THE SCIENCE OF GUINNESS WORLD RECORDS

SCIENCE NORTH SCIENCE NORD

EDUCATION GUIDE

Lesson Plans – K to Grade 12

THE SCIENCE OF GUINNESS WORLD RECORDS

SCIENCE NORTH SCIENCE NORD

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The Science of Guinness World Records

The Science of Guinness World Records 6,000 sq. ft (600 sq. m) traveling exhibition makes it possible for anyone, anywhere to be a record-breaker!

The exhibition will engage visitors of all ages in real science experiences and record-breaking challenges. Visitors will learn about amazing record-breakers and learn more about themselves. Beyond the challenges, visitors will be drawn in by inspirational stories, as well as intriguing artifacts that will be showcased throughout the exhibition.

BE AMAZED by the fastest, longest, highest, and strongest!
Learn the science behind these feats and use this knowledge to develop your skills.

BE AMAZING as you explore, focus, react, and endure!
Challenge yourself, your friends, or your family to climb the leaderboard.

BE OFFICIALLY AMAZING and break a world record!
Celebrate your unique talents and the knowledge that you are scientifically amazing.

ZONE – ENTRANCE

VARIABLES AND EXPERIMENTS RELATED TO GUINNESS WORLD RECORDS™

EXHIBIT DESCRIPTION:

This activity relates to the What Makes a Record? exhibit where visitors learn how a GUINNESS WORLD RECORDS™ title parallels the scientific method in an intriguing way.

GUINNESS WORLD RECORDS™ TITLES MUST BE:	SCIENTIFIC RESEARCH MUST BE:
Repeatable Records have specific conditions and guidelines so attempts can be reproduced.	***Repeatable*** Research follows methods and conditions that can be reproduced.
Measurable Defined criteria or units are used to compare attempts.	***Measurable*** Standardized units are used to compare research data.
Breakable Challengers must be able to beat the record.	***Reliable*** Scientists must be able to repeat the research and get the same results.
Standardizable Attempts are based on a single measurable characteristic.	***Controlled*** Variables are controlled – except for what is being measured.
Evidence-based Attempts require accurate evidence.	***Verifiable*** Research requires accurate evidence and is shared with others.

Variables and Experiments Related to GUINNESS WORLD RECORDS™

ACTIVITY DESCRIPTION:

Students will look at the GUINNESS WORLD RECORDS™ throughout the exhibition. For each record, they will determine the dependent variable, the independent variable and the controlled variables.

BACKGROUND INFORMATION:

What makes a GUINNESS WORLD RECORDS™ title?

- **Measurable –** Can it be measured objectively? What is the unit of measurement? GUINNESS WORLD RECORDS™ does not accept applications based on subjective variables, such as beauty, kindness, or loyalty.
- **Breakable –** Can the record be broken? The record titles must be open to being challenged.
- **Standardizable -** Can the record be repeated by someone else? Is it possible to create a set of parameters and conditions that all challengers can follow?
- **Verifiable -** Can the claim be proven? Will there be accurate evidence available to prove it occurred?
- **Based on one variable -** Is the record based on one superlative, and measured in one unit of measurement?
- **The best in the world -** Has anyone else done better? If the record is new, GUINNESS WORLD RECORDS™ will set a challenging minimum requirement to be beat.

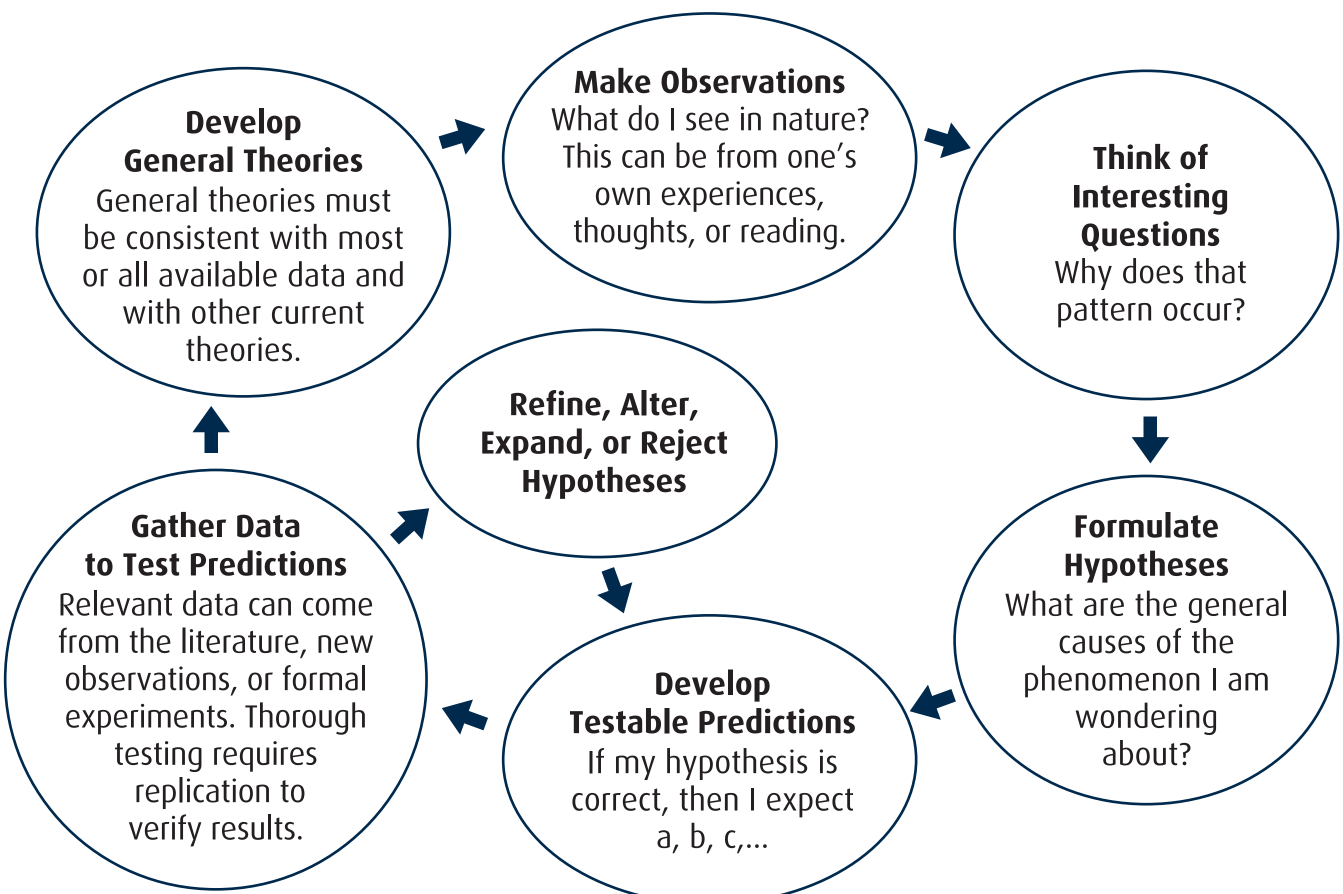
You can go to www.guinnessworldrecords.com/search, make an account and search the records.

David Rush is one of the most prolific GUINNESS WORLD RECORDS™ title holders. He earned an electrical engineering degree from MIT and sets GUINNESS WORLD RECORDS™ titles as a means to promote STEM education. Through determination and a strong understanding of scientific principles, he has managed to break over 100 GUINNESS WORLD RECORDS™ titles.

DavidRush4STEM.com | **https://www.youtube.com/c/DavidRushRecordBreaker**

SCIENTIFIC METHOD:

The Scientific Method as an Ongoing Process



What are the dependent and independent variables?

The **independent variable** causes the change in other variables, while the **dependent variable** is influenced by other variables. The dependent variable is what is observed or measured.

In determining whether or not a record has been broken or achieved, the judges have to ensure that all conditions are kept the same for everyone else who is trying to break this record. For each record there are specific guidelines, which means that specific things are controlled for during the record attempt. The end result, the record that is achieved, is the dependent variable. It is reliant on changing an independent variable. Some records are achieved innately, such as tallest person or longest fingernails. Other records require practice or a change in technique, like fastest juggler or furthest jump. These latter types of records undergo a rigorous process similar to the Scientific Method.

ZONE – ENTRANCE

VARIABLES AND EXPERIMENTS RELATED TO GUINNESS WORLD RECORDS™

MATERIALS:

Handouts – Find the Variables, Experimental Design

PROCEDURE:

Find the Variables:

1. Print a copy of the Find the Variables table on page 9.
2. Go through the exhibit and determine which records can be modified by changing a variable.
3. For these records, determine the goal of the record.
   i) This is essentially the dependent variable.
4. What factors could be changed to get a better result?
   i) These factors would determine the independent variables. Pick one.
5. As you would only change one factor (the independent variable) all the other variables would be the controlled variables.
   i) Essentially, these would be the conditions that must be the same to achieve this record.

Example: *Fastest build and take down of three cup-pyramids.*

Dependent variable: *speed of build (time)*

Independent variables: *number of cups picked up together, angle cups are held, placement of cup stacks before the build, etc.*

Controlled variables: *after picking one of the independent variables, everything else stays the same in order to figure out if that variable will have an effect on the dependent variable (speed of build)*

Design an Experiment:

1. Choose one or two of the records in the exhibit, or you can go to https://www.guinnessworldrecords.com/search, make an account and search the records.
2. Design an experiment that will help you break the record.
3. What are your observations about the record?
4. What could your hypothesis be?
5. How would you go about testing your hypothesis?
6. Name your variables, outline a procedure to follow and test your hypothesis.

Example:
Hypothesis: *Can changing the angle of how the cups are held change how fast three cup-pyramids could be built?*

Dependent variable: *Time it takes to build three cup-pyramids*

Independent variable: *The angle at which the cups are held*

Controlled variables: *Cups are placed in front of builder. Cups are nested in stacks of three – six – three. Cups are all the same size and make. Builder will grab cups individually using left and right hands alternatively.*

Procedure: *Individual will test different angles of stacking the cups, but keep all other conditions the same while stacking. For each angle, the time to stack the cups into three pyramids and take them down will be recorded. The attempt will be recorded several times at each angle to determine whether or not the angle the cups are held has an effect on the speed at which the pyramids are built.*

FIND THE VARIABLES:

EXHIBIT RECORD	DEPENDENT VARIABLE	INDEPENDENT VARIABLE	CONTROLLED VARIABLES

EXPERIMENT DESIGN:

RECORD	OBSERVATIONS	HYPOTHESIS	VARIABLES	PROCEDURE

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ZONE – EXPLORE

THE DIFFERENCE BETWEEN MASS AND WEIGHT

EXHIBIT DESCRIPTION:

This activity relates to the Weight of Records exhibit where visitors compare their weight, or the weight of everyone in their group, to different record-breaking plants and animals.

The Difference Between Mass and Weight

ACTIVITY DESCRIPTION:

Students will learn that the weight of objects is determined by gravitational interactions with mass by using a spring scale.

BACKGROUND INFORMATION:

Mass and weight are proportional to each other. $W = mg$ where g (our local gravitational field) is 9.8N/kg. Mass and weight are used interchangeably because most of us live on the surface of Earth. What happens to weight when you are on a planet with a different gravitational field, or in microgravity on the International Space Station? The mass of your object might not have changed, but the weight will change because g is different. On Earth, we can experience different weights by accelerating at different rates in the same axis as the gravitational force.

ZONE – EXPLORE
THE DIFFERENCE BETWEEN MASS AND WEIGHT

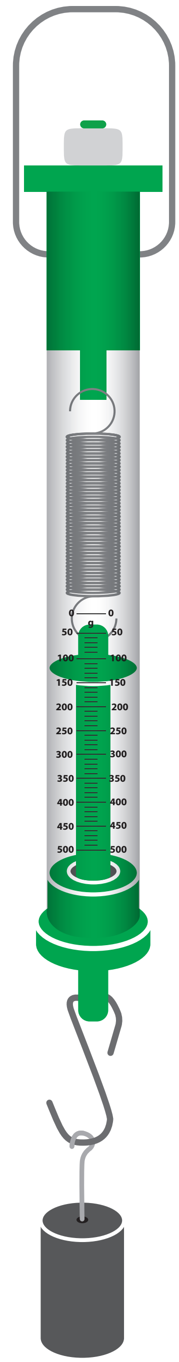
MATERIALS:

- Digital scale
- Spring scale (500g/5N)
- Standard masses (500g, 250g, 100g) with hooks
- Other objects to measure
- Data Table - Mass and Weight of Different Objects

PROCEDURE:

1. Measure mass: Put one of your 500g standard masses on the digital scale and record the value. Repeat with the 250g and 100g standard masses. Record these values in the Mass column your data table (Mass and Weight of Different Objects) in grams. You can also measure other objects that are not standard masses.
2. Measure weight: Without moving your hand, use your 5N spring scale to measure the weight of your 500g, 250g and 100g masses. Record the values in your table in Newtons. If using non-standard objects, record their weights from the spring scale.
3. Compare the values. Are the values similar? Do they fit into the formula W = m X g where g is 9.8 N/kg?
4. With your 250g mass attached to your spring scale, move your hand up. Observe what happens to the value on your spring scale.
5. Have a partner record the highest and lowest Newton values on the spring scale when you are moving your hand.
6. Why are the measurements different from when your spring scale was stationary?

Spring scales measure weight, not mass, and only read correctly when the acceleration in the direction of the spring is constant. As we move our hand up, there is a net upward force and the spring scale pulls harder, showing more force downward or making the mass heavier, but not more massive.



EXTENSIONS/ADAPTATIONS:

Weight on different planets:

On different planets, the gravitational force is different from on Earth due to the mass of the planets. Because gravity is constant on Earth, we simplify by saying Earth's surface gravity is 1. All other planets have different surface gravities in relation to Earth.

Calculate your weight on different planets using the formula Weight = Mass X Surface Gravity, and the Surface Gravity from the table. Assume Mass = Weight on Earth

PLANET	SURFACE GRAVITY (g)
Mercury	0.38
Venus	0.91
Earth	1.0
Mars	0.38
Jupiter	2.36
Saturn	0.92
Uranus	0.89
Neptune	1.12

ZONE – EXPLORE
THE DIFFERENCE BETWEEN MASS AND WEIGHT

DATA TABLE – MASS AND WEIGHT OF DIFFERENT OBJECTS:

OBJECT	MASS (g) DIGITAL SCALE	WEIGHT (N) SPRING SCALE

WITH MOVING SPRING SCALE:

Highest weight of 250g mass: ____________________ (N)

Lowest weight of 250g mass: ____________________ (N)

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ZONE – EXPLORE

NANOTECH – MEMORY WIRE

EXHIBIT DESCRIPTION:

The next two activities relate to the Smallest Stop Motion Film exhibit where visitors explore the science behind nanotechnology by watching the smallest stop-motion film and playing with a simulated scanning tunneling microscope.

Nanotech – Memory Wire

ACTIVITY DESCRIPTION:

Students will observe how shape-memory wire works, and figure out where it can be used.

BACKGROUND INFORMATION:

Nitinol (Nickel Titanium Naval Ordinance Lab) is a metal alloy of nickel and titanium. It belongs to a class of materials called shape memory alloys (SMA). These are materials that display a shape memory effect. SMAs can change their crystal structure, or phase, at a specific temperature. Nitinol has two phases. In one phase, at high temperatures, it has cubic symmetry and is hard and rigid. In its other phase, at lower temperatures, it is less symmetric and more flexible. The atoms in the alloy change their orientation and/or position when pressure is applied at a lower temperature. When heated above its transition temperature, nitinol will revert back to its original rigid atomic configuration. This means, you can twist memory wire into different shapes at a lower temperature, and it will revert to its original shape when heated above a certain temperature. Changing the amounts of nickel and titanium in the alloy will change the transition temperature.

ZONE – EXPLORE

NANOTECH – MEMORY WIRE

MATERIALS:

For each group -

- 1 piece of nitinol wire – cut into 3–inch piece
- 1 piece of aluminum wire – cut into 3–inch piece
- 2 tweezers
- 2 cups or bowls
- Cold tap water and hot water (10 minutes after boiling)
- Data Table – Properties of Different Metal Wires

PROCEDURE:

Note: If the teacher would like to use this as an inquiry-based activity, do not tell the students what the wires are made of. Ask the students to hypothesize which wire is the innovative product before doing the tests.

1. Look at the two different types of wires. What does each look like and feel like? Write down your observations in the data table (Properties of Different Metal Wires).
2. Fill one cup with cold water and the other cup with hot water. Be careful with the hot water. Using the tweezers, dip each of the wires in the cold water, and then into the hot water. Write down your observations.
3. Take the two types of wire and twist them into different shapes.
4. Using the tweezers, dip the twisted wires in the cold water, and then into the hot water. Write down your observations.

EXTENSIONS/ADAPTATIONS:

What temperature causes the fastest change?

Using the nitinol wire, dip your twisted piece of metal into containers of water that gets progressively hotter. Note the temperature at which the wire seems to spontaneously "snap" back to its original shape.

What is the lowest temperature that will cause a change?

Using a similar method as above, note the lowest temperature that will cause the wire to unfurl or start to straighten.

Uses of nitinol:

List uses for this type of material. How could nitinol be useful in medical procedures or other applications?

DATA TABLE – PROPERTIES OF DIFFERENT METAL WIRES:

WIRE TYPE	QUALITATIVE PROPERTIES	RESULTS AFTER DIP IN COLD WATER	RESULTS AFTER DIP IN HOT WATER
#1			
#2			

Which wire is memory wire? ____________

Nanotech – Hydrophobic Sand

ACTIVITY DESCRIPTION:

Students will learn how nanotechnology can change everyday materials like sand and fabric.

BACKGROUND INFORMATION:

A nanometer is one one-billionth of a meter (10^{-9} m). Ten hydrogen atoms are about 1 nm. Nanotechnology is the manipulation of materials at the nanoscale (1-100 nm) to take advantage of some unusual properties like hydrophobicity and lower resistance to electricity. Hydrophobic means water-fearing, or water-repellant. Natural sand is actually hydrophilic. It is attracted to water. Hydrophobic sand is sand where the grains have been treated with a special silicon-based compound. One end of the compound is attracted to the grain of sand, and the other end of the compound is hydrophobic. This creates a layer around each grain of sand that repels water.

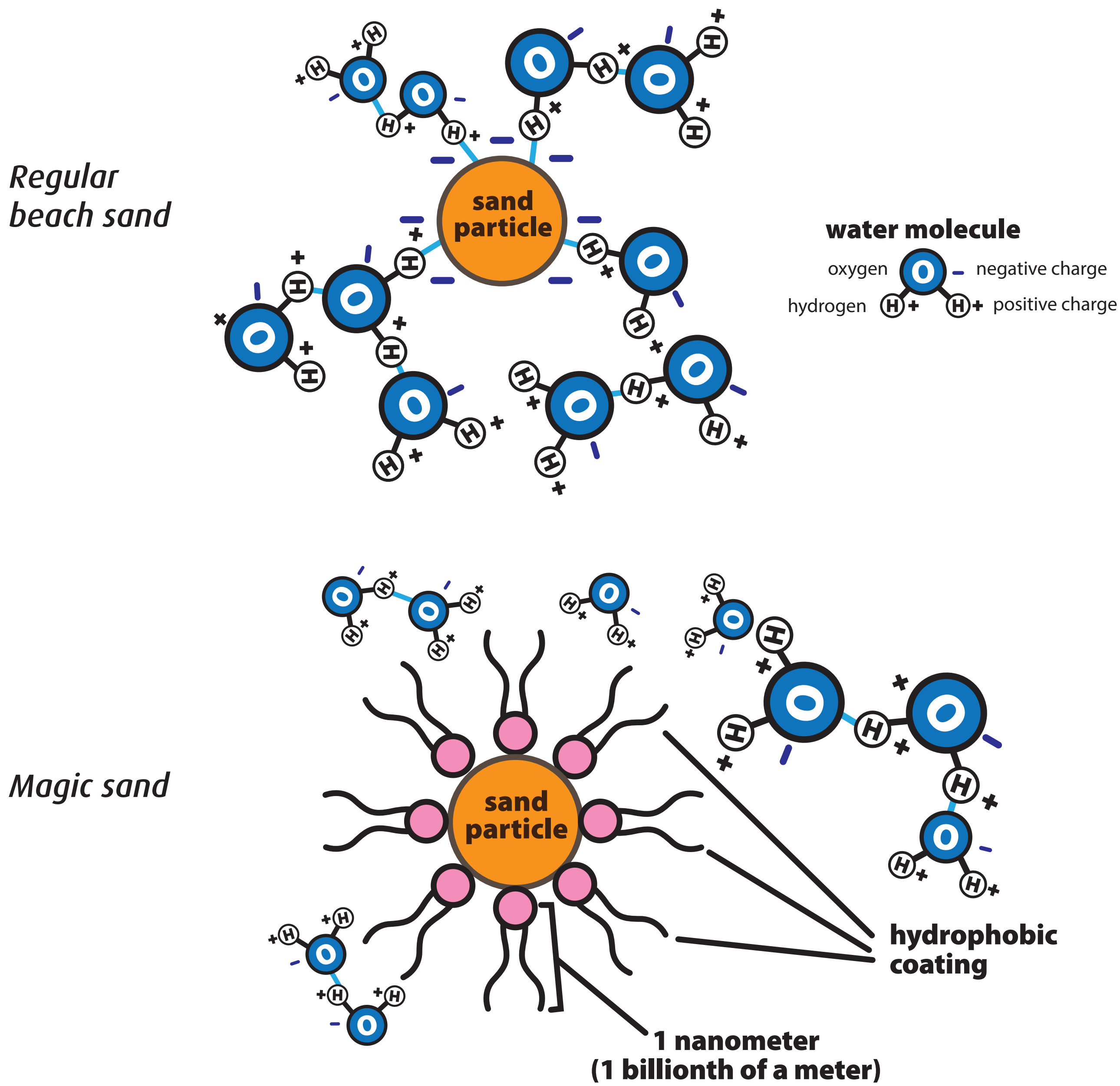


FIGURE: Interaction of water molecules with regular beach sand particles and magic sand particles which have a hydrophobic coating.

ZONE – EXPLORE
NANOTECH – HYDROPHOBIC SAND

MATERIALS:

For each group -

- Sample of regular sand
- Sample hydrophobic sand (also known as Magic Sand)
- 2 shallow dishes
- 2 cups filled with tap water
- 2 measuring teaspoons
- 1 eye dropper
- Data Table – Properties of Different Types of Sand
- Optional – small graduated cylinders

PROCEDURE:

Note: If the teacher would like to make this an inquiry-based activity do not tell the students that the sands are different. Ask the students to hypothesize which sand is the innovative product before doing the tests.

1. Label your shallow dishes #1 and #2. Place 5 teaspoons of regular sand into dish #1 and 5 teaspoons of hydrophobic sand into dish #2. Look at the two different sands. Make qualitative observations about the two different sands. Write your observations in your data table (Properties of Different Types of Sand).
2. Using the eye dropper, slowly drop 10 drops of water onto the sand in dish #1 and observe what happens. Slowly drop 10 drops water onto the sand in dish #2 and observe what happens. Write your observations in your data table.
3. Using your measuring spoon, scoop some sand from dish #1 and sprinkle it over the water in one cup, and observe what happens. Carefully sprinkle some sand from dish #2 over the water in the second cup, and observe what happens. Write your observations in your data table (Properties of Different Types of Sand).

DATA TABLE – PROPERTIES OF DIFFERENT TYPES OF SAND:

SAND	QUALITATIVE PROPERTIES	RESULTS AFTER WATER DROPPED ONTO SAND	RESULTS AFTER SAND SPRINKLED OVER WATER
#1			
#2			

Conlusion: Which sand is hydrophobic sand? ____________

EXHIBIT DESCRIPTION:

This activity relates to the Cause for Applause exhibit where visitors add their clap to the GUINNESS WORLD RECORDS™' collection.

The Science of Sound

ACTIVITY DESCRIPTION:

Students will learn sound is a form of energy created when matter vibrates, and they will do a series of activities to observe and experience sound energy.

BACKGROUND INFORMATION:

Sound is energy that is created when matter vibrates, or moves back and forth. Some living organisms interpret these vibrations as sound when the vibration gets to their ears. The stimulus is converted into an electrical impulse and interpreted by the brain as sound. Sound is a pressure wave. Sound vibrations have to travel through matter, and they travel through matter in a longitudinal wave. The speed of sound depends on how quickly the pressure wave can move through the medium. Matter that is easily compressible will slow down the pressure wave. Sound travels at different speeds through solid, liquid and gas matter because of the difference in compressibility of each type of matter.

MATERIALS:

- Slinky
- Ruler (relatively stiff – wood works well)
- Spoons/wire hangers
- Different types of string (yard, fishing line, cotton string)

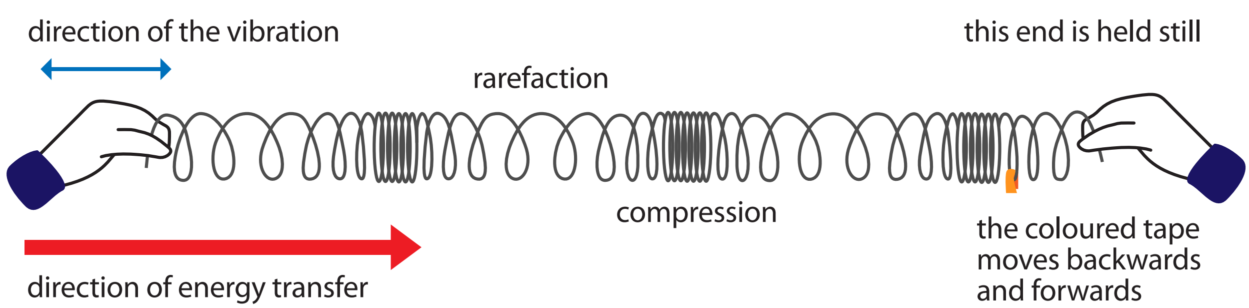
PROCEDURE:

1. What Do Sound Waves Look Like?

a. To picture how sound waves move through matter, take your Slinky and hold it with a partner, about 5 feet apart.

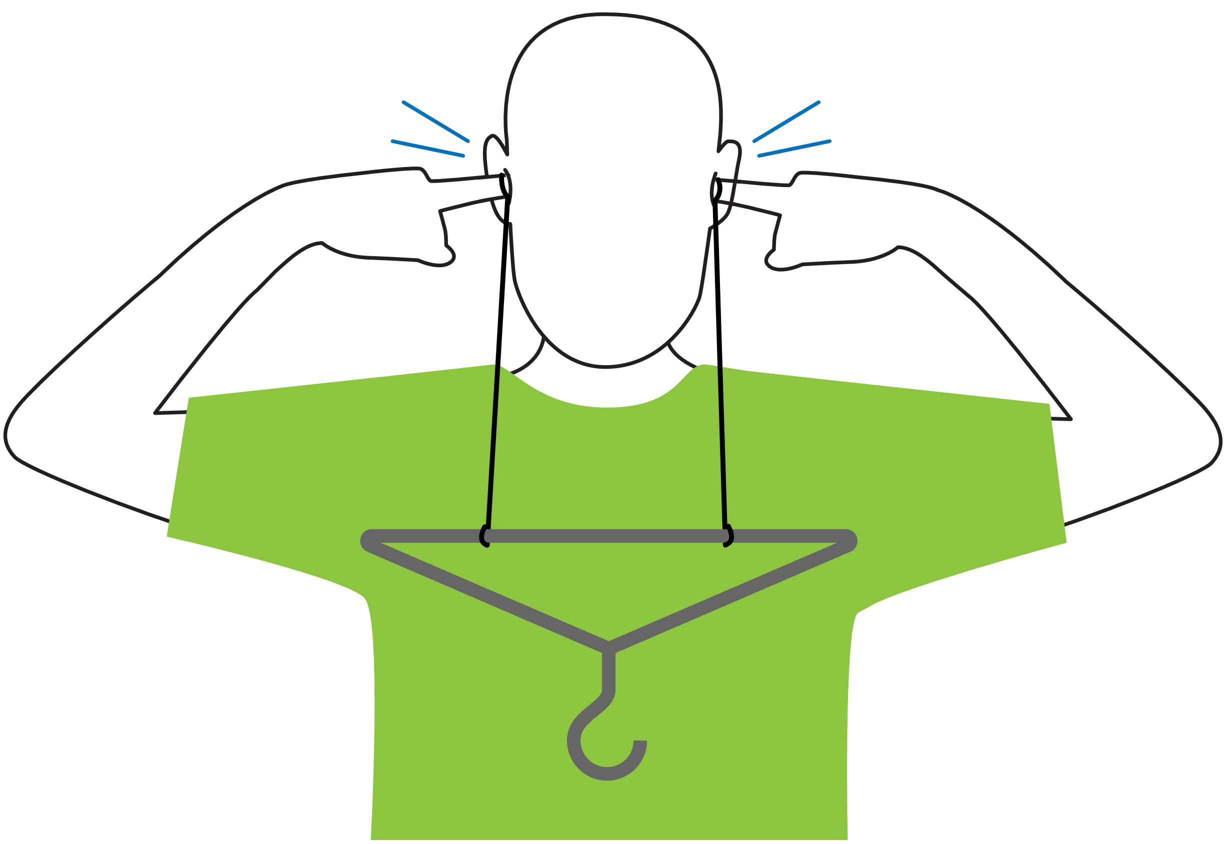
b. Have one person keep their hand still and the partner moves the Slinky back and forth horizontally.

c. You should see the rings of the Slinky compress and separate as the pressure wave moves longitudinally through the Slinky.



2. *Frequency of Sound:*
    a. To change the pitch of a sound, take a ruler and place it on the edge of a table with 8 inches sticking out from the side. (see image below)
    b. Place your hand on the part of the ruler still on the table to hold it securely. With your other hand, flick the end of the ruler that is sticking out. The ruler should vibrate up and down and generate a sound.
    c. Now, try to figure out a way to change the pitch of the sound. *Note: The shorter amount of ruler sticking out from the edge of the table, the higher the pitch of the sound.*
    d. Do you think there would be a difference if you used a yardstick?

3. *Transmitting Sound:*
    a. To hear sound traveling through different materials, make a stereo clothes hanger
    b. Tie a piece of string to each of the bottom corners of a wire clothes hanger. The hook should be pointing down. Loop the string around each of your index fingers.
    c. Swing the hanger so that it bounces off of different objects. What do you hear?
    d. Put your fingers in your ears and do the same thing. Does the sound change?
    e. Does the sound change when you hit different types of materials, for example, something hard like a chair, versus something soft like a winter coat?



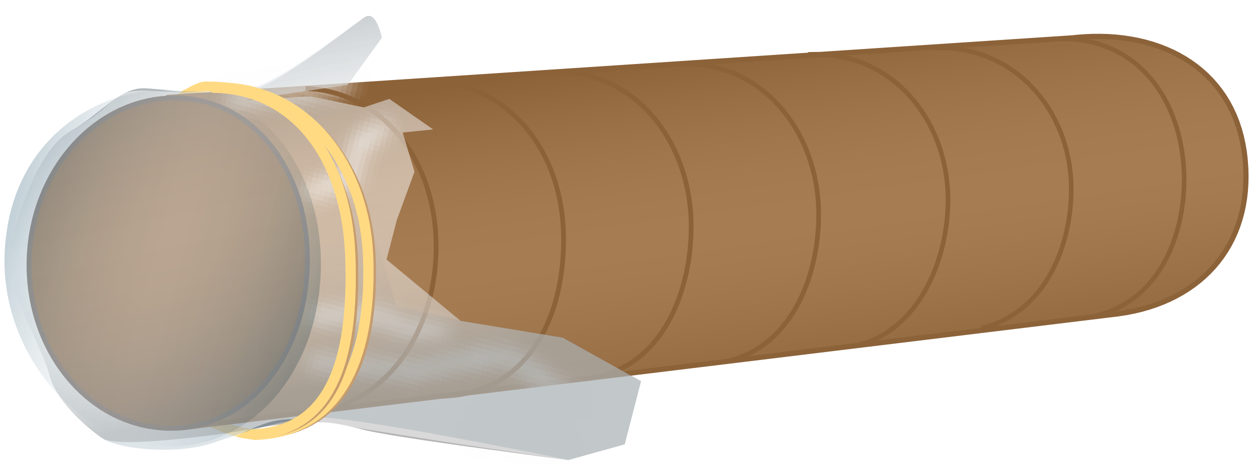
EXTENSIONS/ADAPTATIONS:

Sound through a table:

For hearing sound through a solid, you can have students put an ear on a desk or table and lightly tap or scratch the tabletop with a fingernail. Ask students to describe the difference in sound when their ears are against the tabletop versus not touching the tabletop. You can also experiment with different materials (tile, metal, plastic, etc.) and note how quickly the sound will travel. The denser the material, the faster the sound should travel.

Making your own vibrations:

Students can generate sound by humming. Have students experiment with changing the pitch of the sound they are making. Ask students what they are doing to make the pitch higher or lower. They can make their own instruments, like a kazoo, using wax paper, an elastic and a paper towel roll.



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ZONE – FOCUS
FOLD A HEXAFLEXAGON

EXHIBIT DESCRIPTION:

This activity relates to the exhibit Record Reveal where visitors are provided with steps to solve slider puzzles to help them understand the concept behind algorithms and heuristics.

Fold a Hexaflexagon

ACTIVITY DESCRIPTION:

Students will use an algorithm to fold a trihexaflexagon.

BACKGROUND INFORMATION:

An algorithm is a set of guidelines that describe how to perform a specific task. This means a recipe is an algorithm. Your morning routine to get out of the house on time is an algorithm. Solving a division question by hand uses an algorithm. In computer programming, an algorithm is a sequence of instructions that tells the computer what to do. You can use an algorithm to explain how to fold a trihexaflexagon. A flexagon is a flat model that can be flexed to reveal different faces than what is originally on the front and back. A hexaflexagon is hexagonal in shape.

ZONE – FOCUS

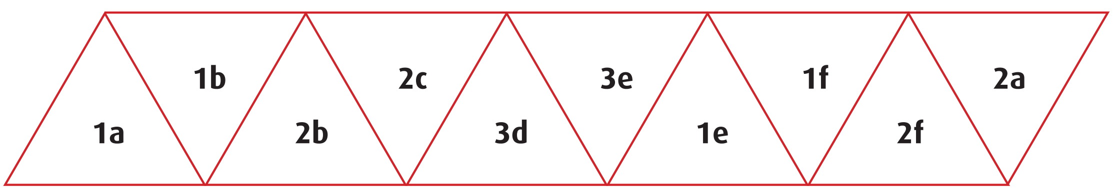
FOLD A HEXAFLEXAGON

MATERIALS:

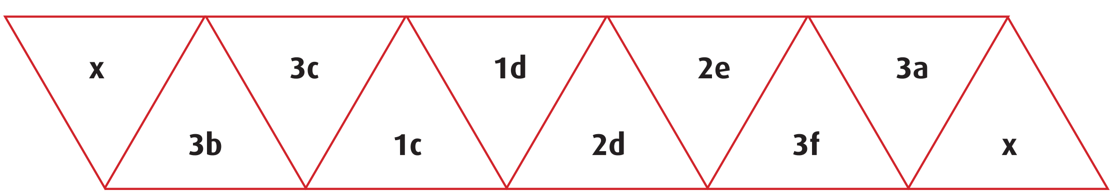
- Strip of paper
- Protractor to measure angles
- Pencil
- Scissors
- Tape
- Template for GUINNESS WORLD RECORDS™ Trihexaflexagon (see page 32)

PROCEDURE:

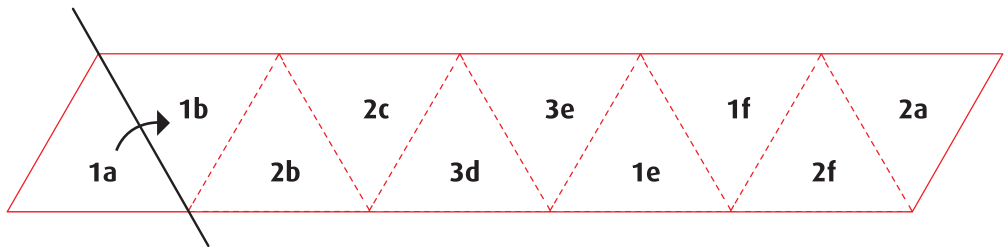
1. Read the instructions below. This is the algorithm to make a trihexaflexagon.
2. On a strip of paper draw 10 equilateral triangles in a row. They should alternate between point down and point up. All the angles in an equilateral triangle are 60°, so use a protractor to make your triangles. You can also use the template provided on page 32.
3. With the left-most triangle pointing up, label your triangle faces as follows: 1a, 1b, 2b, 2c, 3d, 3e, 1e, 1f, 2f, and 2a.



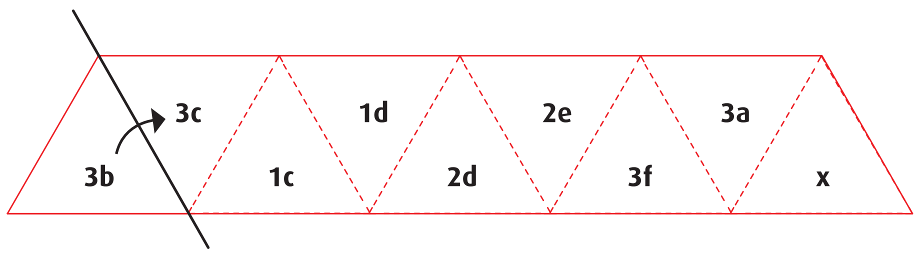
4. Flip your strip toward you and label the back of the strip as follows: X, 3b, 3c, 1c, 1d, 2d, 2e, 3f, 3a, and X.



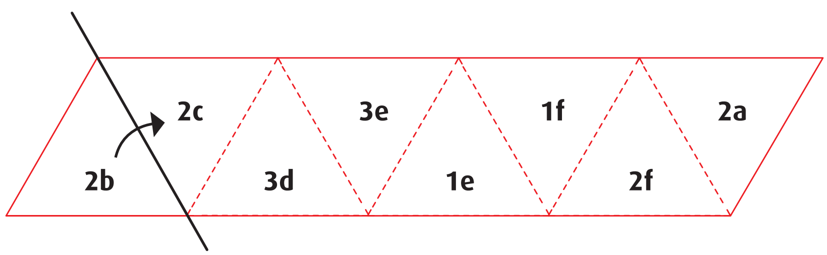
5. Flip your strip back to the original side, starting with 1a.
6. Fold the face of 1a to the face of 1b, lining up the triangles. Keep the faces together.



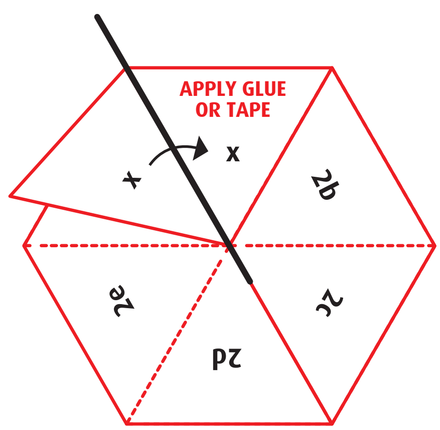
7. Flip your strip and fold the face of 3b to the face of 3c, continuing to line up the triangles and keeping the faces together.



8. Flip your strip and fold the face of 2b to the face of 2c.



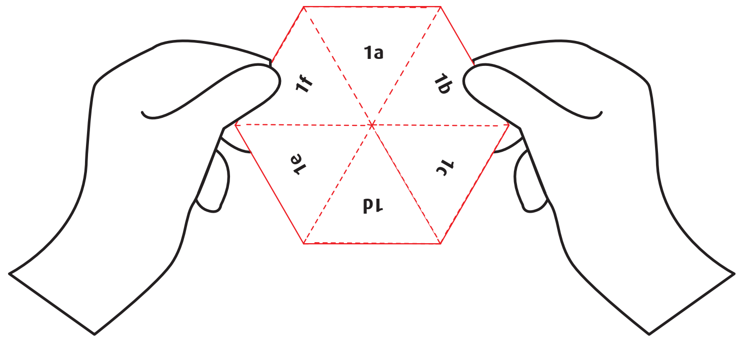
9. Continue with this pattern until you have folded the whole strip of paper, finishing with folding the face of 2f to the face of 2a.
10. Unfold your strip of paper, it should have peaks and valleys in the folds.
11. Starting with the Xs facing you, fold together 3b and 3c. Flip the shape.
12. Fold together 3d and 3e.
13. Fold together 3f and 3a, and your triangles with the Xs should line up. Tape the X faces together at the outer edge to make a hexagon.

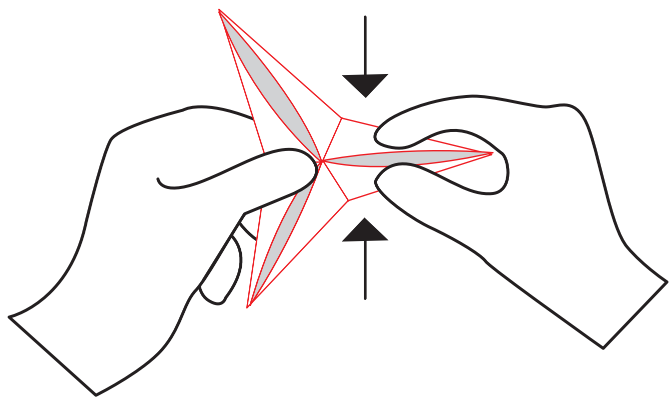


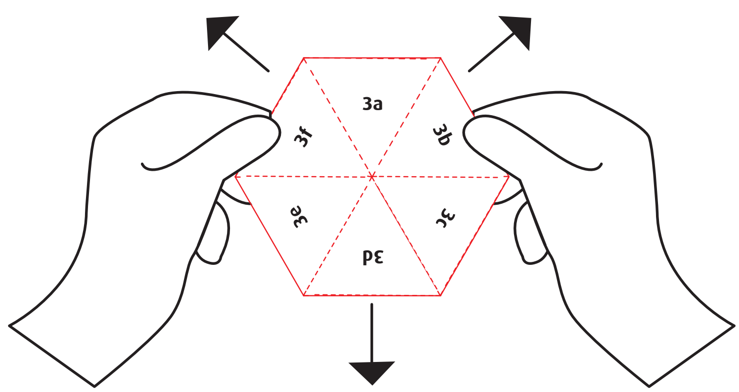
ZONE – FOCUS

FOLD A HEXAFLEXAGON

14. Flip your hexagon. You should have a hexagon with the faces labelled 1a-f. Flip over the hexagon, and it should be labelled 2a-f.
15. To find the hidden third face, hold the hexagon with the 1a-f side facing you. Fold the hexagon away from you. Pinch the triangles together along the folds to make a Y shape.
16. Pull apart the shape from the center, and reveal the third face.
17. You may need to tape the edge of the 3a face to the edge of the 1a face.

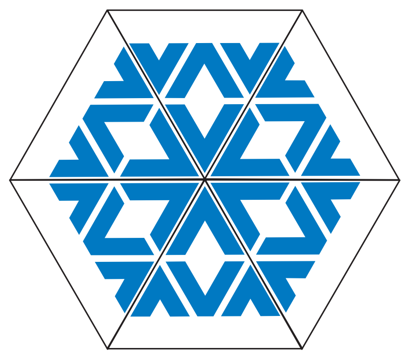


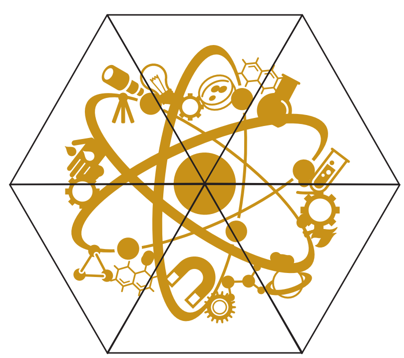




ZONE – FOCUS

FOLD A HEXAFLEXAGON





EXTENSIONS:

Hexahexaflexagon:

Make a hexahexaflexagon with six faces. Map the six faces, and figure out how you can get to each of the faces. A hexahexaflexagon has 19 equilateral triangles in a strip. You may need to mark each face with a different color to follow the paths.

Write your own algorithm:

Pick a simple task, such as making a paper airplane, and write down the instructions to perform this task. Have a partner follow your instructions as they are written. Do you need to make changes to your algorithm?

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ZONE – FOCUS

MNEMONICS EXPERIMENT

EXHIBIT DESCRIPTION:

This activity relates to the Science of Focus exhibit where visitors play with a memory palace.

Mnemonics Experiment

ACTIVITY DESCRIPTION:

Students will learn if mnemonics can improve memory.

BACKGROUND INFORMATION:

Mnemonics is a learning technique that aids in the retention and/or retrieval of information. It is the development of a system that will improve memory. Common mnemonics often involve acronyms, poems, songs or short phrases that help people remember information. For example, The Great Lakes (Super Heroes Must Eat Oats – Superior, Huron, Michigan, Erie, Ontario). The idea is that it is easier to remember personal or humorous information than it is to remember more abstract or impersonal forms of information.

PROCEDURE:

1. Make of list of at least 10 words.
2. Create a mnemonic device to help people remember the list.
3. If you are doing this activity in a class setting, divide the class into three random groups of equal number of students.
4. Show each group the list of words, and give them three minutes to study the list.
5. Group 1 is only allowed to look at the words (Control). Group 2 will be given the mnemonic device that you created. Group 3 will be asked to create their own mnemonic device.
6. Collect the list of words when the three minutes has elapsed. Have the students continue on with regular activities for one hour.
7. One hour later, ask the students to recreate the list of words on a piece of paper. Use a timer to measure how long it takes to recreate the list, and the accuracy of their recollection. Record the results for each student in each group in your data table.
8. Analyze the data collected. Do mnemonic devices help in remembering information? Is it better for someone to create their own nmemonic device than to use a premade one?

EXTENSIONS/ADAPTATIONS:

Themed items vs random items:

Pick items that follow a theme and pick items that are random or unrelated to each other. Follow the same procedures listed above to determine if themed items are easier to remember.

Math:

Plot the average time it takes to recall words. Compare the three groups.
Plot the percentage of words recalled. Compare the three groups.
Analyze your data with the help of your graphs.

Memorize numbers:

Instead of a list of words, have the students memorize a list of numbers. What is the largest list of numbers students can memorize using a mnemonic technique? Try memorizing Pi.

Memorize a deck of cards:

Test the efficacy of using mnemonic techniques to memorize a deck of playing cards. How big of a deck of cards can your students memorize?

DATA TABLE – MNEMONICS EXPERIMENT:

STUDENT NAME	GROUP	TIME TO RECALL (SEC)	NUMBER OF CORRECT WORDS	PERCENTAGE OF CORRECT WORDS
Average:				

EXHIBIT DESCRIPTION:

This activity relates to the Science of Reaction exhibit where visitors test their reaction time to different stimuli.

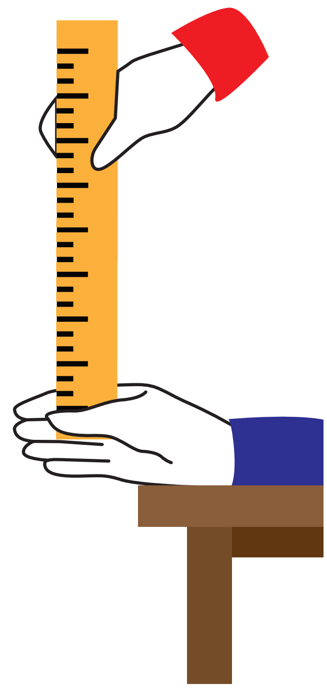
Catch the Ruler

ACTIVITY DESCRIPTION :

Students will be testing their reaction time to visual, auditory and tactile stimuli using a ruler.

BACKGROUND INFORMATION:

The nervous system helps information travel through your body. It consists of your senses, your brain, your spinal column, and the nerves that connect them all together. Even though neurons move information quickly along your nervous system as messages, your body doesn't react instantly. The time it takes from when your eye first notices a ball to when your arm reaches up to catch it is an example of reaction time. Different stimuli, changes in your environment that you react to, will generate different reaction times.

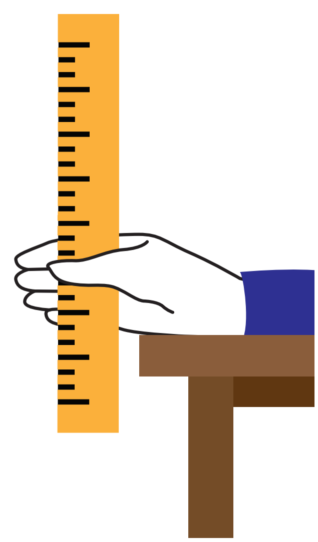


MATERIALS:

- 2 12-inch rulers
- Eye mask or blindfold
- Data Table – Catch a Ruler Reaction Time

PROCEDURE:

1. Work with a partner, and record your data in the data table provided (Catch a Ruler Reaction Time).
2. Student A will sit in the chair with good upright posture, and eyes looking across the room. Their forearm will rest on the table, and their hand extends over the edge of the table.
3. Student A will place their thumb and index finger on either side of the bottom of the vertically placed ruler (Student B is holding the ruler). The number 0 should be on the bottom, in line with the thumb, and the 12 near the top.
4. Student B will release the ruler without telling Student A. Student A tries to catch the ruler with their thumb and forefinger as soon as they see it dropping.
5. Student B drops the ruler. After Student A catches the ruler, record the number on the ruler displayed just over their thumb. The lower the number, the faster the reaction time.
6. Conduct three more trials with the same student, making sure to line up the ruler at 0 inches where the thumb and index finger are.
7. Record the results for each trial in the data table (Catch a Ruler Reaction Time).
8. Repeat with Student B catching the ruler.



EXTENSIONS:

Auditory stimulus:

Repeat the above steps, but the students will catch the ruler when they hear the word “release”. Students close their eyes or wear a blindfold.

Tactile stimulus:

Repeat the above steps, but the students will catch the ruler when they feel a touch on their shoulder.

Two rulers:

Students will have to catch one of two rulers using visual and auditory stimuli. With the visual stimuli, the catcher must grab the correct ruler as fast as possible. With the auditory stimuli, start with saying “left” or “right” when you drop the corresponding ruler. For more of a challenge, just say “release” and randomly choose which ruler to release.

Dominant vs non-dominant hand:

You may need to do more trials to see the difference.

Math:

Calculate your reaction time in seconds using the formula $d = 1/2\ gt^2$ where g is the acceleration due to gravity 9.8 m/s^2.

DATA TABLE – CATCH A RULER REACTION TIME:

TRIAL	VISUAL STIMULUS Distance on Ruler (inches)	AUDITORY STIMULUS Distance on Ruler (inches)	TACTILE STIMULUS Distance on Ruler (inches)
1			
2			
3			
4			
Average:			

EXHIBIT DESCRIPTION:

This activity relates to the Science of Endurance exhibit where visitors hit a sensor that measures force for as long as they can to understand the connection between force and muscle fatigue.

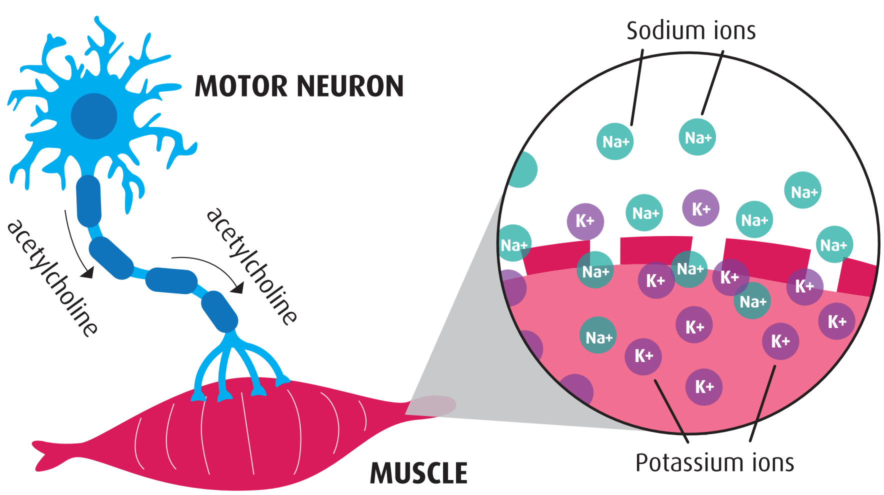
Pinching a Clothespin

ACTIVITY DESCRIPTION :

Students will learn about how muscle fatigue can occur with repeated movements.

BACKGROUND INFORMATION:

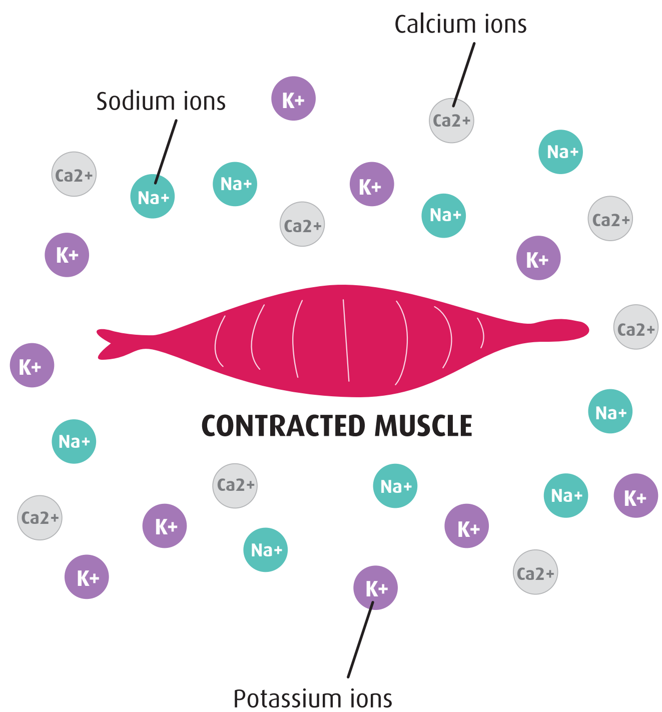
Muscle fatigue happens when your muscles no longer have the ability to contract. Your muscles contract in response to signals from motor neurons. Motor neurons release acetylcholine which triggers pores on the membrane of the muscle cell to open.



Sodium ions on the outside of the muscle cell will flow in and potassium ions on the inside of the cell will flow out. The movement of these ions will create an action potential which causes the muscle cell to release calcium ions. The excess calcium causes the muscles to contract.

With each contraction the ions move away from the cell membrane. With repeated contractions, there might not be high enough concentrations of sodium, potassium and calcium ions near the membrane. Eventually, the muscle is unable to generate the action potential needed to contract the muscle. The muscle has become fatigued.

Sodium, potassium and calcium are abundant in the body, and they will flow back to the area where they are needed over time. As you continue to exercise, muscle fatigue takes more time to set in. This is because as you become stronger, you need fewer contractions to do the same amount of exercise.



ZONE – ENDURE

PINCHING A CLOTHESPIN

MATERIALS:

- Clothespins
- Timer
- Data Table – Clothespin Muscle Fatigue
- Pencil

PROCEDURE:

1. Work with a partner, and use the data table (Clothespin Muscle Fatigue) to record data collected.
2. Student A will hold a clothespin in between their thumb and index finger of their dominant hand.
3. Student A will squeeze the clothespin until their fingers meet. They will relax their grip until the clothespin is closed. This is one squeeze.
4. Student B will count the number of times Student A can squeeze the clothespin in a 20 second period while holding the other fingers of the hand straight out. Make sure to squeeze quickly and completely to get the maximum number of squeezes for each trial.
5. Student A will repeat this process for 5 more times in 20-second intervals and Student B will record the results for each trial in a table in the data table. DO NOT rest your fingers between the trials.
6. Repeat the same procedure for your non-dominant hand.
7. Switch roles with your partner and have them do steps 2 – 7.

EXTENSIONS/ADAPTATIONS:

Maximize squeezes:
Modify your squeezing to have the maximum number of squeezes over the whole experiment time period.

Recovery:
How long does it take for you to recover to your maximum number of squeezes?

Exercise first:
Have a group of students do two minutes of exercise to increase their pulse rate. Have a second group rest before doing the clothespin pinching. Have each group of students do the experiment as described above. Compare the data from both groups. Does exercise increase the number of clothespin squeezes that can occur before fatigue sets in?

Graphing:
Use the data gathered in the trials to create a graph of the 7 trials. X-axis is “Trial Number” and the y-axis is “Number of squeezes in 20 seconds”.

DATA TABLE – CLOTHESPIN MUSCLE FATIGUE:

STUDENT	1	2
20 SEC		
40 SEC		
60 SEC		
80 SEC		
100 SEC		
120 SEC		
AVERAGE		

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ZONE – ENDURE
MAKE A LUNG MODEL

EXHIBIT DESCRIPTION:

This activity relates to the burst hot water bottle artifact where visitors watch a record attempt to blow up and burst hot water balloons.

Make a Lung Model

ACTIVITY DESCRIPTION :

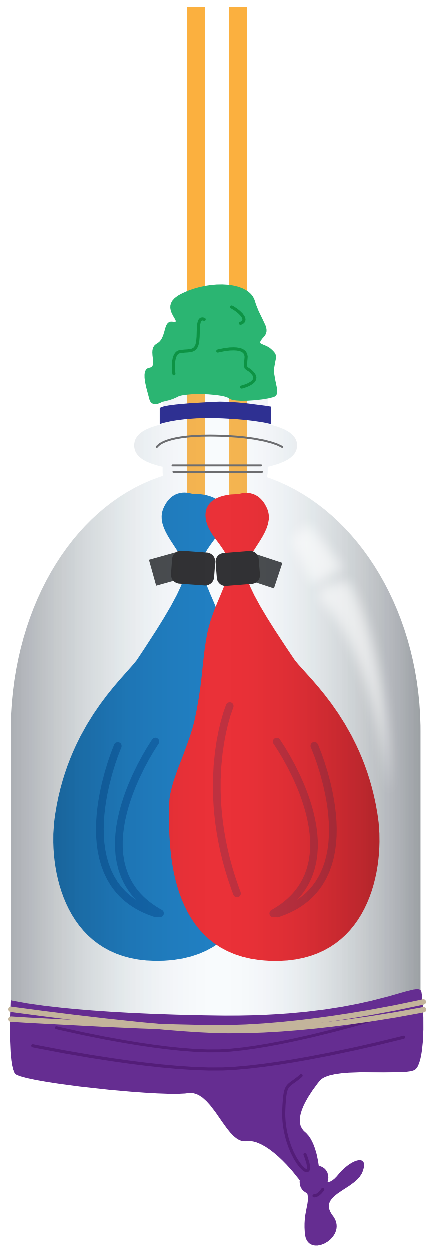
Students will build a simple model of the human respiratory system. This model will be used to explain the structure and function of the respiratory system.

BACKGROUND INFORMATION:

When you inhale, your diaphragm muscle contracts downward and the muscles between your ribs pull upward. This increases the volume of your chest cavity. An increased volume means a lower pressure inside your lungs and air will flow in from the outside. When you exhale, the opposite happens. Your diaphragm relaxes and the ribs and lungs push in. This causes air to be pushed out.

ZONE – ENDURE

MAKE A LUNG MODEL



MATERIALS:

- A clear plastic soda bottle with the bottom half cut off
- 2 straws
- 2 balloons
- Masking tape (or black electrical tape)
- Play dough
- A rubber band
- A piece of plastic bag or third balloon

PROCEDURE:

1. Insert a straw into one of the balloons and secure the balloon to the straw using tape.
2. Repeat this step using the second straw and balloon.
3. Leave the straws sticking out of the top of the bottle and secure them in place by putting play dough around the straws and the opening of the bottle. Create an airtight seal.
4. Secure the piece of plastic bag (or cut third balloon) to the bottom half of the soda bottle using the rubber band.
5. Tape a little piece of paper to the bottom of the plastic bag to make a tab that you can pull.
6. Pull the tab on the bottom of the plastic bag. Observe what happens.
7. Can you explain what is happening in the model and relate it to the human respiratory system?

Pierce a Balloon Without Popping it

ACTIVITY DESCRIPTION:

Students will learn how polymers are useful in our lives.

BACKGROUND INFORMATION:

Balloons are made of rubber. The rubber in balloons are in long chains of molecules. These long chains are called polymers, and it allows the rubber to stretch. When you blow up a balloon, you stretch the long strands of polymer chains. Depending on where you try to pierce a balloon, you might actually pierce the balloon without popping it. If you try to pierce a balloon where the chains are under a lot of stress, the chains will tear apart where the balloon is punctured and the balloon will pop.

ZONE – ENDURE

PIERCE A BALLOON WITHOUT POPPING IT

MATERIALS:

- Balloon
- Wooden skewer (free of splinters)
- Vegetable oil or dish soap
- Permanent marker
- Optional: transparent tape, needle/pin, fresh unpeeled orange

PROCEDURE:

1. Before blowing up a balloon, use your permanent marker to draw small dots all around the balloon. You should draw between 7 and 10 dime-sized dots. Make sure you draw them on either end of the balloon and around the middle.
2. Inflate the balloon about half full, and tie off the end.
3. Observe the size of the dots. You should see that some of the dots will be more stretched than other dots. By looking at the size of the dots, you can determine which parts of the balloon are stretched more than others.
4. Coat your wooden skewer in oil or dish soap.
5. Carefully push the pointed end of the skewer into a small (less stretched) dot near the knot of the balloon. Use gentle pressure and a slight twisting motion to pierce the balloon. Continue to move the skewer through the balloon, exiting through another smaller dot at the top of the balloon.
6. You should have successfully pierced the balloon.
7. As you gently remove the skewer from the balloon, air will leak out, but your balloon will have not popped.

EXTENSIONS/ADAPTATIONS:

Do not pop with a needle:

Using the same principal as above, put a piece of transparent tape over the smaller dots. Use a pin or needle to pierce the surface of the balloon. The tape will keep the stretched chains intact. The hole will cause air to escape, but the balloon will not pop. Does this work if you put tape over the stretched section?

Like dissolves like:

Inflate rubber/latex balloons. Take some fresh orange peel, and squirt it on the inflated balloon. Observe what happens. The active ingredient in orange peel is called limonene. It is a non-polar substance. Rubber is also a non-polar substance. The limonene dissolves the rubber, weakening it, and causes the balloon to pop. Does this happen with all balloons? Can you explain why this may or may not be the case?

ZONE – ENDURE
THE SCIENCE OF BALANCE

EXHIBIT DESCRIPTION:

This activity relates to the Balance Buster exhibit where visitors balance on boards and try to balance for as long as possible.

The Science of Balance

ACTIVITY DESCRIPTION:

Students will learn that balance is controlled by the visual system, the somatosensory system and the vestibular system.

BACKGROUND INFORMATION:

The body uses visual information to orient itself in space and to help regain balance. The body also uses a system of receptors, the somatosensory system, located in muscles, tendons and ligaments to control balance. These receptors send signals about stretch and body position to the brain. This system is essential to balance, but also in injury prevention. Thirdly, the body uses the vestibular system, found in the inner ear, to maintain balance. This is a system of fluid-filled canals and hairs in the inner ear. When the head position changes, fluid in the inner ear cause tiny hairs to move. The movement of the hairs in the inner ear sends signals to the brain. The brain processes the information to determine the position of the head.

MATERIALS:

Optional – turning board

PROCEDURE:

Visual System:

1. With your eyes open, lift one of your legs and balance on the other foot. Count how long you can keep this pose before you need to put down your foot. Try again with your other leg.
2. Next, do this action with your eyes closed. Time how long you can balance. Repeat with your other leg. Does it get easier with practice?

Muscle Receptors:

1. Stand in front of a wall. Take three big steps away from the wall, and turn to face the wall.
2. Put your hands in front of you, as though you are ready to brace for a fall.
3. Have your feet pointing forward, about hip width apart. Slowly start to lean towards the wall, without moving your feet.
4. As you start to lose balance, take a step to prevent yourself from falling. Your body might do this naturally. If you think you might hit the wall, use your hands to brace yourself from hitting the wall.
5. What sensation did you notice in your feet or toes as you leaned forward?

Vestibular System:

1. Work with a partner and find an area that is free of obstacles.
2. Spin around in a circle, and have your partner spot you to make sure you do not bump into anything.
3. Stop spinning and count how long it takes for you to no longer feel dizzy. Do this up to five times. Record your observations in a data table.
4. Repeat this activity of spinning, but this time, put your ear to one shoulder while you are spinning.
5. When you stop spinning, lift your head upright and count how long it takes for you to no longer feel dizzy. Do this up to five times. Record your observations in the data table.
6. Is there a difference in your recovery time for dizziness?

EXTENSIONS/ADAPTATIONS:

Spotting while turning:

Dancers and skaters usually do not exhibit dizziness behaviour while spinning. This is because they use a technique called spotting. Spotting will stabilize the visual cues coming into the brain, and help mitigate the dizziness caused by the vestibular system.

1. While turning, find a spot to look at all the time. When you are too far around in your spin to keep looking at your spot, turn your head around quickly to look at the spot again. This might take some practice. You might need a turning board to help you spin more quickly.
2. If you are spinning too quickly to turn your head without difficulty, keep your eyes on a designated spot, as long as possible and horizontal, as much as possible. This should minimize the visual disruptions.
3. In either case, time how long it takes for you to stop being dizzy.
   Is this different from not using these techniques?

ZONE – EXIT
THE SCIENCE OF BUBBLES

EXHIBIT DESCRIPTION:

This activity relates to largest bubble bottle and wand artifact, visitors can watch footage to learn more about this artifact.

The Science of Bubbles

ACTIVITY DESCRIPTION:

Students will determine if ingredients like glycerin or corn syrup will help to make the biggest bubbles.

BACKGROUND INFORMATION:

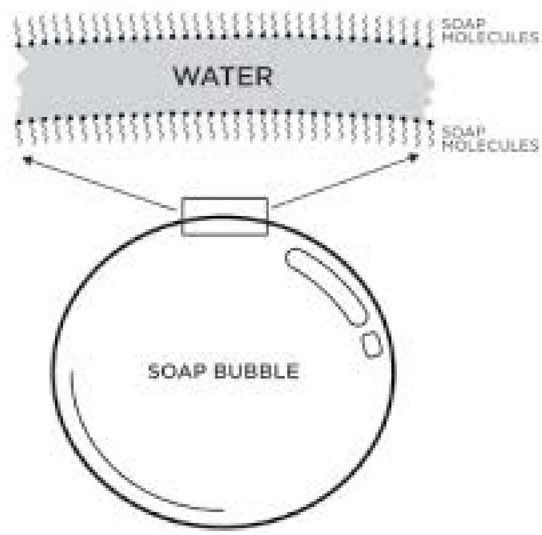
Water molecules are polar. This means that they have a positively-charged end and a negatively-charged end. Polar molecules have a strong attraction for each other. Water molecules do not want to move away from other water molecules and this leads to water having a high surface tension. The surface tension is too high for bubbles to form in water. Dish soap lowers the surface tension of water enough that bubbles can form. The soap will increase the distance between water molecules and reduce their ability to interact with each other. A bubble is a spherical layer of water molecules sandwiched between two layers of soap molecules.

ZONE – EXIT
THE SCIENCE OF BUBBLES

Bubbles pop when the water molecules between the soap layers evaporate. Ingredients like glycerin and corn syrup will slow down the evaporation process.

MATERIALS:

- 3 Wide-mouth containers
- 1 1-cup measuring cup
- 3 Measuring tablespoons
- 3 Cups of distilled water
- Liquid dish soap
- Glycerin
- Corn syrup
- 3 Bubble wands or 3 pipe cleaners
- Permanent marker
- Timer



PROCEDURE:

1. Label your containers “Dish Soap Only”, “Dish Soap and Glycerin” and “Dish Soap and Corn Syrup”
2. Fill each container with one cup of distilled water. Then, add 2 tablespoons of dish soap to each container.
3. To the “Dish Soap Only” add an additional tablespoon of distilled water. To the “Dish Soap and Glycerin” add one tablespoon of glycerin. To the “Dish Soap and Corn Syrup” add one tablespoon of corn syrup. Gently stir the ingredients until you have a homogenous liquid.
4. Practice blowing bubbles from the solutions and catching them on your wands. The bubbles should be the same size. Try to catch at least four bubbles from each solution and time how long the bubbles last. Have a partner time your bubble life span.
5. Calculate the average time of bubble life span for each solution.

EXTENSIONS/ADAPTATIONS:

Concentration of add-ins:

Does the concentration of glycerin or corn syrup affect the length of time a bubble will last? Try different concentrations of glycerin or corn syrup. Does a combination of glycerin and corn syrup make longer lasting bubbles?

Bigger bubbles:

How can you make big bubbles? Instead of timing the life span of the bubbles, measure how big the bubbles get. Start with the original solutions and measure the size of the bubbles. Test different concentrations of glycerin or corn syrup to see if this affects the size of the bubbles. What is the best combination of ingredients to make the biggest bubbles? Does the soap make a difference? Does leaving the solution for a period of time have an effect?

Shape of bubbles:

Does the shape of the bubble wand affect the shape of the bubbles? Does the shape of the wand affect how long a bubble will last?

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