TEACHER'S GUIDE

strange MATTER

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DEAR TEACHERS

Are your students ready for a close encounter with the amazing world of modern materials?

This Teacher's Resource Guide is intended to accompany *Strange Matter*, an interactive, hands-on exhibition about materials and materials science.

The *Strange Matter* exhibition uses science to explore the bizarre world of modern materials and provide a glimpse of where the future of materials research might take us.

Enter the fascinating world of materials and uncover the surprising science behind everyday stuff. High-tech fields like the space program are known for their use of advanced materials, but these materials have also found their way into the stuff of everyday life – from car shock absorbers and eyeglass frames to DVD players and golf clubs.

In this exhibition, *you* become the materials scientist. Zoom down to the micro level and find out why materials behave the way they do. Learn why Post-It notes stick and Teflon doesn't. Play with liquids that defy gravity and morph mysteriously. Discover what your skull and soap bubbles have in common. Get hands-on and test materials to reveal their properties: whack an atom and try to smash a pane of glass with a bowling ball.

This Teacher's Guide is a companion resource to the exhibition. The activities are designed for students in grades 5 through 8 and are curriculum correlated to the U.S. National Science Education Standards.

Six hands-on, inquiry-based activities investigate the science of materials. Students are challenged to examine the things that make up their material world in a different way – through the eyes of materials scientists. Each activity features Teacher's Notes and Student Activity pages. Teacher's pages include background, preparation, and teaching strategies for introducing the activities as well as extension suggestions, related Web sites, and the connection to the *Strange Matter* exhibit.

These activities are designed to be flexible. Feel free to adapt them to suit the needs of your students. Change and modify the activities when appropriate for your class. Choose one activity, or do them all.

Explore the strange matter behind everyday stuff.

Discover Materials Science.

Strange Matter is produced by the Ontario Science Centre and is presented by the Materials Research Society, a not-for-profit scientific association founded in 1973 to promote interdisciplinary goal-oriented research on materials of technological importance. Membership in the Society consists of more than 12,500 scientists from industry, government, academia and research laboratories in the United States and nearly 50 other countries. The Materials Research Society has received funding from the National Science Foundation, Alcan, Dow Chemical, Ford Motor Company and 3M Foundation in conjunction with its presentation of *Strange Matter*.

CURRICULUM CONNECTIONS for ACTIVITIES
from the National Science Education Standards (NSES)

		MY MATTER	MAGNETIC MATTER	SLIMY MATTER	FOAMY MATTER	BOUNCY MATTER	TESTING MATTER
Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiment; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.	[Science As Inquiry, Content Standard A, Grades 5-8: Understandings About Scientific Inquiry]	✓	✓	✓	✓	✓	✓
A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.	[Physical Science, Content Standard B, Grades 5-8: Properties And Changes Of Properties In Matter]		✓	✓	✓	✓	✓
Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.	[Physical Science, Content Standard B, Grades 5-8: Transfer Of Energy]				✓	✓	
Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.	[Physical Science, Content Standard B, Grades 5-8: Properties And Changes Of Properties In Matter]			✓			
The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.	[Physical Science, Content Standard B, Grades 5-8: Motions And Forces]					✓	

		MY MATTER	MAGNETIC MATTER	SLIMY MATTER	FOAMY MATTER	BOUNCY MATTER	TESTING MATTER
Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.	[Science And Technology, Content Standard E, Grades 5-8: Understandings About Science And Technology]						□
Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints include safety and aesthetics.	[Science And Technology, Content Standard E: Grades 5-8: Understandings About Science And Technology]						□
Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.	[Science In Personal And Social Perspectives, Content Standard F, Grades 5-8: Science And Technology In Society]	□					
Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.	[Science In Personal And Social Perspectives, Content Standard F, Grades 5-8: Science And Technology In Society]	□					
Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.	[Science In Personal And Social Perspectives, Content Standard F, Grades 5-8: Science And Technology In Society]	□					

		MY MATTER	MAGNETIC MATTER	SLIMY MATTER	FOAMY MATTER	BOUNCY MATTER	TESTING MATTER
Science and technology have advanced through the contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.	[Science In Personal And Social Perspectives, Content Standard F, Grades 5-8: Science And Technology In Society]	☐					
Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity – as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.	[History And Nature Of Science, Content Standard G: Grades 5-8: Nature Of Science]	☐	☐	☐	☐	☐	☐
It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.	[History And Nature Of Science, Content Standard G: Grades 5-8: Nature Of Science]	☐	☐	☐	☐	☐	☐
Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.	[History And Nature Of Science, Content Standard G: Grades 5-8: Nature Of Science]	☐	☐	☐	☐	☐	☐

THE EXHIBITS OF *STRANGE MATTER*

Exhibit experience pods and a demonstration theatre will reveal the secrets of many materials:

Zoom! will take visitors on a voyage from the macro scale of the world we see around us to the atomic scale where scientists investigate individual atoms using atomic force microscopes.

Crank up a bowling ball and let it fly! In **Smash the Glass**, visitors will discover whether heat-tempered glass has the strength to withstand the shock or if the pane of glass will shatter. Find out where this material is used, whether it be at a NBA basketball game or in your kitchen.

Play with amazing **Magnetic Liquids** to discover whether they are a solid, a liquid…or both! Visitors will be able to swish their gloved hands through a magneto-rheological fluid and, using magnets, morph it from a fluid to a solid. Investigate how ferrofluids (fluids in which iron particles are suspended) are put to use, from the operating room to the laundry room.

Bend and twist Nitinol metal and then watch what happens when you add heat. Unlike other metals, Nitinol, an astonishing example of a **Memory Metal**, returns to its original shape with a blast of hot air. Discover why this metal acts this way, and how this unique property has been put to use in eyeglass frames, cardiac surgery, and orthodontic braces.

Foam is on beer, in cushions, inside human bone and is used by NASA in space. In this experience, watch a dramatic column of foam grow towards the ceiling, and discover its surprising composition. Check out the lightest solid in the world – aerogel, also known as “frozen smoke”.

Younger children can discover materials through hands-on experimentation at the **Touch Table**. Put different materials under the lens of a microscope camera to see how they look magnified larger than life. Play tunes on a wooden xylophone and a xylophone of mixed materials – do similar materials sound the same? Tumble tubes to see how a solid material can flow like a liquid.

Other exhibit experiences include: checking out the one of the world’s hardest materials in **Amorphous Metal**, discovering how materials scientists control **Structure and Defects** to create different properties in materials, and examining the material that led to the computer revolution in **Sand to Supercomputers**.

Could a strand of spider silk actually stop a 747 in flight? What do modern firefighters and medieval knights have in common? In the **Materials Evolution** area you will trace the fascinating and often unexpected development of materials throughout history - from "The Iceman" (3300 BCE) to the present world of the "Material Girl", while discovering which materials have played a key role in human civilization.

In the **Demo Theatre**, hosts will present daily demonstrations that delve deeper into the secrets of everyday stuff. Following each demonstration, visitors can become materials scientists by creating a polymer.

WHAT IS MATERIALS SCIENCE?

You could call it the study of stuff! Just about everything you use every day – the shoes you wear, the dishes you eat from, the CDs you listen to, the bike or skateboard you ride – it's all made of different kinds of stuff.

Understanding how that stuff is put together, how it can be used, how it can be changed and made better to do more amazing things – even creating completely new kinds of stuff: that's what materials science is all about.

What are materials, exactly?

That's a big question – because materials are the basic substances that make up, well, you name it! Materials can be natural – like wood, or human-made – like plastic. There are now about 300,000 different known materials. (If you named one every second, it would take you more than three whole days and nights just to get through the list!) And as materials scientists create and combine materials in new ways, the number's almost infinite.

Most materials fit into a few general categories:

Metals

Whole periods of human civilization – such as the Bronze and Iron ages – are named for metals. These were the first materials to be "engineered," that is, people changed them to fit what they needed to do, rather than just letting their natural properties determine what they could be used for. These days, materials scientists are using metals in ways no one could have pictured even a few years ago – for example, shaping copper into tiny wires a thousand times skinnier than a strand of your hair!

Ceramics

Think about a china teapot – that's one type of ceramic. But ceramics can also be used to create bone and tooth replacements, super-strong cutting tools, or to conduct electricity. With the addition of oxygen or nitrogen, metals become ceramics, too.

Semiconductors

One of these materials – silicon – made it possible for you to read these words right now! That's because silicon is the essential material in an electronic computer chip. "Semiconductor" means a material can conduct electricity with a bit of help in the form of added "impurities". Your CD, DVD player and telephone – all depend on semiconductors.

Polymers

Polymers are just very big molecules made of smaller molecules linked together into long, repeating chains. You may not know it, but you're in touch with polymers every day more than any other kind of material. Rubber bands are made of polymers, so are paints and every kind of plastic. And by the way, most of the food you eat is made of natural polymers!

Other materials are a little tougher to define…

Composites

Composites are combinations of materials, which can be as simple as concrete reinforced with steel bars or as leading edge as an ultralight, carbon-fiber bicycle. The places where different materials meet – the "interfaces" – often produce new properties that are radically different, and better, than those in any single material.

Biomaterials

Every part of your body is a material! Bone, muscles, fingernails, hair, and skin are all examples of different types of materials found in your body with remarkable properties that help you survive – from keeping you upright and protecting you from heat or cold, to cutting and grinding your food. Some scientists try to mimic nature's designs to create materials for other uses, such as using the foam structure of bone as an inspiration for designing materials that are lightweight and strong.

And some materials are just plain weird…

Exotic and Strange Materials

Materials scientists are discovering and creating entirely new types of materials – such as buckyballs and nanotubes, which are very tiny spheres or cylinders made of carbon atoms. Then there are aerogels, which are extremely lightweight, porous materials made almost entirely of air! Nanotechnology is taking materials science into a new dimension, as scientists create new materials atom-by-atom and molecule-by-molecule – leading to properties and performance never before imagined.

Who are materials scientists and what do they do?

You've probably heard of a chemist, a biologist or a physicist, but have you ever heard of a *materials scientist*? Probably not. One reason is that materials science covers a huge range of activity and touches on many different fields – including chemistry, biology, and physics! Sometimes materials scientists are called ceramic or polymer engineers or metallurgists, and you can find them working in industries, labs and universities all over the world.

But diverse as they are, materials scientists look at materials from a unified point of view: they look for connections between the underlying **structure** of a material, its **properties**, how **processing** changes it, and what the material can do – its **performance**.

In the past, people used and changed materials by trial and error. And they worked on a big, visible scale – for example, heating then rapidly cooling chunks of iron to make it harder. Modern materials scientists manipulate and change materials based on fundamental understandings of how the materials are put together, often on the invisibly-tiny scale of atoms. How small is that? To make a speck as big as the period at the end of this sentence, you'd need trillions of atoms!

TEACHER'S NOTES

MY MATTER

THE INVESTIGATOR'S CHALLENGE

STUDENT OBJECTIVE

Students will survey their homes and school and discover the materials that are used to make up their world. They will analyze materials that are chosen for certain products and they will hypothesize about material choices. Students will look at the world around them with the eyes of a materials scientist. They will observe things with "different eyes".

Students will write clues about different materials. They will exchange clues with their classmates, and use the clues about use, properties, and performance to identify materials.

CLASS TIME

Day 1
30 minutes for INTRODUCTION

Day 2
45-60 minutes

HOMEWORK

Day 1

MATERIALS NEEDED

(For class demo)

- Different objects made from the same material (examples of plastic: bottle, bag, toy, etc.)
- The same type of object made from different materials (examples of cups: glass, ceramic, paper, plastic, Styrofoam, etc.)
- Magnifying glasses (students can share these)
- Optical microscopes (optional)

(For student activity/per student or group)

- File cards, 4 x 6 inch (10 cm x 15 cm) 5 cards per student

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **MY MATTER / The Investigator's Challenge**.

Gather all materials needed for the activity.

This Activity is done over 2 days.

The first day introduces the idea of "materials are our world" and the students do the first part of the Student Activity: surveying the classroom for different materials that are used in various objects and products. They continue the activity at home (as a homework assignment), surveying their homes for materials.

On the second day, students share their observations in class discussion. Then students complete the activity by choosing 5 materials from their list and creating clues to identify the materials. Students then exchange clues and try to identify the materials from the descriptions.

TEACHING PROCEDURE AND TIPS

1. Introduce the concept of materials by examining and investigating various objects and the materials they are made from.

Ask the students what a material is. Materials are the stuff that objects are made of. A material is anything that is used in making an object. Have students give examples of materials around the classroom.

Hold up a wooden pencil. What are the materials in this pencil? Wood, paint, graphite, rubber, metal, maybe glue, etc.

Ask students why these materials are used in the pencil instead of other materials, for example, why graphite instead of steel or copper for the lead, why not glass for the eraser, etc. Students will describe the properties of the materials that make them useful in the pencil.

Ask students for examples of other properties a material could have. Write the properties on the blackboard or chart paper, for example: stretchiness/elasticity, hardness, flexibility, roughness/smoothness, color, reflectivity, strength, transparency, magnetic properties, insulating properties, electrical conductivity, etc.

Have examples of different objects made from the same material, for example, a plastic bottle, a plastic bag, a plastic toy, etc.

Ask students why they think plastic was used. What are the advantages of making each item out of plastic? (They will identify some of the properties of plastic: unbreakable, lightweight, strong, doesn't let water seep through, moldable, etc.)

Next, show examples of the same object made from different materials, for example, shopping bags made from paper, plastic, cloth. Or another example: cups made from glass, ceramic, paper, plastic, Styrofoam.

What are the advantages of each material? What are the disadvantages, if any? Does each different material change the use or function of the object? How?

Think of all the different materials that make up a bicycle, for example.

Think about what all the different materials do in that bicycle, how they perform or behave.

Why are those materials used?

How a material is used is determined by its properties. For example, is it hard, can it bend, can it be shaped or molded, is it lightweight, does it insulate from heat or cold, is it elastic … Is there a material that you wouldn't use to make part of a bicycle, for example, the tires? Why?

2. Students do the Activity **MY MATTER / The Investigator's Challenge**. This activity is done over 2 days. On the first day, students survey their classroom for different materials that are used in various objects and products. They look at the materials closely with magnifying tools. Many people may have broken high tech stuff lying around, such as cell phones, speakers, VCRs, calculators. Students could take apart some broken things and look for materials there. If materials are actually broken apart, have students look at the fracture surfaces with magnifying tools.

Then, as a homework assignment, students continue investigating materials around their homes. Encourage students to bring in objects which they have investigated.

3. On the second day, have a class discussion where students share their observations about the materials in our world, HOW they were used, and WHY they were used. What materials did they discover? How were the materials used? Were the materials used in other objects as well? How did the materials contribute to the function of the object? What are the properties of the material? What does the material look like through a magnifying glass or microscope?

4. Students complete the activity by choosing 5 materials from their list and creating clues to identify the materials.

They must describe the materials in clues which explain properties, function, uses, how well they perform their function and so on. They can create as many clues as they like.

Each student receives 5 file cards.

Students list the clues for each material on a file card.

The material is not revealed on the card. Instead, students use a code: their name, plus a number to identify the material.

For example:
Matty Smith # 1,
Matty Smith #2, and so on.

Use this code on the file card to identify the material.

On a separate sheet of paper, have students keep a list of their materials, and their code identifiers as their master answer sheet, so they can verify what the material is.

For example:
Matty Smith #1 PLASTIC,
Matty Smith #2 STEEL, and so on.

5. When completed, students exchange clues and try to identify the materials from the descriptions. Collect all the clue cards, shuffle them, and distribute to students.

Students try to identify the materials from the clues. They can write down their answers.

6. As a class, have students read the clues aloud, suggest answers, and then verify the material.

EXTENSIONS

Create a timeline of materials. Students research some cool materials (such as Teflon, Kevlar, silicon, etc.) to determine when they were invented or discovered. Post the materials and their discovery date (year) on a horizontal timeline created from a roll of craft paper taped up to a wall, perhaps in the hall.

Have students pick a common material, such as paper or plastic. Next, have them imagine that the material suddenly disappears. What would the world be like without that material? How would our lives be different? Students write stories describing observations and experiences in a world without the material of their choice.

WEB LINKS

The STRANGE MATTER exhibition Web site
www.StrangeMatterExhibit.com

The MicroScape Virtual Laboratory
Take an extremely close-up look online at stuff from around your house, such as a penny or the tip of a ball point pen.

http://www.msa.microscopy.com/MicroScape/MicroScapeVL.html

Timeline of inventions such as rubber bands (1845) and cellophane tape (1937)

www.factmonster.com/ipka/A0768871.html33k

Materials for worlds in space

http://science.nasa.gov/ppod/y2003/04apr_misse.htm

STRANGE MATTER
Exhibit Connection

Materials Evolution

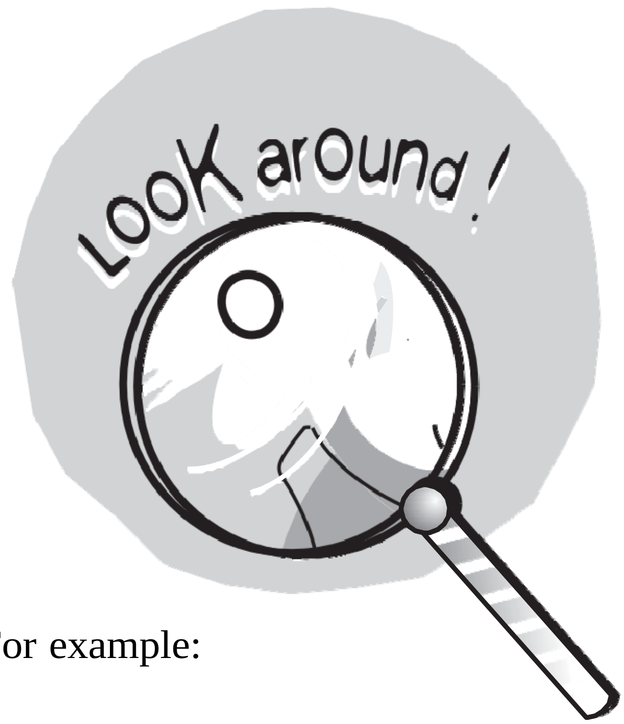
STUDENT ACTIVITY
MY MATTER
THE INVESTIGATOR'S CHALLENGE

Materials scientists look at things differently. They examine and investigate the objects in the world around them. They observe which materials are used to make different objects. They ask themselves questions: Why was that material used? How does it add to the function of the object? Could you use something else? How would a different material change the use of the object?

Your challenge is to investigate your world and the materials in it. See things differently. Be a materials witness. Examine objects around your home and school and observe which materials they are made from. Ask yourself questions about **why** those particular materials were chosen for that object. Pay attention to the answers. They are the clues to the materials.

Look around you with the eyes of a materials scientist as you discover the materials that make up your world.

CREATE QUESTIONs TO THINK ABOUT AS YOU ARE OBSERVING DIFFERENT OBJECTS AND THE MATERIALS THEY ARE MADE FROM.



For example:

- What is the material (or materials) that the object is made from?
- How will the object be used?
- Under what conditions will the object be used?
- How do the materials make that use possible?
- Why is that material (or materials) used for that object?

Investigate MATERIALS BY ASKING AND ANSWERING YOUR QUESTIONS.

Record YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.

Record your observations in chart form on another sheet of paper.

State the object, the material used, and reasons why the material was used. Remember that many objects are made from more than one material.

USE YOUR OBSERVATIONS TO HELP YOU Write CLUES ABOUT MATERIALS.

Pick a material.

Describe that material by explaining what it does, how it performs under different conditions, what its properties are. Here's an example:

Clues

- Does not break when you drop it
- Waterproof
- Does not insulate from hot or cold
- Can be molded into a shape
- Can be dyed different colors
- Can be washed but might melt in dishwasher
- Bendable, but could break if you bend it too much
- Used to make many different kinds of objects like bottles, toys, cups, jewelry, or containers

(Clue answer: PLASTIC)

Write as many clues as you can for the material you have chosen.

Write your clues on a file card, but don't write the name of the material on the card. You don't want to reveal what the material is.

Instead, use a code: your name, plus a number to identify your material.

For example

Matty Smith # 1,
Matty Smith #2,
and so on.

Print this on the file card to identify the material. On a separate sheet of paper, keep a list of materials and their code identifiers so you can verify what the material is.

For example

Matty Smith #1 PLASTIC,
Matty Smith #2 STEEL,
and so on.

Test YOUR CLUES

Do they make sense? Can the material be identified from the clues you have provided?

Look LIKE A MATERIAL SCIENTIST

How do you SEE your world differently when you look at things with the eyes of a materials scientist?

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TEACHER'S NOTES

MAGNETIC MATTER
The Astronaut's Challenge

STUDENT OBJECTIVE

Students will make a fluid with the properties of a liquid but which can be made to defy gravity.

Students will discover and explore a fluid that has some properties of a liquid AND some properties of a solid – a magnetic material that is used out in space and right here on Earth.

CLASS TIME

30 – 45 minutes

MATERIALS NEEDED

(For the class demo)

- Two large glass jars with metal lids (32 oz., 1L)
- Box of straight sewing pins
- Magnets
- Water

(For student activity/per student or group)

- Jar of baby oil
- Small jar with metal lid
- Steel wool, extra-fine (without soap) OR fine iron filings
- Scissors
- Teaspoon
- Non-metal stirring stick (like Popsicle sticks)
- Magnets (strong magnets work best)
- Safety glasses

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **MAGNETIC MATTER, The Astronaut's Challenge**.

Gather all materials needed for the activity.

Extra-fine steel wool without soap is available at hardware stores. One box of 6 rolls should be plenty for a class of 36. If you can only find steel wool with soap, wash out the soap before doing the experiment.

Strong magnets are better for this experiment. (A good source is www.wondermagnet.com.)

TEACHING PROCEDURE AND TIPS

1. Hold up a box of straight pins, start pouring them into the first jar and then "accidentally" spill the pins onto a cleared-off desktop. Ask students for efficient ways for picking up the pins. Use a magnet to pick up the pins. Notice that they all "stick" together. Holding the magnet and pins over the open top, "pour" the pins into the jar. Put the lid on tight. Discuss the properties of the jar that make it a good storage vessel for the pins. It's solid, transparent, has a lid to keep contents in, etc. Mention that you will keep the magnet handy for future cleanups. Students may suggest keeping the magnet on the metal lid because it sticks. Discuss the magnetic properties of magnets and the steel pins. Hold the magnet close to the outside of the jar and observe the movement of the pins. They become magnetized; each is a small magnet. Place the magnet on the lid and observe the behavior of the pins. You have defied gravity using the force of the magnet to control the pins.

2. Now use the second jar, half-filled with water, to demonstrate more properties and the performance of the jar. What makes the jar a good choice for holding liquids? Waterproof, liquid doesn't seep through the material, the lid makes it watertight, we can turn the jar upside down, etc.

Observe the water in the jar as you turn it upside down. (Make sure the lid is on tight.) What happens to the liquid? The liquid always falls to the lowest point in the jar due to gravity. But what if you wanted to control the liquid and keep it at the highest part of the jar? How could you defy gravity?

Compare the jar filled with liquid to the jar filled with pins. How can you make the pins stay at the top? Use the magnet. Can you use the magnet to keep the water at the top of the jar? No, because water isn't magnetic.

How could you keep a liquid in place, defying gravity? Students might suggest that they make the liquid magnetic. How? What if we could add tiny magnetic particles to the liquid?

FYI: There is no such thing as a liquid magnet, but tiny magnetic particles (solids) can be so small that they are suspended in the liquid and the liquid then behaves with magnetic properties.

Now imagine that you are an astronaut in space. What would be happening to the liquid? There is no gravity in space; you can't control the liquid. This can actually be an advantage for scientists in space. Many experiments are done in microgravity (a force of gravity so low that weightlessness occurs, for example, during space travel) precisely because fluids don't need to be kept in containers.

But what if you were in space, a zero gravity environment, and you wanted to control the liquid and keep it in place, for example on the bottom, top, or side of a container?

(This is the teaser for the student activity.)

3. Students do the activity **MAGNETIC MATTER / The Astronaut's Challenge.**

Students will make a magnetic fluid, a kind of ferrofluid. Experimenting, they will produce a new material: a baby oil-based liquid that contains tiny particles of steel wool. They will manipulate this new material using magnets and investigate its properties and performance.

The challenge is how do you hold liquids in place in space? And here on Earth, how do you defy gravity and hold a liquid at the top of a jar?

For the ferrofluid, the smaller the particles, the more fluid the material will be.

For even finer particles, you could have your students use very fine iron filings.

Or you can burn the steel wool in a fireproof pan using a match or torch flame, and then use a mortar and pestle to grind the wool to a powder. You could have some students use the finer iron filings or powder and compare observations and analysis as a class after the activity.

4. After the Student Activity, discuss the students' observations. Did they encounter any problems with their magnetic fluids? What might make this new material better? Smaller particles might combine better in the liquid; more particles or less liquid might help; a different liquid with different properties (more viscous? thicker? thinner? more slippery?) might hold the particles better.

Have students propose names for their magnetic fluid.

5. NASA scientists have developed a magnetic fluid material called a **ferrofluid**.

Keeping liquids in place is a big problem for astronauts in space. Why? There is no gravity. But if you can make a fluid with magnetic properties, you could have greater control over the liquid. Materials scientists developed magnetic fluids when they were searching for a way to control and handle liquid fuel in the gravity-free environment of space.

Ferrofluids have the fluid properties of a liquid and the magnetic properties of a solid. The magnetic particles are extremely tiny, 10 nanometers (nm) in diameter. These are really, really small particles. You'd have to line up 10,000 of them to match the width of the period at the end of this sentence.

6. Students can keep their ferrofluid indefinitely. Dispose of the mixture in the garbage.

7. Talk about the uses of ferrofluids here on earth. Ferrofluids contain incredibly small particles, making them useful in devices that require very sensitive, miniature components. For example, ferrofluids suspended between electronic parts by magnets create airtight liquid seals in computer hard drives and x-ray machines, protecting them from dust and debris.

For example, ferrofluids suspended between electronic parts by magnets create airtight liquid seals in computer hard drives and x-ray machines, protecting them from dust and debris.

Ferrofluids also make excellent lubricants for motor shafts or any other moving part. For example, a vacuum chamber has a rotary seal where the ferrofluid is stuck to a magnetic shaft. The shaft can rotate without friction AND the vacuum can't leak out as it would if there was just air around the shaft. In the International Space Station, astronauts can keep the vacuum of space out while being able to control rotating parts.

In CD and DVD players, magnets and ferrofluids work together as "shock absorbers," controlling vibrations that would cause the player to skip. The same technique is used in audio speakers, where ferrofluids improve sound quality by reducing unwanted vibrations.

Some scientists believe that a magnetic fluid might be found in migrating birds and butterflies. Ask students why they think this is. The magnetic fluid may help in the animal's navigation from north to south, and back again, using the Earth's magnetic field.

For future applications, scientists are trying to shuttle drugs through the body using magnetic fluids. Ask students how and why this might work. Researchers think that magnets could guide a tiny drop of fluid mixed with cancer-fighting agents directly to the tumor, minimizing the amount of drug needed and reducing side effects in the rest of the body.

8. NASA astronauts are conducting ferrofluid experiments in space on board the International Space Station. Students can find out more about the NASA InSPACE program by visiting the Web site:

http://spaceresearch.nasa.gov/general_info/23aug_MRfluids.html

EXTENSIONS

Students can make another magnetic fluid called magneto-rheological (MR) fluid. MR fluid solidifies in the presence of a magnetic field.

For experiment instructions visit:
http://spaceresearch.nasa.gov/general_info/23aug_MRfluids.html

WEB LINKS

www.StrangeMatterExhibit.com

http://spaceresearch.nasa.gov/general_info/23aug_MRfluids.hmtl

RESOURCES

Sources for samples of a REAL ferrrofluid from:

www.ferrofluidics.com/
www.teachersource.com

Get strong magnets from:

www.wondermagnet.com

STRANGE MATTER
Exhibit Connection

Amazing Magnetic Liquids

STUDENT ACTIVITY

MAGNETIC MATTER

The Astronaut's Challenge

Astronauts overcome many challenges in space.

Imagine trying to control the flow of a liquid in zero gravity. What problems would you encounter?

Here on Earth, gravity can be a big problem. Your challenge is to defy gravity! Discover a way to hold a liquid in place at the top of a jar (not at the bottom where it usually stays because of gravity) when the jar is right side up.

You'll combine solids and liquid to produce a new material and investigate the properties and performance of the new material you have produced.

You'll discover how strange matter can solve problems for astronauts in space!

CREATE A QUESTION TO THINK ABOUT AS YOU ARE EXPERIMENTING.

How does this challenge compare to the problem that astronauts have with liquids in space?

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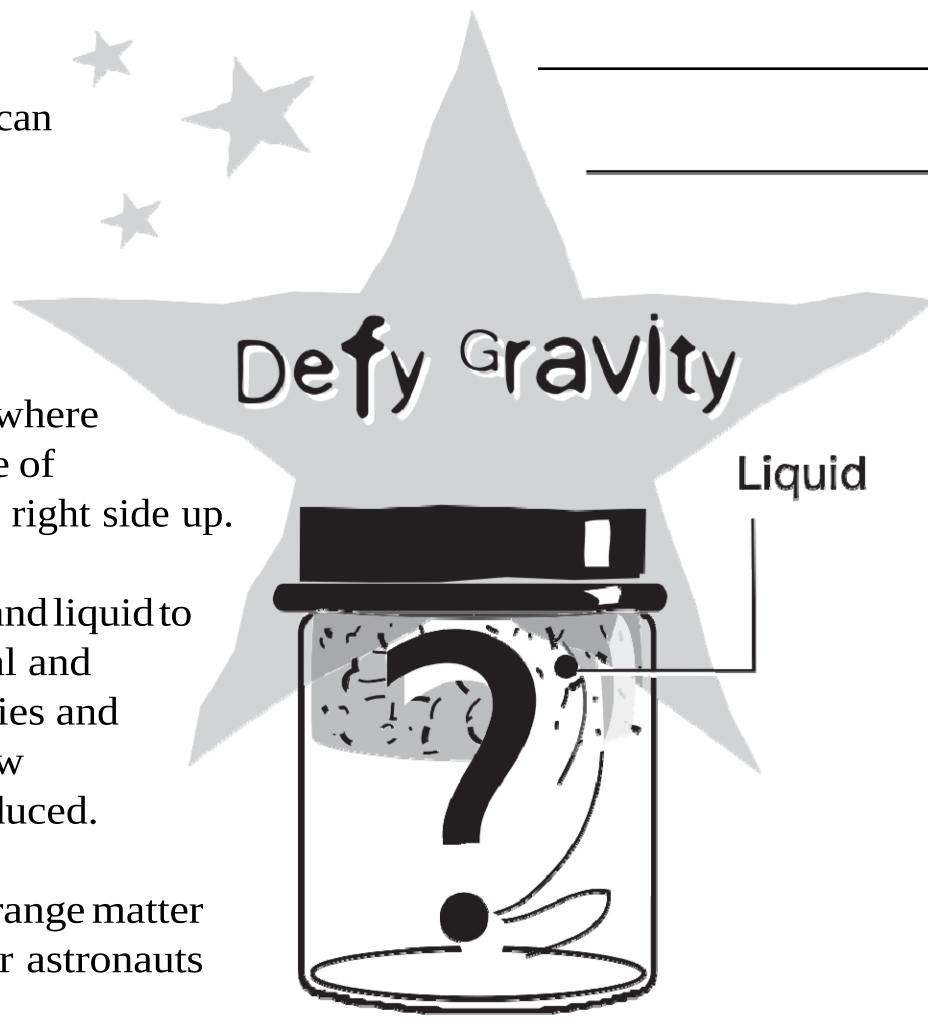

DO THE EXPERIMENT

YOU WILL NEED

- Baby oil
- Extra-fine steel wool (without soap)
- Small jar with tight-fitting metal lid
- Scissors
- Teaspoon
- Non-metal stirring stick (like a Popsicle stick)
- Strong magnets
- Safety glasses
- A sheet of paper

PROCEDURE

1. Place a sheet of paper on your desk.
2. Use scissors and cut across the steel wool to make the tiniest particles possible.
3. Cut up enough steel wool fibers to make about a teaspoonful of particles.
4. Carefully use the paper as a funnel to pour your steel wool particles into the jar.
5. Add a small amount of oil to the jar, just enough to cover the steel wool particles.
6. Stir with a non-metal stirring stick, mixing the particles into the oil.
7. Put the lid on the jar. Make sure it is on tightly.
8. Hold the magnet near the side of the jar. Observe what happens.

10. Move the magnet around and see what happens to the mixture.
11. Take the magnet away from the side of the jar and observe what happens to the mixture.
12. Slowly bring the magnet closer to the side of the jar.

13. Try the magnet at different locations and distances and observe the material.

14. Occasionally shake the jar to stir up the mixture.

15. Use the magnet to create different effects.

16. Try adding more oil and/or more filings. Observe how this new mixture reacts to the magnet. Are there changes from your original concoction?

ANALYZE
YOUR OBSERVATIONS.

Describe and draw your observations.

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Describe the properties of your new material.

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Is your new material a solid or is it a liquid? Why?

Why does it work the way it does?

Hypothesize

HOW YOU COULD IMPROVE THE PERFORMANCE OF YOUR MAGNETIC FLUID.

Describe how astronauts in space could use this material. Add diagrams to explain.

How might you use this new material in your own life here on earth?

Who else might use this material?

TEACHER'S NOTES

SLIMY MATTER

The Toy Designer's Challenge

STUDENT OBJECTIVE

Students will manipulate 2 polymers to make slimy goop and gooey worms. They will investigate the properties, performance, processing, and structure of the materials.

CLASS TIME

30 – 45 minutes

MATERIALS NEEDED

(Preparation and Class Demo)

- Silly Putty™, 1 container
- Paperclips
- Measuring spoons or balance
- 2 clean, large (1 gallon/4 liter) plastic milk jugs
- Safety goggles
- Rubber gloves (optional)

Mystery Material 1

(For student activity/per student or group)

- White craft glue (Elmer's™ white craft glue works well)
- Borax powder (grocery store laundry section)
- Water
- Food color (optional)
- Small, resealable plastic bags

Mystery Material 2

(For student activity/per student or group)

- Gaviscon™ liquid antacid
- Orange juice fortified with calcium

- Food coloring (optional)
- Squeeze bottle with narrow spout
- Large bowl or beaker
- Mixing spoon

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **SLIMY MATTER / The Toy Designer's Challenge**.

Gather all materials needed for the activity.

Elmer's™ white glue and Silly Putty™ can be found in toy stores.

Borax can be bought at your grocery store in the laundry detergent section.

Gaviscon™ liquid antacid and calcium-fortified orange juice can be purchased at grocery or drug stores.

For **Mystery Material 1** you need a solution of borax mixed in water. You can mix it up in advance, or have your students prepare it, depending on their abilities. Dissolve borax powder in water until no more will dissolve. (Saturation is 4 teaspoons / 40 grams of borax powder per 4 cups / 1 liter of water.) Each student will need about 1/2 cup of the solution. Mix up the solution in clean, large (1 gallon/4 liter) plastic milk jugs. Shake well.

CAUTION:
Borax will burn the eyes. Safety goggles should be worn when mixing up the solution.

For **Mystery Material 2** you need sodium alginate (found in the Gaviscon™) and calcium ions (found in the calcium-fortified orange juice). Sodium alginate is a common thickener used in ice cream, and is also found in cheese spread, dental impression materials, and the pimento strips in green olives. In this demo, sodium alginate is mixed with calcium ions to form cross-linked polymer gel "worms".

Rubber gloves are optional for these experiments. The materials are not toxic and can be manipulated with bare hands. As always, you should model good laboratory procedures and have students wash their hands after experimenting with their Mystery Materials.

TEACHING PROCEDURE AND TIPS

1. Introduce the challenge to the full class using Silly Putty™, a popular toy invented in the 1950s. Purchase some Silly Putty™ at a toy store.

As a full class demonstration, have different students play with the Silly Putty™.

Roll it into a ball. Try bouncing it. (It bounces when rolled into a tight ball.)

Have a student pull it apart fast. (It breaks into two pieces.)

Have a student pull it, stretching it slowly. (It stretches limply.)

As they play, students discover the properties of this material.

Discuss how the processing, and the handling of the material changes the properties it exhibits.

Ask students why the material has the name it does.

Often in science, when we mix different materials together we end up with a totally different material. This Silly Putty™ (originally called Nutty Putty) was discovered – by accident – through experimentation. Scientists were looking for a cheap replacement for rubber. Some new strange matter was produced and the scientists started "mucking around" with it. They discovered its amazing properties, and then someone thought it would make a fun material for kids to play with. Great idea. Silly Putty™ is still around over 50 years later!

2. Students do the activity **SLIMY MATTER / The Toy Designer's Challenge.**

Students will experiment with slimy matter to produce polymers with interesting properties. They will explore, test, and analyze the properties and determine how the new materials could be used for play or as a new toy.

Students will be modeling the behavior of materials scientists.

Reinforce safety practices in the "lab", experimenting safely and wisely. Keep unknown materials away from eyes and mouths. (These materials are not toxic and can be manipulated with hands. As always, wash hands after experimenting.)

FOR DISPOSAL: Don't wash the Mystery Materials down the sink. They could clog the drain. Throw them in the garbage.

Mystery Material 1

Students combine white craft glue (Elmer's™) with a borax and water solution, producing a new material with different properties. You can make up the borax and water solution in advance, or have your students prepare it, depending on their abilities.

Dissolve borax powder in water until no more will dissolve. Saturation is 4 teaspoons (40 grams) of borax powder per 4 cups (1liter) of water. Shake well.

As students mix and knead the new material it goes from slime to putty.

Questions to help students with their inquiry:

- What happens when you manipulate the material in different ways?
- What properties does this new material have?
- Bounce it.
- Stretch it slowly.
- Twist it.
- Roll it into a ball again.
- Pull quickly and hard.

Students can save their new material, slimy goop, in small, resealable plastic bags.

Mystery Material 2

Students mix two liquids together and the result is a new material: slimy, gooey worms.

Fill the squeeze bottle with the Gaviscon™ (you can add food coloring). Students squeeze some into a bowl or beaker of calcium-fortified orange juice. Flexible worms form instantly as the polymer becomes cross-linked. The longer the worms stay in the calcium solution, the more rigid they become.

Lift the worms out with the end of a pencil and touch them. The students can handle these non-toxic worms to test their properties.

3. What's happening?

After students have experimented with their new strange matter, explain that the materials they have produced are called polymers. The word "polymer" is Greek: "poly" means "many" and "mer" means "part".

"Poly mer" = "many parts".

A polymer is a large molecule made up of many smaller molecules linked together like a long chain. Use colored paperclips to make a chain.

There are two main types of polymer chains. One has all the same molecules linked together:

-A-A-A-A-A-A-A-A-A-

The other has different molecules forming the polymer chain:

-A-B-A-B-A-B-A-B-A-B-A-B-

Other types of polymer chains come in blocks:

-A-A-A -A-A-A-A-A-B-B-B-B-B-B-B-B-B-B-

The white craft glue, for example, is a polymer called polyvinyl acetate (PVA).

Use paperclips to model polymers. You can demonstrate to the class, or have the students work with paperclips following along with you. Make 3 chains to represent the polymers in the glue holding them vertically and parallel to each other.

Demonstrate movement of the polymer chains with the paperclips. They move easily back and forth.

What properties does glue have? Sticky, yes, but it also flows (although slowly).

When you add the borax solution, you are adding something called a **cross-linker**. What does "cross-linking" imply? It links the chains together cross-wise, like the rungs in a rope ladder connect the two sides. Demonstrate with the paperclip chain. Use the 3 chains to represent the molecules in the glue. Holding them parallel to each other, demonstrate how easily the chains can move around independently. Now link the chains together with paperclips horizontally, cross-wise. Notice how the movement changes and becomes more restricted. When you add the borax solution to the glue, the borax has a chemical reaction with the polyvinyl acetate (PVA). New bonds are formed between the spaghetti-like PVA molecule chains so they become rigid and can't slide.

How does this cross-linking change the properties of the Mystery Material? The properties of this new material are different from glue or the borax solution. It has properties of a liquid *and* a solid.

Students may have experimented with their slimy matter by adding more borax solution. What were their observations? How did the material and its properties change?

Have students predict what would happen if you added more liquid borax solution to the goop material. You might think more liquid would make it runnier and more flexible. But remember that the liquid solution is the cross-linker. Adding more borax solution actually makes the slimy matter drier and stiffer! The flexibility and strength changes when the number of cross-link connections changes – (more connections makes the material less flexible and stronger.)

With the slimy worms, the long chain molecules of alginate (in the antacid) are cross-linked with the calcium (in the orange juice) making the polymer into a gel.

Polymers are everywhere! There are natural polymers and artificial polymers. Just some examples of polymers: paper, egg whites, wool, plastic bottles, Teflon… (Students can keep an ongoing list of things that are made from polymers. They can classify their scavenger hunt surveys from the MY MATTER activity.)

Check out the Macrogalleria Web site for more about polymers.

Have students think about how polymers have changed our lives.

4. Have students prepare a marketing strategy for their polymer play product!

They might write press releases, draw posters, create advertisements, or plan a press conference to unveil their new material at a Toy Fair.

Questions students should consider:

- What is the name of this new polymer play product?
- What is this new material made from?
- What are its amazing properties?
- How is it made and processed?
- What's its structure like?
- How does it perform in tests?
- What is it used for? Why?
- How did you discover this new material?
- How will this amazing new material change the world? What fun will people have with it?

5. You can have a class Toy Fair and have students present their new play products.

EXTENSIONS

Research

Students investigate the history of Silly Putty™.

Watch The Movies

"Flubber" or "Son of Flubber" about an inventor who discovers a strange material with strange properties.

WEB LINK

Visit the MACROGALLERIA Web site:
"A cyberland of polymer fun".
www.psrc.usm.edu/macrog/index.html

STRANGE MATTER

Exhibit Connection
Polymer Lab Demo

STUDENT ACTIVITY

SLIMY MATTER

The Toy Designer's Challenge

Toy designers consider many factors when inventing fun things to play with. Your challenge is to discover a new material that will make a great new toy. You will experiment with strange matter to produce some Mystery Materials. You will explore their properties. You will determine how the new material will be used in your play product.

Materials with amazing properties make great toys! What new toy will you design using strange matter?

CREATE A QUESTION TO THINK ABOUT AS YOU ARE EXPERIMENTING.

What do you need to find out about these slimy materials to successfully complete this challenge?

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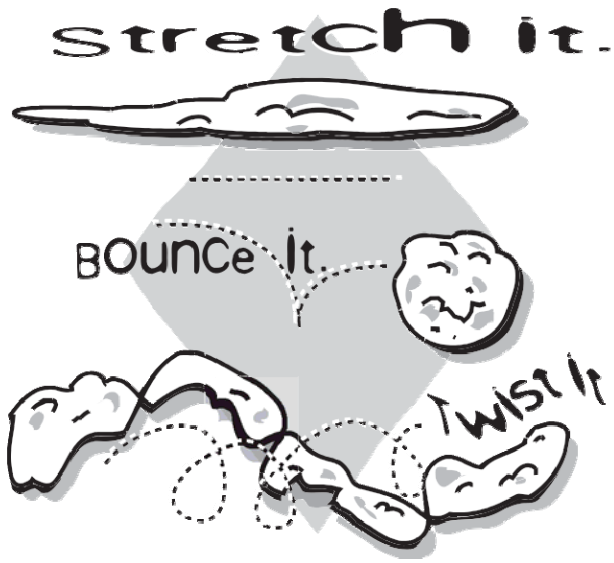
Mystery Material 1



DO THE EXPERIMENT

YOU WILL NEED

- White craft glue
- Borax and water solution
- Resealable plastic bag

PROCEDURE

1. Mix about four parts of glue with one part borax solution in a resealable plastic bag. Tightly zip-lock the bag closed. Knead the mixture well for several minutes. At first the new material will be very sticky, but keep kneading.

2. Take the mystery material out of the bag and play with this strange matter. Investigate its properties. How does it perform when you stretch it? Bounce it? Twist it? etc.

3. Predict what would happen to the material if you added more liquid borax solution to your mystery material. Try it and see!

QUESTIONS TO THINK ABOUT

- What changes took place?
- Describe the material and its properties.
- How does it look?
- How does it feel?
- How does it behave?
- What is its texture?
- Is it stiff?
- Is it flexible?
- Is it stretchy?
- How far can you stretch it?
- What other properties does the material have?
- What is your evidence?

Record **YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.**

Use another sheet of paper to record your observations and data.

ANALYZE
YOUR OBSERVATIONS.

Hypothesize **WHICH WOULD MAKE A GREAT NEW MATERIAL FOR A TOY? WHY?**

How might you use these materials in your life?

Who else might use this material?

How would you convince someone to buy this material?

Mystery Material 2

DO THE EXPERIMENT

YOU WILL NEED

- Gaviscon™ liquid antacid
- Calcium-fortified orange juice
- Food coloring (optional)
- Squeeze bottle
- Large bowl or beaker
- Mixing spoon
- Paper towels
- Measuring cup

PROCEDURE

1. Pour a cup of orange juice into the bowl.

2. Pour the Gaviscon™ into the squeeze bottle. Squirt a stream of Gaviscon™ into the orange juice. Observe what happens.

3. Play with this mystery material. Investigate its properties. How does it perform when you handle it?

Record YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.

Use another sheet of paper to record your observations and data.

QUESTIONS TO THINK ABOUT

- *What changes took place?*
- *Describe the material and its properties.*
- *How does it look?*
- *How does it feel?*
- *How does it behave?*
- *What is its texture?*

- *Is it stiff?*
- *Is it flexible?*
- *How did you find out and what happened?*
- *Is it stretchy?*
- *How far can you stretch it?*
- *What other properties does the material have?*
- *What is your evidence?*

Record other observations, too.

ANALYZE
YOUR OBSERVATIONS.

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Hypothesize WHICH
WOULD MAKE A GREAT NEW MATERIAL FOR A TOY? WHY?

How might you use these materials in your life?

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Who else might use this material?

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How would you convince someone to buy this material?

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TEACHER'S NOTES

FOAMY MATTER

THE CHEF'S CHALLENGE

STUDENT OBJECTIVE

Students will investigate the properties, performance, structure and processing of various foams.

CLASS TIME

Day 1
60 minutes

Day 2
30 minutes
(teacher-led culminating demonstration)

MATERIALS NEEDED

(For class demo)

- Different examples of foams (including canned whipped cream, marshmallows, sponge cake, bone)
- Magnifying glasses
- Hot chocolate mix
- Hot water in an electric kettle
- Styrofoam cups
- Chocolate chips
- Whipped cream in a can

- Marshmallows
- Plastic bubble wrap
- Hair dryer

(For student activity / per student or group)

- Large bowls
- Whisks
- Forks
- Spoons
- Hand beater
- Electric beater (optional)
- Egg whites
- Whipping cream (unwhipped)
- Soap dish detergent
- Plastic bottles
- Thermometers for measuring liquids

(For the Culminating Demonstration)

- Ice cream (optional)
- Baking pan (optional)

- Oven (optional)
- Toaster oven (optional)
- Small propane torch, sold in kitchen specialty stores (optional)

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **FOAMY MATTER, The Chef's Challenge**.

Gather all materials needed for the activity.

This activity is done over 2 days.

On the first day, students experiment with foams and design an experiment (a recipe) for baking ice cream using an edible foam as an insulator.

The following day (or at the end of the first day's experimenting if time permits) the teacher can demonstrate one of the student's recipes using the oven in the school kitchen (or a toaster oven, or a small propane torch found in specialty stores, often used for melting sugar on the top of custards).

Feel free to modify the Activity to suit the needs of your students (for example, focusing on one or two foams in the initial experimenting, or skipping the hot chocolate demonstration).

TEACHING PROCEDURE AND TIPS

1.. Foam is not exclusively a solid, liquid, or gas. It is made of bubbles or cells of gas within a liquid or a solid, and it combines characteristics of all three states of matter.

There are solid foams and liquid foams.

Foams are a very common material.

Have students look around their homes and school and make a list of as many different kinds of foams that they can find. Also have them record what the foam is used for, and hypothesize as to why that foam material is used for that purpose.

Have students bring in samples of foams to examine in class. Some examples of foam include Styrofoam cups and packing materials, foam pillows, whipped cream, shaving cream, hair mousse, dish detergent, shampoo, bubble bath, house insulation, marshmallows, cappuccino foam, soda, bread, soap and water in a bottle that can be shaken up, sponges, whipped egg whites, meringues, sponge cake, etc.

Have some unusual examples that the students might not think of as foams, such as a bone, a cork, cheese, the stem of a plant.

2. Working individually or in groups, students will examine and explore the foams. They can observe the materials more closely with a magnifying glass. Break solid foams apart if possible. Have students whip egg whites and cream to make foams.

Have students create a chart to compare the different foams, their structure and appearance (proportional sketches or word descriptions of the structure with air bubbles), the properties, and the uses for the foam. Examples of properties might include light weight, low density, squishy, bubbly, spreadable, etc.

Ask students what all foams have in common. AIR and properties associated with air (lightweight, good insulator).

3. Lead a full class demonstration using hot chocolate to illustrate insulation.

You will need a Styrofoam cup, a ceramic mug, hot water from an electric kettle, hot chocolate powder mix, chocolate chips, and the foams from your investigation (canned whipped cream, marshmallows, etc.)

Discuss and compare the properties of the ceramic mug and the Styrofoam cup. Pour boiling water into each of the cups. Investigate and compare their properties. The Styrofoam cup is cool to the touch because it is a foam, filled with air pockets and therefore the foam is a good insulator. The air does not conduct heat so the cup doesn't heat up from the hot contents and remains cool.

Present this challenge to the students: how could you place 3 chocolate chips on top of a cup of hot chocolate and keep them from melting? Ask students for their ideas and hypotheses. They may suggest many creative solutions. The most appetizing might be a layer of whipped cream or a marshmallow between the hot chocolate and the chocolate chips. Why? Foams are good insulators. Air is an excellent insulator and foams are made of a lot air. And some foams taste better than others!

4. Demonstrate the insulating properties of air in foams with an analogy using bubble wrap and a hair dryer.

Take two pieces of bubble wrap each about 1 foot by 1 foot (30 cm x 30 cm). Hold the pieces together so that the bubble surfaces are facing each other. Fit the bubbles and spaces between the bubbles together like a puzzle, making one sheet of continuous air-filled bubbles. Make sure that the 2 pieces of bubble wrap are held tightly together touching each other.

Have a student hold this bubble wrap horizontally, one hand holding each side. Blow hot air from the dryer onto the underside of the bubble wrap. Have another student put his/her hand on the top side and describe how it feels (it shouldn't feel too warm).

Now have students burst the bubbles in the bubble wrap. Holding the 2 pieces of plastic tightly together, repeat the experiment with the hair dryer. This time more heat gets through when all those air pockets are burst because there is less air to provide insulation.

5. NASA scientists invented an amazing material called Aerogel, the lightest material on earth. At least 98% of the volume of the material is air! That's what makes Aerogel a great insulator, the best ever made.

Aerogel is a silicon-based solid with a porous, sponge-like structure 1,000 times less dense than glass (another silicon-based solid)!

At the *STRANGE MTATTER* Exhibition Demo, scientists take a piece of Aerogel about the size of a deck of playing cards, place a crayon on top, and then hold the flame from a blow torch on the underside of the Aerogel. What happens? Nothing! The crayon doesn't melt because it is insulated from the heat by the Aerogel.

of the scoop with marshmallows, or sponge

6. Students do the activity **FOAMY MATTER / The Chef's Challenge**.

Students design experiments that would use foams and their properties to keep a scoop of ice cream from melting when it is baked in the oven at 500 F for 3 minutes. The teacher will check their experiment plans to see if they are doable. When their experiment plans are approved, the students prepare their foams and test their properties to determine if they will work.

NOTE: Students will **not bake** their concoctions during the challenge. **The baking test can be done at the end of the experimenting as a full class demonstration led by the teacher, if desired**. Have students share their recipes with the class and hypothesize and analyze which recipe has the most chance of success. Then bake that recipe together as a class in the school kitchen with teacher supervision.

Alternatively, you could use a toaster oven for the baking. Have students measure the inside dimensions of the toaster oven as part of their experiment because the height and depth will affect their plans.

Or you could use a small propane torch to heat up and scorch the recipe to see if the insulating material protects the ice cream inside.

During The Chef's Challenge, students will experiment with foams and their properties as they test their hypotheses. Their challenge is to make a foam that is long lasting, firm yet light and full of air to insulate the ice cream. They may have creative solutions to the challenge. They may make foams by whipping the cream or beating the egg whites. This adds air to the materials. They may decide to cover the bottom cake, etc.

Students can test properties like firmness, spreadability, durability, etc. As well, they can test insulating properties using hot water, as in the hot chocolate demonstration.

Questions to help students with the inquiry: How big are the air bubbles in the foam? How do they affect the properties and performance of the foam? Do the bubbles collapse quickly making the foam flat? Is the foam long lasting? Does it spread easily and can you mold it? How high can you pile it up? How thick a layer do you think you need? How many air bubbles in the foam (they can use magnifying glasses to examine). Does the foam take a shape and keep it for 3 minutes? How does the foam function or perform on top of the hot water (does it melt? does it remain the same?) How does the foam respond to the heat from an incandescent light bulb?

CAUTION: Stress safety with your students. Some non-edible insulating materials such as Styrofoam and plastic are flammable and should NOT be placed in the oven.

The best edible insulators for the ice cream would be beaten egg whites, or whipped cream. A marshmallow layer would work too, but the marshmallows might burn on the outside.

There is a dessert recipe that actually does bake ice cream! Traditionally, Baked Alaska is a dessert where ice cream is placed on a bed of sponge cake and then totally covered with egg whites (some sugar can be added to sweeten). When it's baked in a hot oven, the egg whites cook into warm meringue and the foam insulates the ice cream, preventing it from melting. The result is a tasty treat, warm on the outside, cold on the inside.

EXTENSIONS

Students research cookbooks and the Internet for other foamy food recipes: bread, soufflés, angel food cake, root beer, etc.

WEB LINK

NASA's Spacecraft Stardust is using Aerogel as a sponge to collect extraterrestrial materials from a comet. Check out the Web site at:

http://stardust.jpl.nasa.gov

STRANGE MATTER
Exhibit Connection

Foams and Aerogel
Demo Theatre

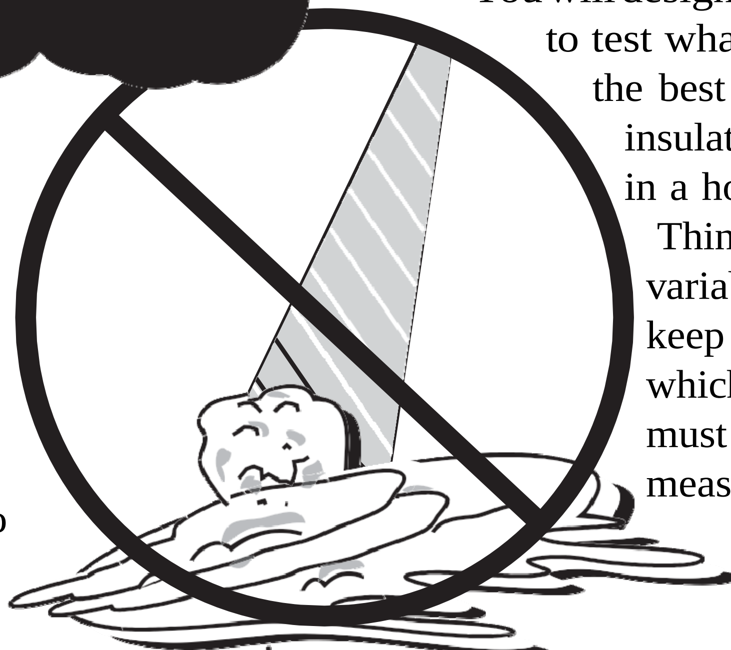
STUDENT ACTIVITY

FOAMY MATTER

THE CHEF'S CHALLENGE

Good cooks are good Materials Scientists!

You will design an experiment to test what would be the best material for insulating ice cream in a hot oven. Think about which variables you would keep constant and which variables you must change and measure.



Melting Ice Cream

Great chefs are known for their creative recipes!

Your challenge is to develop a recipe for a tasty treat with ice cream.

The twist is that the concoction must be baked in the oven at 500 F for 3 minutes!

The goal is to have a hot, cool combo that is COLD on the inside and WARM on the outside – one scoop of ice cream with something tasty around it to keep it from melting in the hot oven. (And don't forget to protect the bottom of the scoop of ice cream!)

What will you concoct? What will you use to keep the ice cream from melting?

CREATE A QUESTION TO THINK ABOUT AS YOU ARE EXPERIMENTING.

What do you need need to know to successfully complete this challenge?

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Hypothesize.

EXPLAIN WHY YOU THINK YOUR IDEA WILL WORK.

DEscribe **YOUR EXPERIMENT.**

HOW WILL YOU TEST YOUR HYPOTHESIS? INCLUDE THE MATERIALS YOU WILL NEED, THE PROCEDURE FOR YOUR EXPERIMENT, SAFETY MEASURES TO KEEP IN MIND, AND A SYSTEM FOR RECORDING YOUR OBSERVATIONS.

AFTER YOUR TEACHER APPROVES YOUR PLAN, TEST YOUR HYPOTHESIS.

DO **THE EXPERIMENT.**

Record **YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.**

Use another sheet of paper to record your observations and data.

QUESTIONS TO THINK ABOUT

- How big are the air bubbles in the foam? How do they affect the properties and performance of the foam?
- For example, do they collapse quickly, making the foam fall flat?
- Is the foam long lasting?
- Does it spread easily and can you mold it?
- How high can you pile it up?
- How thick a layer do you think you need?
- How many air bubbles in the foam? (Use a magnifying glass to check.)
- Can the foam take a shape and keep it for 3 minutes?
- How does the foam function or perform on top of the hot water? (Does it melt? Does it remain the same?)
- How does the foam respond to the heat from an incandescent light bulb?

ANALYZE

YOUR OBSERVATIONS. WHAT DO YOU CONCLUDE?

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NAME **YOUR TASTY TREAT!**

BASED ON YOUR ANALYSIS, WRITE A RECIPE FOR OVEN-BAKED ICE CREAM.

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TEACHER'S NOTES

BOUNCY MATTER

THE SPORTS EQUIPMENT MANAGER'S CHALLENGE

STUDENT OBJECTIVE

Students will design a fair test for comparing the bounciness of balls made from different materials.

CLASS TIME

60 minutes

MATERIALS NEEDED

(For student activity/per student or group)

- Balls made of different materials (e.g. tennis ball, rubber ball, baseball, golf ball, ping pong ball, sponge ball, super ball, etc.)
- Round spheres made of different materials (e.g. marble, ball bearings, a gumball, etc.)
- Measuring stick or tape measure
- Tape (masking or electrical) strong enough to hold up the measuring stick
- Safety glasses

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **BOUNCY MATTER, The Sports Equipment Manager's Challenge**.

This activity is best done in the gym where students have lots of space to experiment.

Gather all materials needed for the activity.

Have a variety of different balls for the students to experiment with. Include different sports balls (tennis, soccer, baseball, volleyball, etc.) as well as other spherical objects such as a ball of string, gumball, chewing gum rolled into a ball, etc.

Students may make their own suggestions.

TEACHING PROCEDURE AND TIPS

1. As a full class demonstration, dissect a few old balls to see the kinds of materials they are made of, for example, a rubber ball, a tennis ball, a golf ball.

2. Introduce the idea of a "fair test" by using 2 different balls, for example, a baseball and a tennis ball.

Ask students to predict which ball they think will bounce higher and why. Compare the bounce of each ball but do it unfairly. For example, use a lot of energy to throw the tennis ball to the floor for the bounce, and just drop the other ball. Students should notice the unfairness, which leads into a discussion about how to make the test fair (controlling and testing variables in a fair way). Discuss the ways you could test the bounciness in a fair way. Talk about the things to take into account when comparing balls in a test, such as not throwing the ball, always dropping from the same height every time, being consistent with the measuring, using the bottom of the ball as the marker for the height, recording accurately, testing more than once (5 times) and recording all trials, testing them all on the same surface, and so on.

Students may suggest that because balls are different sizes the test is unfair. Use a small super ball and a larger ball such as a baseball or soccer ball to demonstrate that size may not be as big a factor as others (such as the material or materials the ball is made of, or the surface it bounces on). Some balls are made out of many different materials – baseball, softball, football. If you have old balls, you may want to dissect them to examine the materials for comparison.

(**For your information**, a super ball is made out of something the inventor called "zectron, super secret compounds combined under extreme pressure and temperature.")

3. Students do the activity **BOUNCY MATTER / The Sports Equipment Manager's Challenge**. Students will design a fair test for comparing the bounciness of balls made from different materials.

Have students work in groups, working cooperatively to design their experiment. Students must have their experiment design approved by their teacher before they carry out the tests. Students then work in groups, doing their tests on various balls made of different materials.

4. After the activity, as a class, discuss the tests and the observations.

Which balls have more bounce?

Why are some balls bouncier than others?

Why aren't all sports balls made of the same materials?

Why are certain materials chosen for balls in different sports?

Bounciness is based on the elasticity of the materials that the object is made from.

Some materials change shape when you compress them and then they spring back into their original shape when you release the force. This is a property called elasticity.

You can demonstrate elasticity with a rubber band. When you stretch it or compress it and then stop, it "bounces" back to its original shape.

When you bounce a ball, one side is compressed. The ball's elasticity makes it spring back into its original shape and it bounces back up to you.

If a ball is made from materials that aren't elastic it won't bounce.

Many balls are made from rubber, an elastic material.

You might be surprised at some other materials that are elastic: metal, glass, concrete, for example. The amorphous metal in the *STRANGE MATTER* exhibit is extremely bouncy. These materials deflect and bounce back like rubber balls do, but on such a small scale that we can't see it with our naked eye.

5. The material a ball is made of determines how it will be used – the kinds of sports or games you can play with it. Have students explain why certain balls are used for a specific sport or game. For example, which sports require really bouncy balls? Which require balls that are less bouncy and more easily controlled? What would happen if you used a different ball in a sport?

For example: a super ball in baseball!

What would happen if you changed the material of the playing surface? Students can try this by comparing the bounce off a wood floor, a carpeted floor, a cement floor.

6. What would happen if you changed the temperature of the ball, for example, put it in the freezer for a few hours? Students can try this at home as a homework assignment. Have them put a few elastic rubber bands in the freezer, too. The frozen rubber loses its elasticity. The rubber band breaks; the ball is less bouncy. Hockey pucks are actually frozen before the game to reduce their bounciness.

EXTENSIONS

Students research the history of the ball from a sport of their choice (for example, soccer, football, tennis, etc.) to see how balls have changed as new materials were invented.

Students use the Internet to research manufacturer's standards for different sports balls. Students could also research rules for sporting events. What makes a regulation ball different from others?

WEB LINKS

Determining basketball standards

http://sportsfigures.espn.com/sportsfigures/lp_bouncingBasketballs.jsp?iAm=null

What happens when you bounce a metal ball on a metal plate?

www.mrsec.wisc.edu/edetc/amorphous

The science of bouncing balls

http://www.exploratorium.net/baseball/bouncing_balls.html

STRANGE MATTER
Exhibit Connection

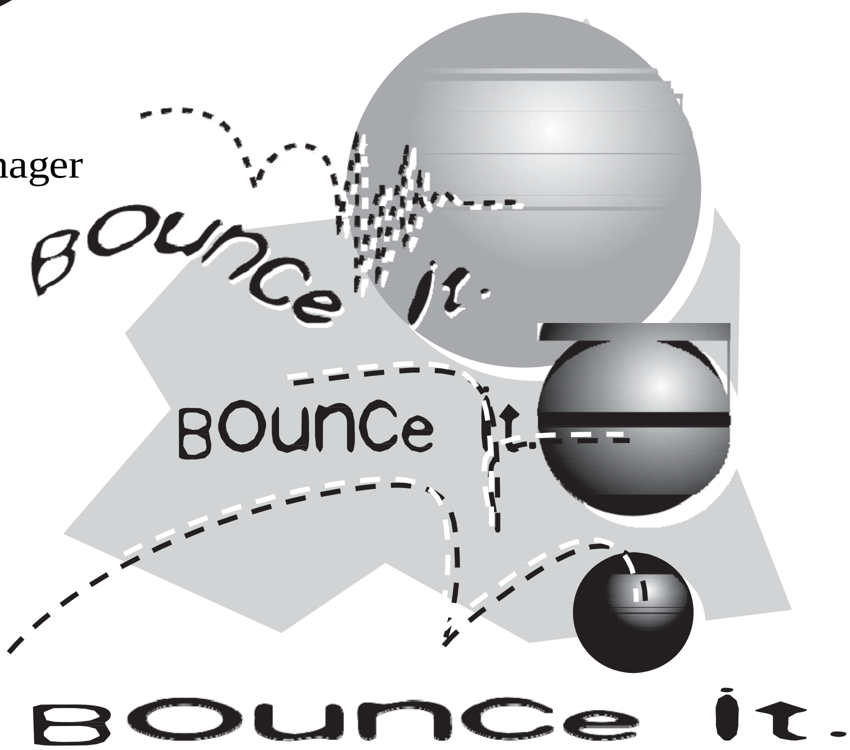
Amorphous Metals

STUDENT ACTIVITY

BOUNCY MATTER

THE SPORTS EQUIPMENT MANAGER'S CHALLENGE

Your challenge is to design an experiment to test the bounciness of balls and other spherical objects made from different materials.



The Equipment Manager is an important member of any sports team. He or she makes sure all the equipment is in excellent condition before the game. That can mean checking to see if the balls have the bounciness that the sport's authorities have approved.

Not all balls bounce with the same bounciness.

Some sports require balls that are very bouncy, others not so bouncy, depending on the nature of the game and the playing surface.

Manufacturers have to make balls so that their bounce conforms to certain standards regulated by each sport. This is a job for Material Scientists. They develop and design sports equipment using just the right materials so the balls have just the right bounce.

CREATE QUESTIONs FOR YOUR INVESTIGATION.

What do you really need to know to successfully complete this challenge?

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Think ABOUT HOW YOU WILL DO THE EXPERIMENT.

Which variables should you keep constant and which variables must you change and measure?

DESCRIBE YOUR Experiment.

How will you test your hypothesis? Write down your plan for the experiment. Include the materials you will need, the procedure for your experiment, safety measures to keep in mind, and a system for recording your observations.

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AFTER YOUR TEACHER APPROVES YOUR PLAN,

DO YOUR EXPERIMENT. GATHER BALLS OF DIFFERENT MATERIALS AND

Test THEM FOR BOUNCINESS.

Record YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.

Use another sheet of paper to record your observations and data in chart form.

ANALYZE YOUR OBSERVATIONS.

Based on your experience, which balls have more bounce?

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Based on your experience, why are some balls bouncier than others?

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Why aren't all sports balls made of the same materials?

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Why do you think certain materials are chosen for balls in different sports?

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TEACHER'S NOTES

TESTING MATTER

THE CONSUMER PRODUCT TESTER'S CHALLENGE

STUDENT OBJECTIVE

Students will test materials for their properties and their performance. They will design simple tests to determine the properties and performance of different materials.

CLASS TIME

45 – 60 minutes

MATERIALS NEEDED

(For class demo)

An assortment of familiar objects and different materials. For example: rubber bands, balloons, Styrofoam packing peanuts, plastic bags, pieces of paper, paperclips, pencil, balls of different materials, sponges, coins, dollar bills, marshmallows, etc.).

(For student activity/per student group)

- Paper towel
- Plastic wrap
- Aluminum foil
- Wax paper
- Yardstick, meter stick or tape measure
- Water
- Measuring cup
- 25-cent coin
- Pen
- Large, empty juice can with top lid removed
- Rubber band (one that will fit tightly around the juice can)
- Scissors
- Safety glasses
- Magnifying glasses
- Optical microscopes (optional)

PREPARATION

Read through the Student Activity page and the Teacher's Notes for **TESTING MATTER / The Consumer Product Tester's Challenge**.

Gather all materials needed for the activity.

Have an assortment of objects and different materials, enough for a few pieces per student (or group of students) for the introductory activity.

TEACHING PROCEDURE AND TIPS

1. Display the assortment of materials at the front of the classroom. Pick a material and discuss the properties and performance of that material. The **properties** of a material are characteristics that describe the appearance or behavior of a material in different conditions. The **performance** of a material describes how that material functions under different conditions.

Hand out a few materials to each student or group. Have students devise simple tests for examining various materials to investigate their properties and their performance. What property are they testing? What is the performance of the material? How will they measure the properties and performance of the materials? For example, use a ruler or measuring tape to see how far a piece of elastic stretches, compared to a piece of paper of the same length. Share observations with the class. Or test for squishiness: the sponge and the marshmallow will squish, the coin won't squish by hand (but it could be squished by a machine applying a lot of force), the pencil won't squish, but the eraser on the end will a little, etc. How will you measure the squishiness? One way might be to compare the original size of the object to the compressed size in the form of a ratio.

Refer to the Glossary for a list of properties and their definitions.

2. Students do the activity **TESTING MATTER / The Consumer Product Tester's Challenge**.

The students test different materials for the properties of elasticity (pulling or stretching), strength (the point when a material breaks apart), and toughness (how the material resists impact and perforation).

At the end of the Activity, students are asked to invent other tests for these materials. Some examples might be: a crumple test (testing elasticity), or a tear test (another test for toughness), or a test for absorbency.

EXTENSIONS

Students investigate how extreme cold affects the properties and the performance of materials. Select a few different materials for testing (a rubber band, plastic wrap, a plastic cup, a tennis ball, pantyhose, etc.). Determine their properties and performance. Now put the materials in the freezer for at least an hour and then test them. This could be done as a homework assignment if there is no access to a freezer at school.

WEB LINKS

Investigate crash tests for passenger vehicles designed by the Insurance Institute for Highway Safety

http://www.hwysafety.org/vehicle%5Fratings/ce/offset.htm

Investigate mechanical testing machines
www.instron.com (Click on Products)

www.StrangeMatterExhibit.com

STRANGE MATTER

Exhibit Connection
Touch Table
Smash the Glass

STUDENT ACTIVITY

TESTING MATTER

THE CONSUMER PRODUCT TESTER'S CHALLENGE

Many manufacturers make claims about what their stuff can do – the properties and the performance of their products.

But before a product reaches the marketplace, consumer product testers conduct a series of tests designed to prove that the product is safe to use and will do what the manufacturer claims it will do.

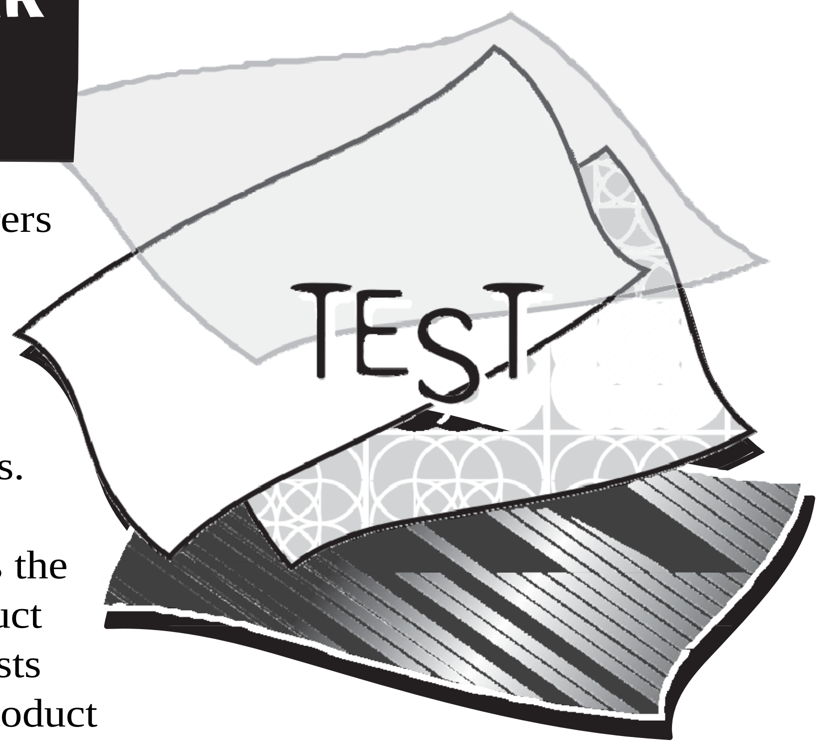
Many materials are described as "strong". But what does strong really mean?

Compare these materials used in the kitchen: paper towel, plastic wrap, aluminum foil, and wax paper.

Which material is the strongest? Stretchiest? Toughest? Most absorbent?

Investigate materials like Materials Scientists do.

Are the materials up to the challenge?



Test THE MATERIALS WITH THIS EXPERIMENT.

YOU WILL NEED

- Paper towel
- Plastic wrap
- Aluminum foil
- Wax paper

- Yardstick, meter stick or tape measure
- Water
- Measuring spoons
- Measuring cup
- 25-cent coin
- Pen
- Large, empty juice can with top lid removed
- Rubber band (one that will fit tightly around the juice can)
- Scissors
- Safety glasses
- Magnifying glasses
- Optical microscopes (optional)

EXPERIMENT #1

1. Cut the materials into strips. You will need one strip of each material measuring 2 inches wide (5 cm) and 8 inches long (20 cm).

2. Place your ruler or measuring stick on a flat surface.

3. Place the strip of the first material to be tested at the zero end of the measuring stick, against the flat surface.

4. Stretch the material strip firmly but gently (you don't want to rip it!). Keep stretching as far as it will go.

5. Measure the stretched material. What is the length? What is the width? Record your observations in a chart.

6. Stop stretching the material and let go of it. Observe what happens. Record the length and width of the material after you stopped stretching. Compare this to the original dimensions and the stretched dimensions.

7. Repeat these steps for each of the different materials in turn, first the plastic wrap, then the aluminum foil, and finally the wax paper and paper towel.

EXPERIMENT #2

1. Place the paper towel on top of the open end of the can.

2. Use the rubber band to hold the paper towel tightly over the can.

3. Hold the ruler or measuring stick vertically beside the can. Rest the zero measurement end against the desk or table (the numbers will increase as you go up the measuring tool).

4. Hold the coin one inch above the top of the paper towel (for example, if the can is 5 inches high, hold the coin at 6 inches.)

5. Drop the coin, edge side first. Observe.

6. Drop the coin again, this time increasing the height by 1 inch from where you dropped before.

7. Keep dropping the coin, increasing the drop height by 1 inch each time. Continue until the quarter breaks through the paper towel. Record that drop height.

8. Repeat these steps for each of the different materials in turn, first the plastic wrap, then the aluminum foil, and finally the wax paper.

EXPERIMENT #3

1. Test the strength of the different materials when they are wet.

2. Design an experiment to determine the properties and performance of these materials when they are wet.

3. Compare the results with the properties and performance of the materials when they are dry.

4. Record your observations.

How does water change the properties and performance of these materials?

Record YOUR OBSERVATIONS AND INCLUDE YOUR EVIDENCE IN YOUR DATA.

On another sheet of paper, record your observations and data in chart form for each experiment.

ANALYZE YOUR OBSERVATIONS.

What did you observe in each experiment?

Which material performed the best in each test?

What can you conclude about the materials from these tests?

Invent OTHER TESTS.

What other tests could you do to compare these materials?

Would the same material always be the winner in all of these tests? Why?

RESOURCES

BOOKS for TEACHERS

Additional background information on materials

AMATO, Ivan. **Stuff: The Materials the World is Made of**. New York: Avon Books, 1997.

BALL, Philip. **Designing the Molecular World**. Princeton, NJ: Princeton University Press, 1994.

BALL, Philip. **Made to Measure: New Materials for the 21st Century**. Princeton, NJ: Princeton University Press, 1997.

BALL, Philip. **Stories of the Invisible: A Guided Tour of the Molecules**. New York: Oxford University Press, 2001.

CAHN, Robert W. **The Coming of Materials**. New York: Pregamon Press, 2001.

DELMONTE, John. **Origins of Materials and Processes**. Lancaster, Eng.: Technomic, 1985.

ELLIS, Arthur B. et al. **Teaching General Chemistry: A Materials Science Companion**. Washington, DC: American Chemical Society, 1993. (university level chemistry but good information resource)

FORESTER, Tom. **The Materials Revolution**. Cambridge: MIT Press, 1988.

GORDON, James Edward. **The New Science of Strong Materials or Why You Don't Fall Through the Floor**. Princeton, NJ: Princeton University Press, 1984.

HUMMEL, Rolf E. **Understanding Materials Science: History, Properties, Applications**. New York: Springer Verlag, 1998.

PERKOWITZ, Sidney. **Universal Foam: from cappuccino to the cosmos**. New York: Walker, 2002.

SASS, Stephen L. **The Substance of Civilization: Materials and Human History from the Stone Age to the Age of Silicon**. New York: Arcade Publishing, 1998.

Materials: a Scientific American Book. San Francisco: W.H. Freeman, 1967.

BOOKS for STUDENTS

Information about materials

BRYANT-MOLE, Karen. **Materials (Images)**. Parsippany, NJ: Silver Press, 1997.

COOPER, Christopher. **Matter**. London, Eng.: Dorling Kindersley, 2000.

GORDON, Maria and GORDON, Mike. **Fun with Materials**. Austin, TX: Raintree Steck-Vaughn, 1996.

JACKMAN, Wayne. **Plastics**. East Sussex, Eng.: Wayland, 1991.

LAMBERT, Mark. **Focus on Plastics**. East Sussex, Eng: Wayland, 1987.

PEACOCK, Graham. **Materials**. East Sussex, Eng.: Wayland, 1994.

PEACOCK, Graham. **The Super Science Book of Materials**. East Sussex, Eng.: Wayland, 1993.

TAYLOR, Peter. **Materials. Starting Design & Technology series**. London, Eng.: Cassell, 1990.

WEISS, Malcolm E. **Why Glass Breaks, Rubber Bends, and Glue Sticks.** New York: Harcourt Brace Jovanovich, 1977.

WHYMAN, Kathryn. **Plastics**. New York: Gloucester Press, 1988.

GENERAL SOURCES OF MATERIALS

Ready to explore materials science further online? These selected Web links will get you started. However, we can't guarantee all their content is up to date and accurate.

Edmund Scientific
60 Pearce Ave.
Tonawanda, NY 14150-6711
(800) 728-6999
Fax (800) 828-3299
http://www.scientificsonline.com/ec/products/Display.cfm?xloop=1

Flinn Scientific, Inc.
P.O. Box 219
Batavia, IL 60510-0219
(800) 452-1261
Fax (866) 452-1436
http://www.flinnsci.com/index.html

NADA Scientific LTD.
P.O. Box 1336
Champlain, NY 12919-1336
(800) 233-5381
Fax (514) 246-4188
http://www.nadasci.com/

Arbor Scientific
P.O. Box 2750
Ann Arbor, MI 48106-2750
(800) 367-6695
http://www.arborsci.com/

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
(919) 584-0381
http://www.carolina.com/

Institute for Chemical Education
(books, kits, activities)
Department of Chemistry
University of Wisconsin-Madison
1101 University Ave.
Madison, WI 53706
(608) 262-3033
Fax (608) 262-0381
http://ice.chem.wisc.edu/

SOURCES for FERROFLUIDS SAMPLES

Educational Innovations
(203) 229-0730
Fax (203) 229-0740
www.teachersource.com

FERRO TEC
www.ferrofluidics.com/

SOURCES for MAGNETS

www.wondermagnet.com

SOURCES for MEMORY METALS

(Note: a minimum order may be required)

Institute for Chemical Education
Department of Chemistry
University of Wisconsin-Madison
1101 University Ave.
Madison, WI 53706
(608) 262-3033
Fax (608) 262-0381
http://ice.chem.wisc.edu/catalogitems/ScienceKits.htm#Nanoworld

Shape Memory Applications, Inc.
1070 Commercial Street
Suite 110
San Jose, CA 95112
(408) 727-2221
Fax (408) 727-2778
http://www.sma-inc.com/

Mondo-tronics
PMB-N, 4286 Redwood HWY
San Rafael, CA 94903
(415) 491-4600
Fax (415) 491-4696
http://www.mondo.com/

NADA Scientific Ltd.
P.O. Box 1336
Champlain, NY 12919-1336
(800) 233-5381
Fax (514) 246-4188
http://www.nadasci.com/

Images SI Inc. (Nitinol toy)
http://www.imagesco.com/articles/nitinol/01.html

ON-LINE RESOURCES

Materials Science and Technology
(MAST) Modules
Department of Materials Science
and Engineering
University of Illinois at Urbana Champaign
http://matse1.mse.uiuc.edu/home.html

Materials Science and
Engineering Teaching Resources
Materials Research Institute
Penn State University
http://www.mri.psu.edu/mse-tr/

Safety in the Classroom
National Science Teachers Association
http://science.nsta.org/enewsletter/2003-06/member_high.htm.

KITS

Institute for Chemical Education
Department of Chemistry
University of Wisconsin-Madison
1101 University Ave.
Madison, WI 53706
(608) 262-3033
Fax (608) 262-0381
http://ice.chem.wisc.edu/catalogitems/ScienceKits.htm#Nanoworld

Materials World Modules
Northwestern University
2225 North Campus Drive
Materials and Life Sciences Building,
Room 2078
Evanston, IL 60208
(847) 467-2489
Fax (847) 491-4181
http://www.materialsworldmodules.org/home.html

Shape Memory Applications, Inc.
1070 Commercial Street
Suite 110
San Jose, CA 95112
(408) 727-2221
Fax (408) 727-2778
http://www.sma-inc.com/

American Plastics Council
http://www.HandsOnPlastics.com/

National Plastics Center and Musuem
(978) 537-5654,
Fax (978) 537-3220
http://www.plasticsmuseum.org/e-van-plastivan.html

MICROSCOPY RESOURCES

Sources and information on microscopy and magnifying tools.
http://www.msa.microscopy.com/ProjectMicro/PMBooks.html

WEB SITES for STUDENTS

Visit the Web site for the *Strange Matter* exhibition.

www.StrangeMatterExhibit.com

THE CHALLENGE OF MATERIALS

This site features quizzes, a matching game, and lots of information about materials and materials science, including choosing the right material for the job and materials that have changed our lives.

http://www.sciencemuseum.org.uk/on-line/challenge/

ZOOM IN AND ZOOM OUT / POWERS OF 10

Start 10 million light years away from the Earth and zoom in through successive orders of magnitude until you reach the subatomic universe inside a single oak leaf - an amazing trip!

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

MACROGALLERIA

Billing itself "a cyberwonderland of polymer fun", this site offers information on where how and where polymers are used, how they are made, and how materials scientists study them.

http://www.psrc.usm.edu/macrog/index.htm

MICROWORLD: EXPLORING THE STRUCTURE OF MATERIALS

A Web site for high-school students that includes biographies of materials scientists, profiles of kids interested in materials science, and close-up examinations of materials such as Kevlar.

http://www.lbl.gov/MicroWorlds/

MICROSCAPE VIRTUAL LABORATORY

Take an extremely close-up look online at stuff from around your house, like a penny or the tip of a ball point pen.

http://www.msa.microscopy.com/MicroScape/MicroScapeVL.html

AMERICAN PLASTICS COUNCIL

This Web site about plastics and polymers features a "virtual plastics classroom" for teachers and links to the latest plastics news.

http://www.americanplasticscouncil.org/

HANDS ON PLASTICS

Created for middle-school teachers by the American Plastics Council, this site's suitable for anyone wanting a quick run-down on the history of plastics and polymers, the various kinds of plastics, and how plastics can be recycled. There are science experiments and online simulations, as well as a kit teachers can order.

http://www.HandsOnPlastics.com/

GLOSSARY

Amorphous

Without a definite shape or form. In amorphous materials, the atoms are arranged randomly instead of in an organized pattern.

Biodegradable

Something that will decompose or rot or decay in the environment because microorganisms can break it down.

Brittle

Easily broken. Breaks suddenly without first deforming.

Compression

Squeezing or forcing together.

Ductility

The ability of a material to undergo changes in shape (plastic deformation), such as being drawn into wires, rather than breaking; a term often applied to metals.

Elastic deformation

A temporary change in shape in response to a stress; removal of the stress restores the original shape.

Electrical conductivity

The ability of a material to carry an electric current.

Ferrofluid

A suspension of a magnetic solid in a liquid that responds to an external magnetic field.

Ferrous metals

Metals containing iron.

Hardness

Ability to resist scratching or indentation.

Malleability

A material's ability to be easily shaped by hammering, pressing, or bending (a term often applied to metals).

Manufactured

Things that are made.

Mold

Hollow shape for forming a material.

Molding

Forming a material into a shape by pouring or forcing it into a container.

Nanometer

One billionth of a meter. One twenty-five-millionth of an inch.

Nanostructure

Something that has a dimension smaller than about 100 nanometers (such as clusters of atoms or thin layers).

Nitinol

A “smart material” or “shape memory metal” that is an alloy of nickel and titanium with the formula NiTi; the solid has the ability to return to a previous shape when heat is added.

Non-ferrous metal

A metal that doesn’t contain iron.

Opaque

Does not allow light through.

Piezoelectricity

A phenomenon whereby the application of an electric field to certain solids causes them to change shape; conversely, their mechanical deformation produces an electrical signal.

Properties

Characteristics that describe the appearance or behavior of a material in different conditions.

Reflectivity

The amount of light reflected relative to the total incident light.

Shape-memory

A material that when bent or twisted (deformed), has the ability to return to its previous shape.

Smart material

A material that is capable of sensing changes in its environment and responding to them.

Strength

The amount of stress (force per area) a material can withstand before breaking.

Tempering

Using heat to change the hardness of metal for a specific need.

Tensile

Drawn out or stretched.

Thermal or Electrical Insulator

A material that is a poor conductor of heat or electricity, respectively.

Thermoplastic

Plastics which can be softened and shaped when heated more than once.

Thermosetting plastic

Plastics which can only be formed once.

Toughness

A material's ability to resist breaking when a force is applied.

Translucent

Allows light to pass through in a diffused manner so that objects cannot be seen through it distinctly.

Transparent

A material you can see through.

Work-hardened

A material made hard by "working" it, for example, by hammering.