind there are no doubt environments out there that we haven't even begun to imagine!

The engineers and scientists working on NASA's New Millennium Program don't exactly sit around thinking up ways to torture potential space-faring materials. But they have a pretty good idea of what conditions may be like out there and know the only way to really test new materials or other advanced new technologies is to send them into space on a special test mission. In addition to new materials, New Millennium Program missions test new propulsion and communication technologies, new types of computer and data handling systems, new navigation technologies and new types of imaging and mapping instruments. This way, future missions of discovery to other solar system bodies will have the advantages of the latest and best technologies for space without having to risk their missions on the new and untried.

EO-1 rendering goes here

Caption: A New Millennium Program mission called Earth Observing 1 will test new imaging technologies that will help us understand changes (such as the disappearance of the rain forests) that affect the environment.