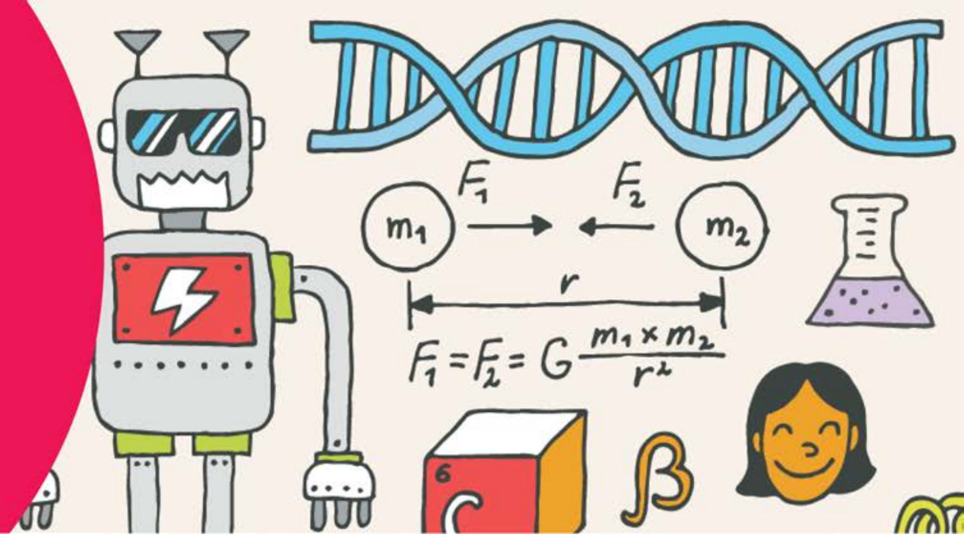
The Science of Sports



Ingenium

CANADA SCIENCE AND TECHNOLOGY MUSEUM

MUSÉE DES SCIENCES ET DE LA TECHNOLOGIE DU CANADA

Canada

Section 1: Introduction to the Digital Learning Kit

Whether it is in the schoolyard, during gym class, or on television, most elementary school students have had some experience playing and watching sports. Teaching science within the context of sports is a great way to take advantage of students' existing interest in the subject, and to find real-life applications of science theory.

The Science of Sports is a teacher resource package that enables students to explore science concepts and examine their application in sports. This digital learning kit presents concepts about the human body, forces, and energy in a way that is accessible and interactive — combining hands-on activities, outdoor play, and online discovery.

What this Learning Kit Can Do for You

While the learning kit's sections are thematic, they also encourage cross-thematic learning. There are activities within each section to suit the needs of students at a range of grade levels.

This learning kit enables you and your students to explore themes — such as human organ systems, forces, and energy — online, in the gymnasium, and outdoors. The included activities and worksheets will enrich your exploration of a number of excellent online resources, such as the Ingenium website. Blank worksheets and detailed examples can be reproduced without cost for use in your classroom. Activities are modular, and can be completed independently of the full resource package.

In addition to addressing scientific concepts, the learning kit's activities reinforce knowledge and skills in areas such as mathematics, and health and fitness. In addition to activity sheets, you will find suggestions for classroom discussions, class projects, and assignments for independent study. The learning kit also offers suggestions on how to incorporate 20 minutes of physical activity into science lesson plans.

CURRICULUM LINKS

This learning kit is cross-curricular. Activities included in the learning kit focus on human organ systems, forces, and energy. By completing the worksheets and activities in this learning kit, students will also exercise their numeracy skills, critical-thinking skills, and physical skills, fulfilling specific requirements of various curricular areas.

Pan-Canadian Protocol

The *Common Framework of Science Learning Outcomes*, developed by the Council of Ministers of Education, Canada, includes many elementary school links to the integrated themes of human organ systems, forces, and energy. Links to the Pan-Canadian Protocol are as follows:

Grades 4 to 6:	104-1,6,7,8; 205-1,3,4,5,7,9; 206-2,3,5; 207-1,2,3,4; 300-19; 302-4,5,6,9; 303-12,14,15,17,18,23
Grades 7 to 9:	307-12; 309-2,3

Ontario Curriculum

Grade 4	Health and Physical Education	Active Living Movement Competence Healthy Living
	Mathematics	Measurement Data Management and Probability
Grade 5	Science	Understanding Life Systems: Human Organ Systems Understanding Structures and Mechanisms: Forces Acting on Structures and Mechanisms Understanding Earth and Space Systems: Conservation of Energy and Resources
	Health and Physical Education	Active Living Movement Competence Healthy Living
	Mathematics	Measurement Data Management and Probability
Grade 6	Science	Understanding Matter and Energy: Electricity and Electrical Devices
	Health and Physical Education	Active Living Movement Competence Healthy Living
	Mathematics	Data Management and Probability
Grade 7	Science	Understanding Structures and Mechanisms: Form and Function
	Health and Physical Education	Active Living Movement Competence Healthy Living

Quebec Curriculum

Primary Cycle 2	Science and Technology	Material World B. Energy 1. Forms of energy 3. Transformation of energy C. Forces and motion 3. Gravitational attraction on an object 5. Characteristics of motion 6. Effects of a force on the direction of an object D. Systems and interactions 2. Simple machines E. Techniques and instrumentation Living Things A. Matter 1. Characteristics of living things 2. Organization of living things B. Energy 1. Sources of energy for living things
Primary Cycle 3	Science and Technology	Material World B. Energy 2. Transmission of energy C. Forces and motion 3. Gravitational attraction on an object 4. Pressure 7. Combined effects of several forces on an object E. Techniques and instrumentation Living Things A. Matter 1. Characteristics of living things
Primary Cycle 2	Mathematics	Statistics 4. Displays of data using tables and graphs
Primary Cycle 3	Mathematics	Arithmetic: Operations involving numbers A. Natural numbers 7. Develops processes for written computation 12. Performs a series of operations in accordance with the order of operations 15. Uses a calculator Measurements E. Capacities 2. Measures capacity using conventional units F. Masses 2. Measures mass using conventional units

		Statistics 5. Understands and calculates arithmetic mean
Primary Cycles 2 and 3	Physical Education and Health	Competency 1: Performing movement skills in different physical settings Competency 3: Adopting a healthy, active lifestyle
Secondary Cycle 1	Physical Education and Health	Competency 1: Performing movement skills in different physical settings Competency 3: Adopting a healthy, active lifestyle

USEFUL WEB RESOURCES FROM INGENIUM

Canada Science and Technology Museum
https://www.ingeniumcanada.org/educational-programs

Physics of Energy
https://ingeniumcanada.org/education/tell-me-about/physics-of-energy

For general information about energy, visit:
Let's Talk Energy – Engaging Ideas for Canada's Future
https://energy.techno-science.ca/

Canada Science and Technology Museum YouTube Video: Crazy Kitchen
http://www.youtube.com/watch?v=aAkw8p5oszI&blend=1&lr=1&ob=5

Section 2: The Human Body

INTRODUCTION

The field of physiology, which includes the study of the mechanisms and requirements of organ systems, has changed the world of sports. Specially formulated supplements and sports drinks were originally created for high-performance athletes; however, many of them have now become available to everyone.

This section explores the respiratory, circulatory, and musculoskeletal systems, as well as why sweat is important in regulating body temperature. The information presented to students will not only give them more insight into how physical activities affect the human body, but will also help them to make informed decisions about consumer products and performance-enhancing substances in the future.

This section includes the following components:

- 2.1. The Respiratory System
- 2.2. The Circulatory System
- 2.3. The Musculoskeletal System
- 2.4. Sweat and Why It's Important

Worksheets for all activities are included at the end of this section. They can also be found by clicking on the image to the right of the activity description.

ACTIVITY 2.1: THE RESPIRATORY SYSTEM

(Suitable for Grades 4 to 6)

In order to stay alive, all animals — humans included — need to breathe oxygen. The respiratory system is responsible for getting oxygen into the body. Once inside, this gas will eventually migrate into the bloodstream, which will transfer it to muscles and organs. Oxygen is necessary for life, because it reacts with the sugars and fats in the foods we eat, producing energy that our bodies can use.

Concepts

Respiration starts with the contraction of a muscle called the diaphragm. This contraction causes the chest cavity (the space inside the ribcage) to expand, allowing air to rush in (for more information on this, please see Part 2: Build a Breathing Simulator).

Air enters our bodies through the mouth and nose, which are both connected to the trachea by the larynx. Small particles in the air are filtered out — trapped in small hairs or mucus along the way.

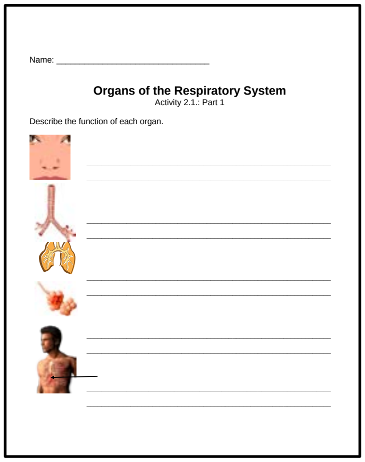
The trachea separates into two bronchi, each directing air to a lung. Inside the lungs, the bronchi divide into many smaller tubes, through which the air will have to pass.

Finally, air reaches the alveoli, which are tiny air sacs. These sacs are lined with small blood vessels called capillaries. It is at this stage that the oxygen passes from the alveoli into the bloodstream. Blood vessels then carry the oxygen-rich blood to the heart, where it is pumped throughout the body.

Part 1: Organs of the Respiratory System

Objective: To identify and explore the major organs of the respiratory system.

Give each student a copy of the activity sheet. Students will describe the function of each organ by referring to textbooks or the Internet.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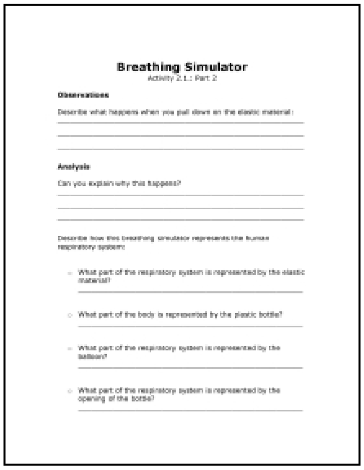
Organs of the Respiratory System

Activity 2.1.: Part 1

Describe the function of each organ.

Part 2: Build a Breathing Simulator


Breathing Simulator
Activity 2.1.: Part 2

Observations

Describe what happens when you pull down on the elastic material:

Analysis

Can you explain why this happens?

Describe how this breathing simulator represents the human respiratory system:

- What part of the respiratory system is represented by the elastic material?
- What part of the body is represented by the plastic bottle?
- What part of the respiratory system is represented by the balloon?
- What part of the respiratory system is represented by the opening of the bottle?

Objectives: A) To understand how oxygen enters the body. B) To understand that air is matter, and will occupy a given volume.

To make a breathing simulator, students will need to follow the instructions listed in the activity sheet. Each student or group of students will need:

- A 1 L or 2 L empty pop or water bottle (stronger plastics work better)
- A balloon
- Water-resistant tape
- A large piece of elastic material (such as a large balloon that has been cut open, or an elastic exercise band)

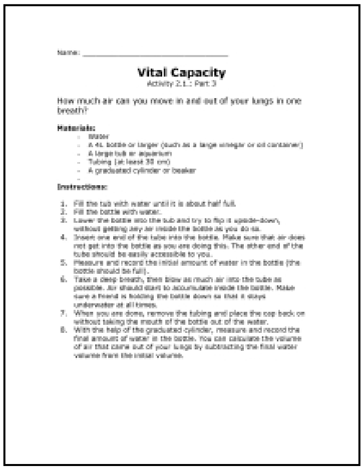
Students can be encouraged to bring in pop or water bottles from home to recycle for this activity.

As they are constructing their breathing simulator, students should note their observations on the activity sheet. After the activity, ask students to share and explain their observations.

Explanation: The elastic material, placed at the bottom end of the bottle, acts as a diaphragm: when it is stretched, it expands the chest cavity (the space inside the bottle). This creates an area of low air pressure (there are fewer air molecules by unit of volume inside the bottle). The air pressure on the outside of the bottle is now higher than that on the inside.

Air from the outside will therefore try to enter the bottle in order to equalize the pressure, inflating the balloon which has been placed over the bottle's spout. The end result should be equal air pressure inside and outside of the bottle.

Part 3: Measuring Vital Capacity



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Vital Capacity

Activity 2.1.: Part 3

How much air can you move in and out of your lungs in one breath?

Materials:

- Water
- A 4L bottle or larger (such as a large vinegar or oil container)
- A large tub or aquarium
- Tubing (at least 30 cm)
- A graduated cylinder or beaker

Instructions:

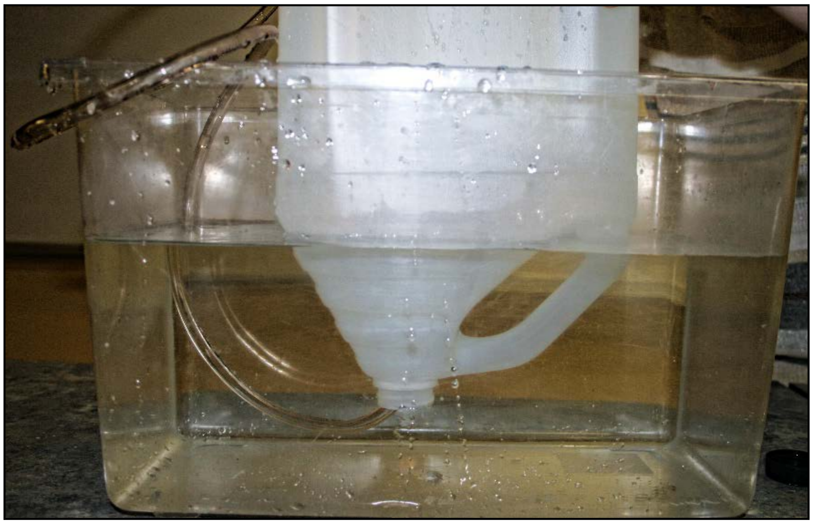
1. Fill the tub with water until it is about half full.
2. Fill the bottle with water.
3. Lower the bottle into the tub and try to flip it upside-down, without getting any air inside the bottle as you do so.
4. Insert one end of the tube into the bottle. Make sure that air does not get into the bottle as you are doing this. The other end of the tube should be easily accessible to you.
5. Measure and record the initial amount of water in the bottle (the bottle should be full).
6. Take a deep breath, then blow as much air into the tube as possible. Air should start to accumulate inside the bottle. Make sure a friend is holding the bottle down so that it stays underwater at all times.
7. When you are done, remove the tubing and place the cap back on without taking the mouth of the bottle out of the water.
8. With the help of the graduated cylinder, measure and record the final amount of water in the bottle. You can calculate the volume of air that came out of your lungs by subtracting the final water volume from the initial volume.

Objectives: A) To understand that there is a limited amount of air that can be moved in and out of the lungs. B) To understand that air is matter, and will take up space inside the ribcage.

In general terms, vital capacity refers to the amount of air a person can move in to and out of the lungs with each breath. Vital capacity is dependent on the volume (or size) of the lungs.

1. Using the directions on the activity sheet, have each student measure their own vital capacity. For this activity, each student or group of students will need:
    - Water
    - An empty 4 L bottle or larger (such as a large vinegar or oil container)
    - A large tub or aquarium
    - Tubing (at least 30 cm)
    - A graduated cylinder or beaker

2. Ask students to record their observations.



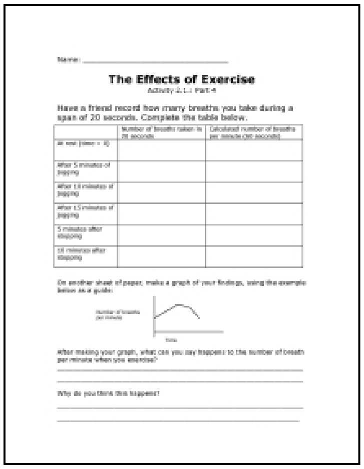
Note on Vital Capacity: Vital Capacity (VC) is the volume of air a person can move in to and out of the lungs by first inhaling the largest possible volume of air, then exhaling the largest possible volume of air. There is always a certain amount of air left in the lungs called Residual Volume (RV). Total lung capacity is equal to the VC plus the RV. Since it is not possible to determine the Residual Volume in this activity, the total lung capacity is not addressed here.

Interesting fact: People born at higher altitudes will have a naturally higher lung capacity (and bigger lungs) than those living at lower altitudes. This is because there is less oxygen at high altitude, and the body must breathe in more air in order to absorb enough oxygen to function.

Part 4: Effects of Exercise

Objective: To observe that a person's breathing rate is not constant; it will adjust to the amount of oxygen needed by the body.

1. In pairs, have students record the number of breaths per minute at rest, every five minutes as they are jogging, and every five minutes after they have stopped exercising.
2. Ask them to record their findings on the activity sheet.
3. With the data they have collected, students will be able to graph the number of breaths per minute over time.


Name: ______________________

The Effects of Exercise

Have a friend record how many breaths you take during a span of 20 seconds. Complete the table below.

	Number of breaths taken in 20 seconds	Calculated number of breaths per minute (60 seconds)
At rest		
After 5 minutes of jogging		
After 10 minutes of jogging		
After 15 minutes of jogging		
5 minutes after stopping		
10 minutes after stopping		

On another sheet of paper, make a graph of your findings, using the example below as a guide:

After making your graph, what can you say happens to the number of breaths per minute when you exercise?

Why do you think this happens?

ACTIVITY 2.2: THE CIRCULATORY SYSTEM

(Suitable for Grades 4 to 6)

The circulatory system includes the heart, arteries, veins, and blood. It is responsible for providing muscles and vital organs with oxygen and nutrients. The circulatory system is closely monitored in high-performance athletes. Heart rate is used, for example, to determine how hard an athlete has been working.

Blood is made up of several different components: plasma (mostly water and nutrients), white blood cells (which are a part of our immune system), and red blood cells. Red blood cells contain a pigment called hemoglobin, which is responsible for getting oxygen from the lungs to the muscles and organs. Some athletes cheat by injecting red blood cells into their bodies in order to increase the amount of oxygen that reaches their muscles. This can improve their performance and endurance, but can also result in higher blood viscosity, leading to heart conditions or clotting. This practice is commonly called "blood doping" and is both illegal and dangerous.

Some athletes will try to boost their red blood-cell count naturally by training at high altitude. In these areas, the concentration of oxygen in the air is decreased, which results in lower amounts of oxygen in the circulatory system. This stimulates the body to produce more red blood cells. When the athlete returns to a lower altitude, they will have a higher count of red blood cells than if they had trained with the same intensity and regularity at the lower altitude.

Concepts

In the lungs, blood will acquire oxygen and release carbon dioxide. The blood is then brought back to the heart, where it will be pumped out to the rest of the body. The blood vessels that carry oxygenated blood are called arteries. The arteries branch off into smaller vessels to transport blood to all parts of the body. The smallest blood vessels are called capillaries; these surround muscles and organs, and are the means by which oxygen leaves the blood and enters other tissues. At the same time, carbon dioxide from the tissues enters the bloodstream and is carried back to the heart by veins.

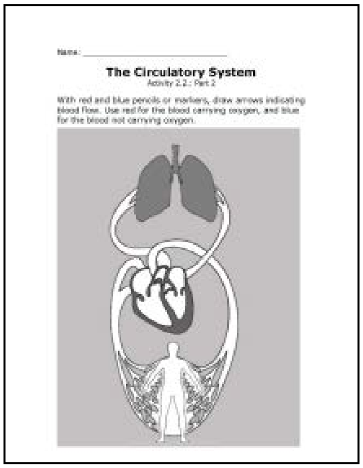
Part 1: What is Blood?

Objective: To discover that blood is not just a liquid, but a suspension of cells and nutrients.

Classroom Demonstration: Blood is made of several components, such as plasma (mostly water and nutrients), red blood cells (responsible for bringing oxygen to cells and eliminating carbon dioxide), and white blood cells (a system of defence that fights infections as part of our immune system). To demonstrate that blood is not just a liquid but really a suspension of various cells, you can create an analogous mixture as a class demonstration.

To do this, take a 1 L clear container and add 550 mL of water (you can add a sprinkle of salt and sugar, as these are also present in the plasma). Next, add 440 mL of sand (each grain represents a red blood cell), and finally 10 mL of small white beads (as small as possible) to represent white blood cells. Close the lid of the bottle or container and shake. Voila: blood!

Part 2: Organs of the Circulatory System


The Circulatory System
Activity 2.2.: Part 2

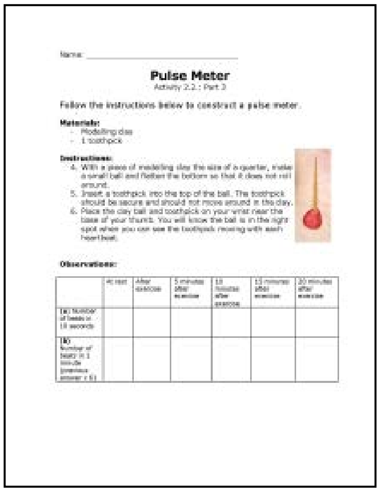
Objective: To identify and explore the major components of the circulatory system.

1. Give each student a copy of the activity sheet. Ask them to trace the flow of blood through the heart, arteries, and veins.

2. Students should understand that the heart pumps blood to both the lungs and the body. The blood returning from the body through the veins contains very little oxygen. The heart pumps this blood to the lungs, where oxygen is added. The oxygenated blood then returns to the heart, where it is pumped to the rest of the body.

3. There are many animations on the Internet illustrating blood flow.

Part 3: Making a Pulse Meter


Pulse Meter
Activity 2.2.: Part 3
Follow the instructions below to construct a pulse meter.
Materials:
Instructions:
Observations:

Objective: To calculate heart rate.

Athletes will frequently monitor their heart rates to determine how hard they have been exercising. As it is sometimes difficult to find a pulse, students can construct a device that will make the task easier. Each student will need:

- Modelling clay (about the size of a quarter)
- A toothpick

1. Students should follow the instructions on the activity sheet to construct their pulse meter.

2. Ask each student to calculate their heart rate per minute. Students should be able to count the number of beats for 10 seconds, and then calculate their heart rates in beats per minute.

3. Athletes often measure their recovery time — the time it takes for the heart rate to return to its normal resting rate. Have students do a vigorous activity for 20 minutes (e.g., an obstacle course, climbing the school stairs as fast as they can, etc.). Afterwards, get each student to measure their heart rate. Repeat at five-minute intervals. Students should record this data on their activity sheets.

Long-Term Assignment

Throughout the school year, for instance every two weeks, have students measure their heart rate recovery times. As students are required to do some physical activity each day, they may be able to lower their recovery times by the end of the school year.

ACTIVITY 2.3: THE MUSCULOSKELETAL SYSTEM

(Suitable for Grades 4 to 6)

The musculoskeletal system includes muscles, bones, ligaments, and tendons. All of these work together to allow the human body to move. In this section, students will learn about muscle contraction and reflexes. They will also explore how muscles and bones work together to function as simple machines.

Concepts

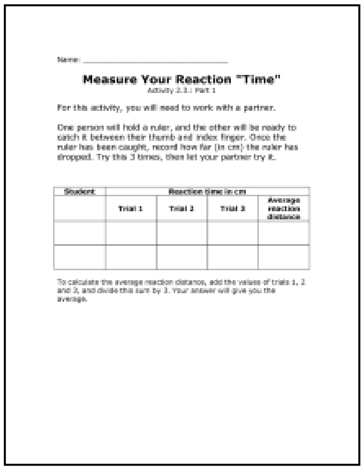
The underlying structure of the human body is made of bones. Bones give us our form, allow certain movements, and protect our internal organs. Muscles attach to the bones, allowing the bones to move as the muscles expand and contract.

The human skeleton, as it is located inside the body, is called an endoskeleton. This is different from an exoskeleton, which is located outside the body as in many insects. Bones are composed of cells and calcium. Just like muscles, bones are living tissues that require oxygen and nutrients. Bones are constantly being broken down and rebuilt. Just as our muscles get larger with more exercise, our bones can be modified to respond to physiological needs (although this process is much slower).

Ligaments are tissues that link one bone to another. Tendons, on the other hand, attach muscles to the skeleton. Ligaments and tendons work with bones and muscles, to allow movement of the body.

Classroom Discussion: Ask your students if they know which bones (or group of bones) act as support in our bodies (for example: the spine), which bones act as protection (for example: the ribcage), and where in our bodies bones allow for movement (the joints). Write down the students' answers on the board. You can use a picture or poster of the human skeleton to help students during this discussion.

Part 1: Reaction Time


Name: ______________________

Measure Your Reaction "Time"

Activity 2.3.: Part 1

For this activity, you will need to work with a partner.

One person will hold a ruler, and the other will be ready to catch it between their thumb and index finger. Once the ruler has been caught, record how far (in cm) the ruler has dropped. Try this 3 times, then let your partner try it.

Student	Reaction time in cm			
	Trial 1	Trial 2	Trial 3	Average reaction distance

To calculate the average reaction distance, add the values of trials 1, 2 and 3, and divide this sum by 3. Your answer will give you the average.

Objective: To learn about how our muscles are stimulated, and the importance of reaction time in sports.

The contractions and expansions of muscles are controlled by the nervous system. If you wanted to lift an apple, for example, your brain would send a message to the nerves in your arm, which would signal the muscles to expand and contract until the apple was securely in your hand.

Sometimes, the message to activate your muscles does not need to come from the brain. This is called a reflex. In the case of a reflex, the message will come from nerves in your spinal cord. The reaction time will be much shorter, as the message does not need to travel as far.

There are many ways to test the time it takes for the brain to process a stimulus (something seen or felt), before sending a message to the muscles to expand or contract:

1. In a big field, have students arrange themselves in one line. Make sure everyone can hear you. Tell them that when you say “green light” they should run forward, and if you say “red light” they should stop in their tracks. Students will discover how long it takes them to stop after they hear “red light.” You can also try saying “red light” twice to see how many students start running, as they will be expecting to hear “green light.”
2. The game of baseball is also a great way to have students test their reaction times, as well as the coordination between their eyes, brain, and muscles.
3. One way to test reaction time is to have one student catch a ruler that another student drops into their hand, and measure in centimetres how far the ruler dropped. This distance is representative of the reaction time. The longer the distance, the slower the reaction time. Have each student measure this distance, and record the data in a table. For students who have a fast reaction time, you can ask them if they participate in any sports that would require this skill — perhaps are a hockey goalie or a handball player.

Part 2: Muscles and Bones as Levers

Objectives:

a) To explore the different classes of levers.

b) To understand that some of our bones and muscles can work together as levers.

Muscles and bones work together to keep the body upright, to lift the weight of each limb and, when needed, to lift, push, or pull other objects. Some of our muscles and bones form simple machines called levers. A simple machine is a device that helps us perform work (to move an object for a certain distance) with less force.

A lever consists of a straight rod and a pivot point, called the fulcrum. When one part of the lever is acted upon by a force (i.e., a push or a pull), the other part can move a weight (an object). There are three different classes of levers, each with varying positions for the force, the weight, and the fulcrum.

1. Make a Class 1 lever, with an eraser as the fulcrum and a ruler as the rod. Use this lever to lift something like another eraser. You can have all students do this with you at the same time. Discuss with students where the weight was placed, where the force was applied, and where the fulcrum was placed.
2. With the same materials, make a Class 2 lever and a Class 3 lever.

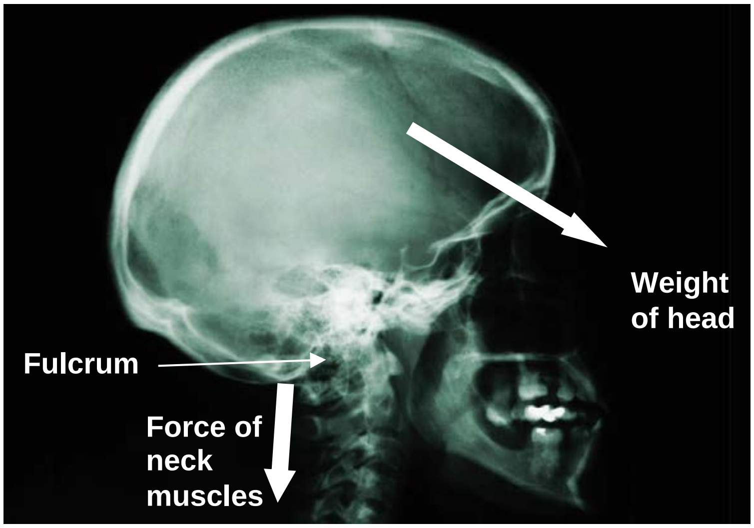
Classroom Discussion: Ask students what we use levers for, and if they have ever used one in everyday life. They may mention teeter-totters, wheelbarrows, catapults, or various toys. However, all humans (and animals) use levers every day, as their bodies are full of them. Ask them if they can think of examples in the body.

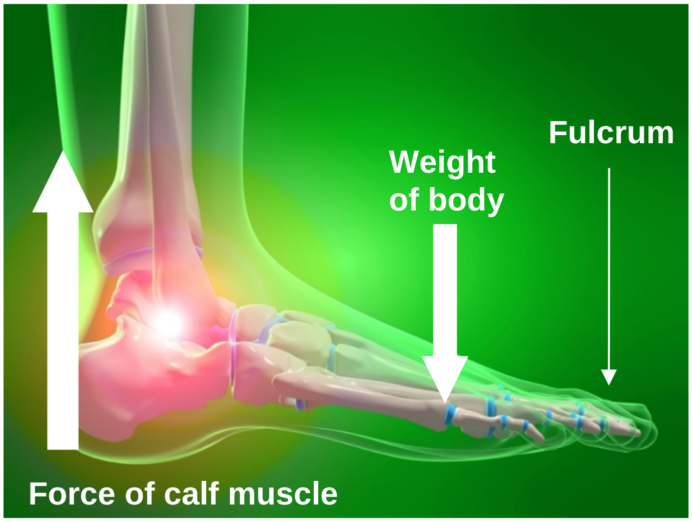
Most levers in the human body are Class 3 levers. Class 3 levers are not as good at lifting large weights, but they are useful in another capacity: increasing speed at the extremity of the lever, which allows for faster movements.

Deeper Study: Levers in the Human Body

Class 1 Lever

Ask students if they can find a Class 1 lever in their bodies. In a Class 1 lever, force is applied on one side of the fulcrum, while the weight is on the other side, just as in a teeter-totter. After allowing students time to explore, tell them that a great example is the neck. The fulcrum is the joint connecting your head to your neck, the weight is your head, and the force is applied by the muscles in your neck.



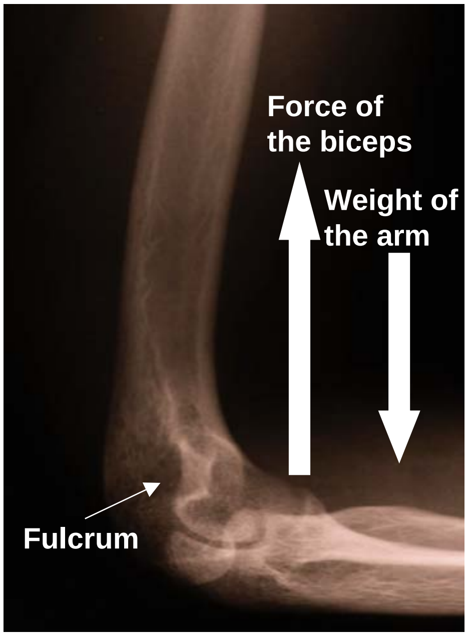


Class 2 Lever

Ask students if they can find a Class 2 lever in their bodies. In a Class 2 lever, the weight is placed between the force and the fulcrum, just like in a wheelbarrow. After allowing the students time to explore, ask everyone to get on their tippy-toes. Ask them where in their feet they think the fulcrum is. The answer should be “the toes.” Ask them what they think the weight is; the answer should be “the weight of the entire body.” You can ask them where they feel the pressure of their weight. The answer should be “very close to the fulcrum” (i.e., their toes). Ask them where the effort is coming from — in other words, which muscles do they feel contracting. The answer should be “the calf muscles.”

Class 3 Lever

Ask students if they can find a Class 3 lever in their bodies. In a Class 3 lever, the effort is exerted between the fulcrum and the weight. Have students explore this principle on their own for a bit. If you want to give them a hint, ask them to lift something heavy in one of their hands. Have them observe where the weight is, where the fulcrum is, and what muscles are doing the work. They should find the fulcrum at the elbow joint; the weight is the weight of their arm, plus whatever they are holding in their hand. The effort is made by the bicep. If they have observed closely, they will notice that this muscle is attached in front of the elbow joint — meaning between the weight and the fulcrum — making this system a Class 3 lever.



Part 3: Levers in Sports

Objective: To demonstrate that levers are integral parts of our daily activities.

Sports often incorporate equipment that acts like a lever, such as a hockey stick. In the school gym, ask each student to shoot a puck towards a net. Ask them what the rod of the lever is, where the fulcrum is, and where the effort is made. Have students play ball hockey *without* sticks; in other words, using only their hands. Afterwards, discuss the advantages and disadvantages of a longer lever.

If your gym is equipped with flat, square trolleys, you can also try the following activity. Ask each student to sit on a trolley, lined up facing the wall with at least two metres between each other. The goal is for students to roll across the gym, propelling themselves by using their hands as oars. Explain that they are using their arms as levers.

Name: __________

Levers in Sports

Activity 2.3 : Part 3

For a sport of your choosing, answer the questions below.

Sport: __________

Describe at least one way in which a player uses a lever:

Is this lever part of the player's body?

Describe where the fulcrum, the rod, the force and the weight are in relation to one another:

Make a diagram, including all the things mentioned in the last question:

How does this lever increase the ability of the player to perform?

What would happen if the player could no longer use the lever? Would they still be able to play?

Research Assignment: Ask students to choose a sport that makes use of levers or other simple machines. Have them complete the activity sheet and present their findings to the class.

ACTIVITY 2.4: SWEAT AND WHY IT'S IMPORTANT

(Suitable for Grades 4 to 7)

Glands are organs that secrete substances either into the bloodstream (these are called endocrine glands), or into body cavities and onto the surface of the body (these are called exocrine glands). Endocrine glands can secrete chemicals called hormones, which travel through the bloodstream and alter the function or metabolism of the cells that receive them. On the other hand, sweat glands are exocrine glands, as they secrete a mixture of water and salts onto the surface of the skin.

In this section, students will learn about the importance and composition of sweat, and will take a critical look at sports drinks.

Classroom Discussion: Engage all students in strenuous physical activity for at least 20 minutes. Afterwards, in a group discussion, have students describe all the changes that their bodies underwent during the activity (for example: rapid breathing, faster pulse, redness in the face, perspiration, fatigue, etc.).

Hopefully, some students will have noticed that they perspire during heavy physical activity. Ask students why they think this happens, and note all of their hypotheses on the board for everyone to see. You can discuss how the students would go about testing these hypotheses.

After this brainstorming session, you can tell students that sweat is used to cool down the body when it is exerting itself. There are glands underneath the skin that secrete this liquid. Ask the students if they can think of why a liquid on the surface of the skin would help to cool it down.

Classroom Demonstration: To demonstrate the answer, take two medium balloons: one filled with air, and the other filled with water. Using a Bunsen burner or a barbecue lighter, direct the flame close to the bottom of the air balloon. Ask students what they think will happen. The balloon should pop, because the flame will melt the rubber.

Do the same with the water-filled balloon and ask students what they think will happen this time. The balloon should not pop. The balloon stays intact because the heat from the flame gets absorbed by the water. The water molecules 'use' the heat from the flame to change from a liquid state into a gaseous state. The same thing happens to our bodies when we sweat. The sweat on our skin will use the heat from our bodies to help it evaporate, thus leaving our bodies cooler.

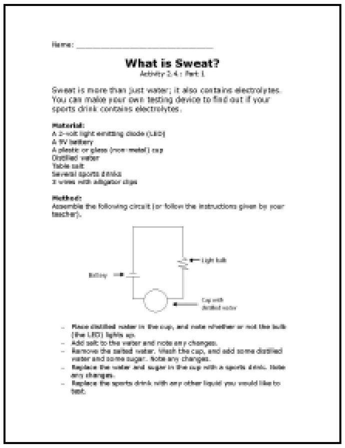
Part 1: What is Sweat?

Objective: To explore the properties of electrolytes.

Ask students what they think sweat is made of. If they have ever tasted a drop of their own sweat, they know that it is slightly salty. Sweat contains many substances, including salts that form electrolytes in water. Sports drinks often contain salts to replenish the body's supply, although the amount of salt that is lost through exercise can be easily replenished through a normal diet.

Electrolytes help maintain the balance of fluids inside and outside cells. Without their presence, it would be difficult to get water into the cells, even if you drank a lot of it.

Students can explore the conductive properties of electrolytes by following the instructions on the activity sheet. For this activity, each team of students will need:


Name: ____________

What is Sweat?
Activity 2.4 : Part 1

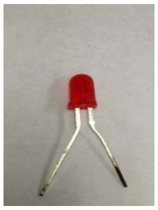
Sweat is more than just water; it also contains electrolytes. You can make your own testing device to find out if your sports drink contains electrolytes.

Material:
A 2-volt light emitting diode (LED)
A 9V battery
A plastic or glass (non-metal) cup
Distilled water
Table salt
Several sports drinks
3 wires with alligator clips

Method:
Assemble the following circuit (or follow the instructions given by your teacher).

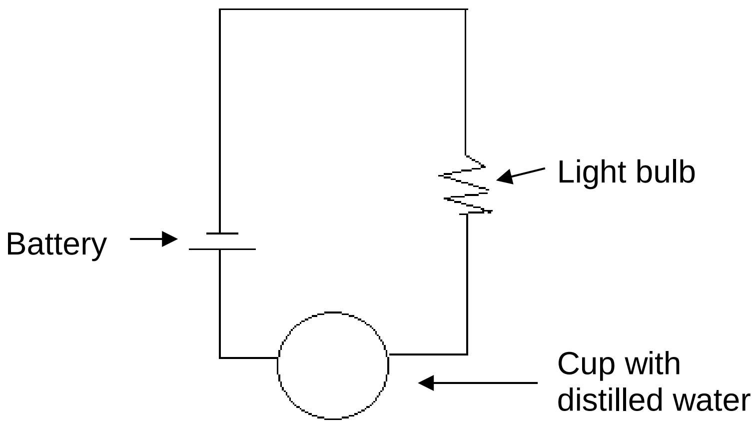
- Place distilled water in the cup, and note whether or not the bulb (the LED) lights up.
- Add salt to the water and note any changes.
- Remove the salted water. Wash the cup, and add some distilled water and some sugar. Note any changes.
- Replace the water and sugar in the cup with a sports drink. Note any changes.
- Replace the sports drink with any other liquid you would like to test.

- A 9V battery
- A plastic or glass (non-metal) cup
- Distilled water
- Table salt
- Several sports drinks
- A 2-volt light emitting diode (LED) or small light bulb
- Three wires with alligator clips



(Available in most electronics stores)

Students will have to build the following circuit. Ensure that the two wires inside the cup are not touching.



Concepts

Electrolytes are atoms that carry an electrical charge — either positive or negative. Electrolytes will make a substance, such as water, electrically conductive. Electrolytes are present in our blood and other bodily fluids, such as sweat and tears. They help regulate the amount of water inside and outside our cells, as well as fulfilling many other functions.

For instance, table salt (NaCl) separates into two different types of electrolytes in water: Na^+ and Cl^-. These two electrolytes are found in the body, and are important to ensure that the water we drink makes its way into the cells that need it.

When we sweat, the salt in our body gets depleted. This is why many sports drinks include salt.

Part 2: Sports Drinks

Name:

Making Your Own Sports Drink

Activity 2.4.: Part 2

Follow the instructions below to make your own sports drink.

3. Name your sports drink and draw a logo.

4. Base:

1L of water
1/3 cup (80 ml) of sugar
¼ tablespoon (4 ml) of salt
3. Flavours and colours:

This is the time to get creative! You can use many things to flavour and colour your drink, but make sure you are not adding too much sugar or salt.
For example, you could add:
- Vanilla, orange, banana or any other type of extract.
- Unsweetened water flavouring (the type that comes in powdered form)
- Small amounts of food colouring

4. Sell your product:

Give a brief presentation to your class. Tell them what makes your sports drink unique and better than all the others.

5. Taste test:

Taste your own sports drink, and taste the sports drinks made by your classmates, to determine which one is best. Make sure you ask your teacher's permission first.

Objective: To understand the components of sports drinks, and to think critically about how they are marketed.

Sports drinks are typically made with three main ingredients. Firstly, they contain water to rehydrate the body after excessive perspiration. Secondly, they contain sugar for taste and energy, and to accelerate the rate at which water is absorbed by the body. Thirdly, they contain salt to replenish electrolytes.

Students can follow the instructions on the activity sheet to create their own sports drink. For this, each student or team of students will need:

- 1 L of water
- 45 ml (3 tablespoons) of sugar
- 4 ml (1/4 tablespoon) of salt

In addition, students can choose flavours and colours for their drinks. They can use many things to flavour and colour their drink, but make sure that they do not add too much sugar or salt. For example, they could add:

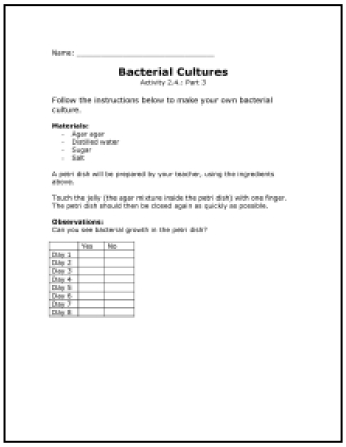
- vanilla, orange, banana or any other type of extract
- unsweetened water flavouring
- small amounts of food colouring

Afterwards, ask students to think of creative ways to advertise their products such as:

- creating a poster
- recording a radio ad
- creating a short TV commercial
- creating a social media campaign

Discussion point: There is an increasing body of evidence indicating that sports drinks are not necessary for the average athlete to replenish their electrolytes. Ask your students what they think are the merits of energy drinks. What are the advantages or disadvantages? This subject could be held as a debate, or students could research the subject in small groups to discuss.

Part 3: Why Does Hockey Gear Stink?



Name:

Bacterial Cultures

Activity 2.4.: Part 3

Follow the instructions below to make your own bacterial culture.

Materials:
- Agar agar
- Distilled water
- Sugar
- Salt

A petri dish will be prepared by your teacher, using the ingredients above.

Touch the jelly (the agar mixture inside the petri dish) with one finger. The petri dish should then be closed again as quickly as possible.

Observations:
Can you see bacterial growth in the petri dish?

	Yes	No
Day 1		
Day 2		
Day 3		
Day 4		
Day 5		
Day 6		
Day 7		
Day 8		

Objective: To illustrate that bacteria live on our skin. It is these bacteria, accumulating in hockey gear, that cause an unpleasant odour.

Ask students if they have ever noticed that hockey equipment (or any other sports equipment) develops a strong odour after several uses.

Sweat itself does not stink; it is the bacteria living on the skin's surface, or on pieces of sports equipment, that causes an unpleasant odour. By following the instructions on the activity sheet, students will be able to see the colonies of bacteria that live on their skin.

For this activity, each student or team of students will need:

- A new (sterile) Petri dish prepared with:
- Agar-agar (a powder found in health food stores or from science suppliers)
- Water
- Sugar
- Salt

(For best results, replace with salt and sugar with LB broth or another ‘bacteria food’ available at a low price from science suppliers)

You will need to prepare the Petri dishes in advance. To prepare the Petri dish:

- Follow the directions on the agar-agar package and dilute it in boiling water.
- Add sugar and salt while the mixture is still boiling.
- Pour the agar mixture into a Petri dish or small bowl. Cover and refrigerate until jelly-like.

After students inoculate the Petri dish, it can take a few days for the colonies of bacteria to become visible.

Extension Activity (Grade 7): Some glands, called endocrine glands, release substances such as hormones into the bloodstream. Hormones are natural chemicals found in the body. They induce changes in the metabolism of specific parts of the body. For example, adrenaline is a hormone that can increase heart rate, constrict blood vessels, etc. Some athletes will illegally supplement their bodies with certain hormones in order to boost their performance. There are many risks attached to this type of activity. Students can research a few common hormones that are used as performance enhancers.

Some common examples include:

- Human growth hormone (HGH)
- Anabolic steroids
- Erythropoietin or Hematopoietin (EPO)

Other lesser-known performance-enhancing hormones include:

- Human Chorionic Gonadotrophin (HCG)
- Adrenocorticotropic hormone (ACTH)
- Tetrahydrogestrinone (THG)
- Glucocorticosteroids

Students should describe what these hormones are, what they normally do in the body, why they are used as performance enhancers (benefits), as well as the risks related to using them.

Name: ________________________________

Organs of the Respiratory System

Activity 2.1: Part 1

Describe the function of each organ.

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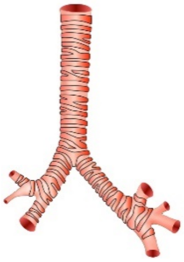

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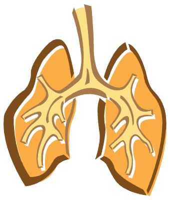

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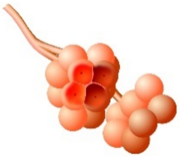

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Name: ________________________________

Breathing Simulator

Activity 2.1: Part 2

Observations

Describe what happens when you pull down on the elastic material.

___

___

___

Analysis

Can you explain why this happens?

___

___

___

Describe how this breathing simulator represents the human respiratory system.

- What part of the respiratory system does the elastic material represent?
  ___
- What part of the body does the plastic bottle represent?
  ___
- What part of the respiratory system does the balloon represent?
  ___
- What part of the respiratory system does the opening of the bottle represent?
  ___

Name: ________________________________

Vital Capacity

Activity 2.1: Part 3

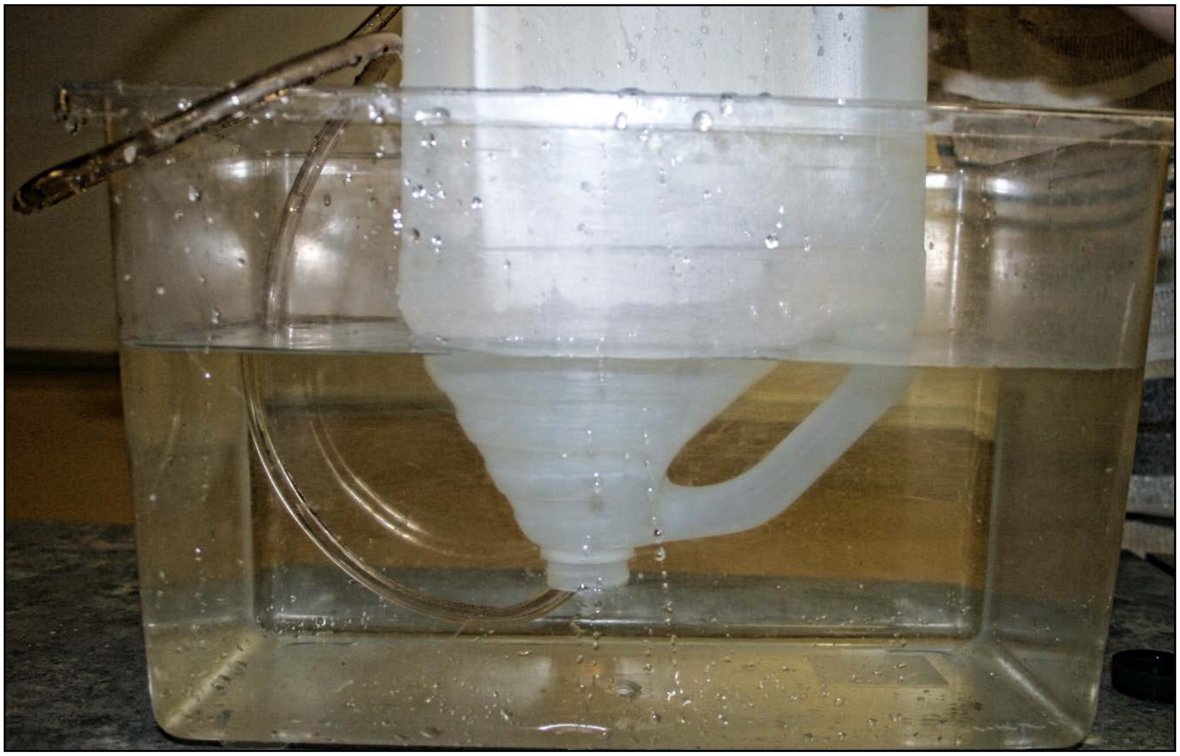
How much air can you move in and out of your lungs in one breath?

Materials:

- Water
- An empty bottle with a volume of at least 4 L (such as a large vinegar or oil container)
- A large tub or aquarium
- Tubing (at least 30 cm)
- A graduated cylinder or beaker

Instructions:

1. Fill the tub with water until it is about half full.
2. Fill the bottle with water.
3. Lower the bottle into the tub and flip it upside-down, without getting any air inside the bottle.
4. Insert one end of the tube into the bottle, making sure that no air gets into the bottle. The other end of the tube should be easily accessible to you.
5. Measure and record the initial amount of water in the bottle (the bottle should be full).
6. Take a deep breath, and then blow as much air into the tube as possible. Air should start to accumulate inside the bottle. Make sure that a friend is holding the bottle down so that it stays underwater at all times.
7. When you are done, remove the tubing and place the cap back on the bottle without taking its mouth out of the water.
8. With the help of the graduated cylinder, measure and record the final amount of water in the bottle. You can calculate the volume of air that came out of your lungs by subtracting the final water volume from the initial volume.



Observations:

Name	Initial water volume (mL)	Final water volume (mL)	Air volume/ lung capacity (mL)

Name: ________________________________

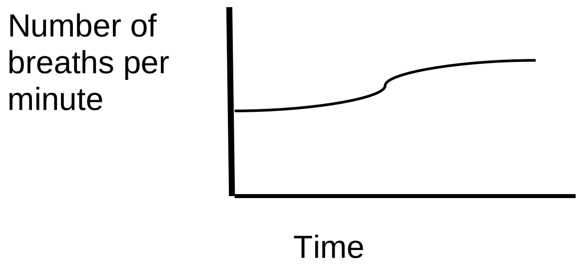
The Effects of Exercise

Activity 2.1: Part 4

Have a friend record how many breaths you take during a span of 20 seconds. Complete the table below.

	Number of breaths taken in 20 seconds	Calculated number of breaths per minute (60 seconds)
At rest (time = 0)		
After 5 minutes of jogging		
After 10 minutes of jogging		
After 15 minutes of jogging		
5 minutes after stopping		
10 minutes after stopping		

On another sheet of paper, draw a graph to present your findings using the example below as a guide:



According to your graph, what happens to the number of breaths per minute when you exercise?

____

____

Why do you think this happens?

____

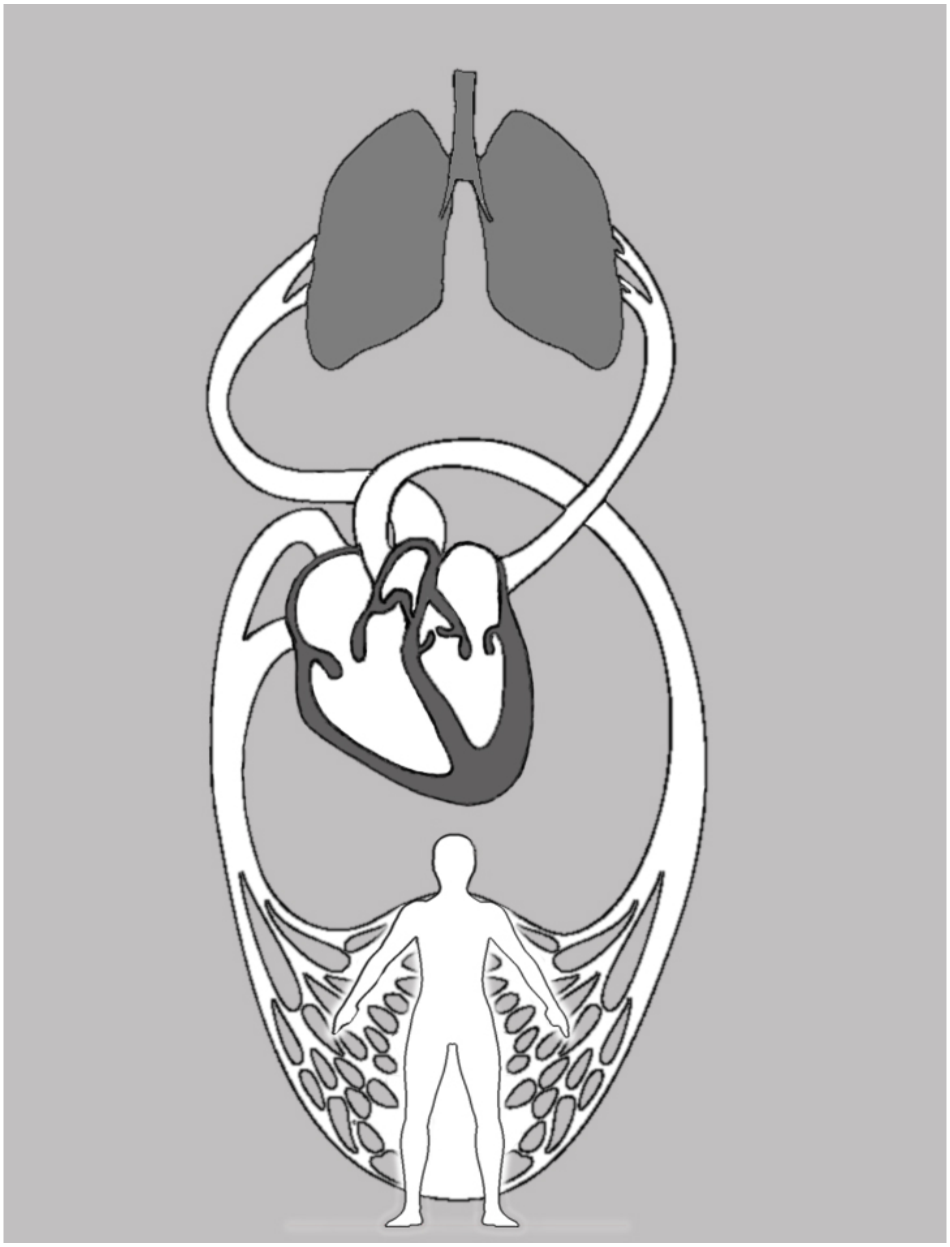
____

Name: ________________________________

The Circulatory System

Activity 2.2: Part 2

Using red and blue pencils or markers, draw arrows indicating the flow of blood. Use red for the blood carrying oxygen, and blue for the blood not carrying oxygen.



Name: ________________________________

Pulse Meter

Activity 2.2: Part 3

Follow the instructions below to construct a pulse meter.

Materials:

- Modelling clay
- Toothpick

Instructions:

1. Use a piece of modelling clay the size of a quarter to form a small ball; flatten the bottom so that it does not roll around.
2. Insert a toothpick into the top of the ball. The toothpick should be secure and should not move around in the clay.
3. Place the clay ball and toothpick on your wrist near the base of your thumb. You will know the ball is in the right spot when you can see the toothpick moving with each heartbeat.

Observations:

	At rest	After exercise	5 minutes after exercise	10 minutes after exercise	15 minutes after exercise	20 minutes after exercise
(a) Number of beats in 10 seconds						
(b) Number of beats in 1 minute (previous answer x 6)						

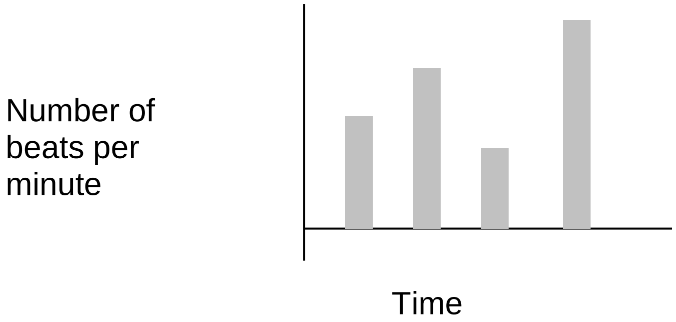
Name: ___________________________________

Pulse Meter

Activity 2.2: Part 3

Results:

On a separate sheet of paper, graph the beats per minute (section b) over time. You can use the example below as a guide.



Analysis:

What happens to the heart rate (beats per minute) as you increase the duration of exercise?

____

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____

Why do you think this happens?

____

____

____

____

Name: ___________________________________

Measure Your Reaction 'Time'

Activity 2.3: Part 1

For this activity, you will need to work with a partner.

One person will hold a ruler, and the other will be ready to catch it between their thumb and index finger. Once the ruler has been caught, record how far (in cm) the ruler has dropped. Try this three times, then let your partner try it.

Student	Reaction 'time' in cm			
	Trial 1	Trial 2	Trial 3	Average reaction distance

To calculate the average reaction distance, add the values of trials 1, 2 and 3, and divide this sum by 3. Your answer will give you the average.

Name: ________________________________

Levers in Sports

Activity 2.3: Part 3

For a sport of your choosing, answer the questions below.

Sport:____

Describe at least one way in which a player uses a lever:

____

____

Is this lever part of the player's body?

____

____

Describe where the fulcrum, the rod, the force, and the weight are located in relation to one another:____

____

____

Draw a diagram, including all the elements mentioned in the last question:

How does this lever increase the player's ability to perform?

____

____

What would happen if the player could no longer use the lever? Would they still be able to play?

____

____

Name: ________________________________

What is Sweat?

Activity 2.4: Part 1

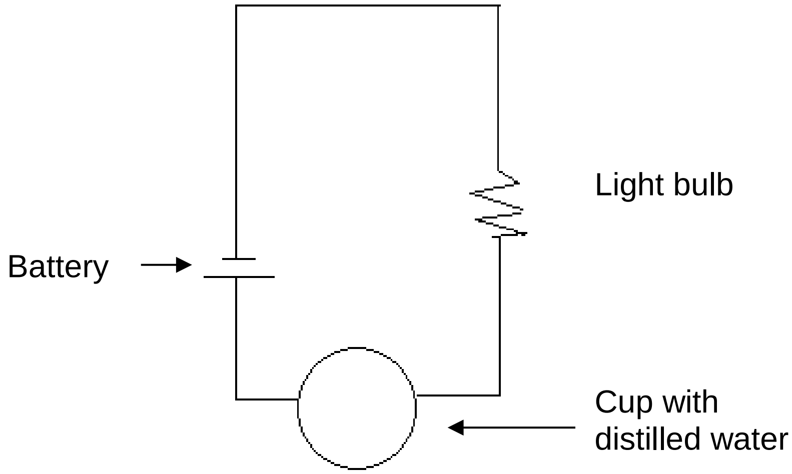
Sweat is more than just water — it also contains electrolytes. You can make your own testing device to find out if your sports drink contains electrolytes.

Material:

- A 2-volt light emitting diode (LED) or small light bulb
- A 9V battery
- A plastic or glass (non-metal) cup
- Distilled water
- Table salt
- Several sports drinks
- Three wires with alligator clips

Method:
Assemble the following circuit (or follow the instructions given by your teacher). Make sure that the wires in the cup are not touching.

1. Place distilled water in the cup, and note whether or not the light turns on.
2. Add salt to the water and note any changes.
3. Remove the salted water. Wash the cup, and add some distilled water and some sugar. Note any changes.
4. Replace the water and sugar in the cup with a sports drink. Note any changes.
5. Replace the sports drink with any other liquid you would like to test.



Name: ________________________________

What is Sweat?

Activity 2.4: Part 1

Observations:

	Distilled water	Distilled water + salt	Distilled water + sugar	Sport drink	Other liquid
Does the light turn on?					

Analysis:

When did the light turn on? What substance had to be present?

____

____

____

Why do you think this substance is present in sports drinks?

____

____

____

Name: ________________________________

Making Your Own Sports Drink

Activity 2.4: Part 2

Follow the instructions below to make your own sports drink.

1. Name your sports drink and draw a logo.

2. Ingredients:

- 1 L of water
- 45 ml (3 tablespoons) of sugar
- 4 ml (¼ tablespoon) of salt

3. Flavours and colours:

Get creative! You can use many things to flavour and colour your drink, but make sure you are not adding too much sugar or salt.
For example, you could add:

- Vanilla, orange, banana or any other type of extract.
- Unsweetened water flavouring (the type that comes in powdered form)
- Small amounts of food colouring

4. Sell your product:

Give a brief presentation to your class. Tell them what makes your sports drink unique and better than all the others.

5. Taste test:

With your teacher's permission, taste your own sports drink, and sample sports drinks made by your classmates to determine which one tastes the best.

Name: ________________________________

Bacterial Cultures

Activity 2.4: Part 3

Your teacher will provide you with a petri dish that contains a special jelly where bacteria can grow.

Open the petri dish, touch the jelly in the dish with one finger, and then close the dish as quickly as possible (to avoid any bacteria, besides that on your finger, from getting into the dish).

Observations:
Can you see bacterial growth in the petri dish?

	Yes	No	If yes, describe what you see
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			

Section 3: Forces

INTRODUCTION

We often list bridges, buildings, and dams when talking about structures, but the human body can also be considered a structure. It is made up of several parts that are arranged in a particular way to support the force of its own weight. It can also support a load (or additional weight). In this section, students will review the classification of structures, define the centre of gravity, observe different forces acting on structures, and experiment with the force of friction by using the human body — or structures regularly found in sports — as the basis for their study.

This section contains the following components:

3.1. Classification of Structures
3.2. Centre of Gravity and Stability
3.3. Forces Acting on Structures
3.4. Friction

Worksheets for all activities are included at the end of this section. They can also be found by clicking on the image to the right of the activity description.

ACTIVITY 3.1: CLASSIFICATION OF STRUCTURES

(Suitable for Grades 4 to 7)

The human body is a naturally occurring structure. It comprises a variety of structure types and different materials. Each type of structure has evolved to serve a specific purpose within the body (e.g., to protect, to support, etc.), just as engineers and architects carefully select structure types when building a dam or a tower. The body is also made up of different materials such as bones, muscles, nerves, and skin. And, just as in man-made structures, the materials have specific properties tailor-made to suit their function.

By exploring the structures and materials in the human body, students will review the types of structures, as well as where and why they are found in the body.

As an extension of these concepts, students will discover why certain shapes and specific materials are chosen in the manufacture of sport equipment.

Concepts

Structures are objects made up of smaller parts that are arranged together in a specific way, making them capable of supporting a load. Generally, structures are classified into one of the three categories below.

Solid structure: A structure made by stacking or piling individual pieces on top of one another, as in a brick wall or a dam. Solid structures are held in place by their own weight, and are thick enough and strong enough to stay in place. They are usually built of strong, heavy materials.

Frame structure: A structure that acts as scaffolding or a skeleton, such as a bicycle frame. Frame structures reduce the amount of material needed, but they must be anchored or braced to stay upright, and may have some weaknesses at the joints. Frame structures are not as strong and resistant to external forces as solid structures, which are constructed with heavy materials.

Shell structure: A structure that has a curved or dome-like shape. It is the outer layer that provides rigidity and strength, without being supported by a frame or solid wall inside. The shape of the shell allows any force acting upon it to be distributed across the structure, so that every part of it supports a very small portion of the total force. Shell structures are very thin and convenient, but they are also vulnerable to small imperfections, which can weaken them.

Classroom Discussion: Begin by asking students what kinds of structures they see around them. Write their answers on the board, so that everyone can see and add to the list later on, if necessary. Ask students to classify the structures as either natural or man-made. Ask students if they can name some characteristics of structures (e.g., they are mostly made of solids; they are usually built to be stable; they are usually built to carry a load, etc.). Ask students to group the structures that are written on the board into categories (solid, frame, or shell).

Part 1: Classroom Demonstration on Shell Structures

Objective: Demonstrate the strength of shell structures.

For this demonstration, you will need:

- Two cafeteria trays
- Four egg cups (you can also cut out four individual cells from an egg carton)
- Four eggs
- Heavy objects such as additional books, bricks, etc.
- Scale (optional)

Place the four egg cups on the cafeteria tray and insert an egg in each cup. The egg cups should be arranged in a square. Place the other tray on top of all four eggs. Each egg should be supporting one corner of the tray. Start adding your heavy objects on top of the tray, one by one. You can weigh each object you add on the eggs until they crack, to see how much they supported.

After the demonstration, ask your students:

- What type of structure is represented by the egg? (shell)
- Where in the human body can we also find a shell structure? (skull)
- What are the advantages of shell structures? (thin, strong and can enclose something inside)
- What do athletes wear on their heads for further protection? (helmet)
- What type of structure is a helmet? (shell)
- What is the difference between the shell structure of the skull and that of the helmet? (the materials: the skull is made of bone, and the helmet is made of plastic)

Part 2: Frame Structures

Objective: To construct a frame structure, in order to observe and understand its advantages and limitations.

Racquets are good examples of frame structures. The outside of the racquet, the frame, supports the tension of the strings on the inside. Students can build their own miniature tennis racquets. For this activity, each student or group of students will need:

- 10 craft sticks (minimum)
- String
- Tape, hot glue, or white glue

Students can choose to build a round or square tennis racquet. They will have to think of creative ways to make the outside frame resistant to the tension of the strings. The strings should be tied to the frame (rather than glued to the frame). You can organize a tennis tournament (using a real tennis ball) to determine who has built the strongest racket.

Part 3: Solid Structures

Objective: To construct a solid structure in order to observe and understand its advantages and limitations.

Solid structures are made by piling up small pieces of material to form a larger shape. In this activity, students will construct a baseball bat, using materials of their choosing.

Students can work in teams of two or three. They will have to think about the general shape of their bat, and the materials that they will use for its exterior and interior. For example, for the exterior structure, students could use the inner rolls from paper towels, empty water bottles, or empty potato chip tubes. The interior could be filled with packed newspaper, rubber balls, etc.

After construction, bring all of your students into the gymnasium to test their bats. This experiment can be done with a softball instead of a baseball, in order to increase the chance of contact between the bat and the ball.

The distance travelled by the ball can be measured and recorded for each team, if a competition-style activity is desired.

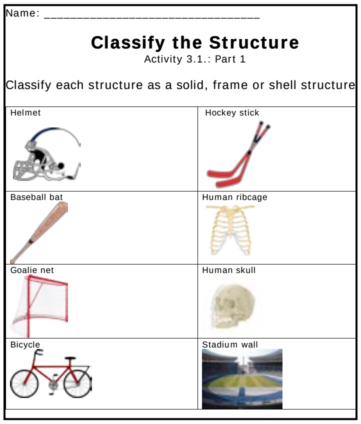
Additional information

Some Major League Baseball (MLB) players have been disciplined for using doctored bats. For example, in 2003 Sammy Sosa was suspended for using a “corked” bat. Doctored bats have been altered or tampered with, and are illegal in the MLB. In the case of a corked bat, a hole is drilled in the centre and filled with cork. This makes the bat lighter than the regulation bat. It is unclear, however, whether having a lighter bat gives the hitter any significant advantage. Although it would allow for a faster swing, it would also decrease the energy available to be transferred to the ball. This means that corked bats might increase the number of hits, but would not enhance the distance travelled by the ball.

Part 4: Types of Structures

Objective: To classify the different structures found in sports as solid, frame, or shell structures.

Ask students to complete the activity sheet. They can complete this in class, using the examples on the board as a guide.


Name: ____________________________

Classify the Structure

Activity 3.1.: Part 1

Classify each structure as a solid, frame or shell structure

Helmet	Hockey stick
Baseball bat	Human ribcage
Goalie net	Human skull
Bicycle	Stadium wall

ACTIVITY 3.2: CENTRE OF GRAVITY AND STABILITY

(Suitable for Grades 4 to 6)

Athletes are constantly looking to keep their bodies stable and balanced in order to give more force to their movement, or to be more efficient in their technique. To do this, athletes must have a good sense of where their centre of gravity is. In the following activities, the centre of gravity will be equal to the centre of mass — the point on an object where its mass is equally distributed. The position of a structure’s centre of gravity will affect its stability.

Part 1: Defining the Centre of Gravity

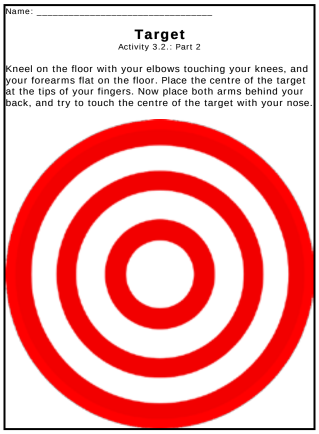
Objective: To define the centre of gravity, and learn how to find it.

An object’s centre of gravity is its balance point. If a pivot (or fulcrum) is placed at an object’s centre of gravity, it will not topple to one side or the other. Note that an object’s centre of gravity is not necessarily in the geometric centre of that object.

Classroom Demonstration

1. Have one student hold a metre stick in front of the class. Ask them to balance the metre stick horizontally on one finger. Mention that the centre of gravity is exactly in the middle, as there is equal weight on either side.
2. Have students find the centre of gravity for objects on their desks. Ensure they note that the centre of gravity is not always the geometric centre of the object.
3. Have a student stand in front of the class with their feet together and their body as rigid as possible. Ask a classmate to push them slowly towards the right. The student will eventually lose their balance. This happens when the centre of gravity has shifted past the right foot. To avoid losing their balance, the student can take a wider stance. This changes the shape of the body, making it more stable.
4. Ask students to define the term ‘centre of gravity’ in their own terms.

Part 2: Finding the Centre of Gravity



Objective: To observe that the centre of gravity will vary from person to person, according to their body shape.

As our bodies grow, our centre of gravity will shift. Generally speaking, the centre of gravity for shorter people will be closer to the ground, as compared to that of taller people. Body shape, however, can also affect the position of the centre of gravity.

1. On a crash mat or soft surface, have all students kneel on the ground with their arms extended in front of them.
2. Have them bring their elbows in towards them so that their elbows are touching their knees. Their forearms should be flat on the floor in front of them.
3. Place the centre of the target (on the activity sheet) at the ends of their fingertips.
4. Students will then place both hands behind their backs. (Students can also keep their arms to their sides if they wish, to be able to brace themselves in the event that they fall forward.)
5. Students must now try and touch the target with their nose without losing their balance.

Some students may be able to do this, and some may not. Students can observe that, when their centre of gravity is past their knees, they are no longer stable and will fall forward. For those unable to do it, you can suggest the following strategies:

- Spreading the knees apart to widen the base of the body.
- Holding a heavy object (or the hands of a classmate) behind their backs to act as a counterweight.
- Getting closer to the target (in this case, students will not have to lean as far forward).

Extension Activities: In the gymnasium, set up the high-jump equipment. Set the bar just below waist height for your smallest students. Tell students that the object of the activity is to jump over the bar. Do not show students any of the standard techniques used in high-jumping. Let them figure out the best way to get over the bar. Once the whole class has jumped once, raise the bar and go through the group again. Repeat three to four times. Their technique may change as the bar gets higher. Afterwards, ask students what they found to be the easiest way to jump over the bar. Ask them if their technique changed as the bar got higher, and why.

Background Information

In high jumping, an athlete needs to get their centre of gravity over the bar with the least effort possible. If using a scissor-kick technique, the jumper's centre of gravity is high above the bar. This requires the jumper to use a lot of energy, as they need to jump high enough to get both the centre of gravity (located around the waist) and the lower portion of the body over the bar.

Jumpers can also use the straddle technique, which consists of diving headfirst over the bar. This is more effective, as the centre of gravity is closer to the bar. However, the most effective way known to date is the Fosbery Flop. Jumpers using this technique will rotate their body during the jump, so as to have their backs facing the bar while in the air. The jumper will arch their back in order to have as much body mass below the bar at all times. This means that the jumper's centre of gravity stays either below the bar or very close to it during the jump. This allows athletes to use less energy to jump over the bar, therefore allowing them to jump higher.

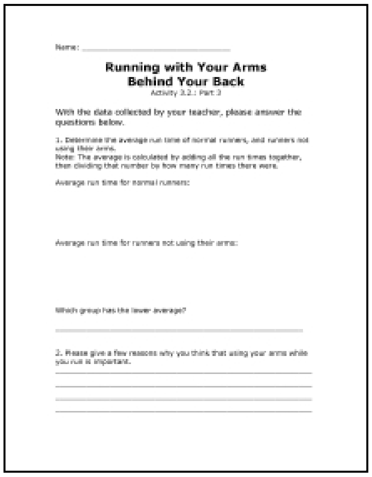
This technique was pioneered by American high jumper, Dick Fosbery. Many ridiculed his new technique, until he won gold at the 1968 Olympic Games. This is still the technique used by high jumpers today.

Part 3: Balance During Physical Activity

Objective: To observe that humans use specialized movements to stay balanced.

When doing any kind of physical activity, it is important to stay balanced. To demonstrate this, have students run normally, as well as with their arms behind their backs.

Time each student's run (or have the students time one another), and record their findings in a large chart, such as the one below. Make the time results available to students by posting the sheet on the board. Ask every student to use these results in order to fill out the activity sheet. Alternately, you may wish to have all students participate in running, but select five volunteers to share their times for the chart. The class can use these times when calculating the averages on their worksheets.


Name: ______

Running with Your Arms Behind Your Back

Activity 3.2.: Part 3

With the data collected by your teacher, please answer the questions below.

1. Determine the average run time of normal runners, and runners not using their arms.
Note: The average is calculated by adding all the run times together, then dividing that number by how many run times there were.

Average run time for normal runners:

Average run time for runners not using their arms:

Which group has the lower average?

______

2. Please give a few reasons why you think that using your arms while you run is important.

______

Type of run	Students	Run time
Normal	Student 1	
	Student 2	
	Student 3	
	Student 4	
	Student 5	
With hands behind back	Student 1	
	Student 2	
	Student 3	
	Student 4	
	Student 5	

Generally, students will run faster when they are allowed to use their arms. The movement of the arms helps the students stay balanced. Runners with their arms behind their backs must shift their whole body from side to side to stay balanced. This wastes energy that might otherwise be used for running faster.

Part 4: Using Senses for Balance

Objective: To observe that sight and position-sensing organs in the inner ear allow us to stay balanced.

Classroom Activity: Have students stand on one foot, trying to keep their balance. Then ask them to close their eyes and do the same thing. They will find that it is much harder to stay balanced with their eyes closed. Our brains rely on our sensory organs (such as our eyes and ears) to maintain balance.

- The Canada Science and Technology Museum's Crazy Kitchen + exhibit is a good example of how we can lose our balance, or even feel dizzy, when our senses tell our brains conflicting messages about the body's position in space. We have a YouTube video showing and explaining the Crazy Kitchen.

Ask students if they have ever felt this effect in everyday life. Examples include motion sickness, the feeling you experience when riding some roller coasters or watching an IMAX movie, or even when wearing virtual reality googles.

ACTIVITY 3.3. FORCES ACTING ON STRUCTURES

(Suitable for Grades 4 to 7)

The human body is a naturally occurring structure. It is strong enough to support its own weight, and carry an extra load. In our everyday lives, we regularly feel the forces of compression, tension, and torsion. In the following activities, students will explore how different forces affect their bodies, and how special equipment can protect the body from these forces.

Concepts
Structures are subject to the forces that act upon them, notably:

- Compression: a squeezing force
- Tension: a stretching force
- Torsion: a twisting force

Structures can be subjected to a combination of these forces. For example, a flexed beam exhibits compression on one side, and tension on the other.

Structure can resist these forces by moving and bending. There is always a limit, however, depending on the size, shape, and types of materials used. When a structure reaches this limit, it will break.

Classroom Demonstrations

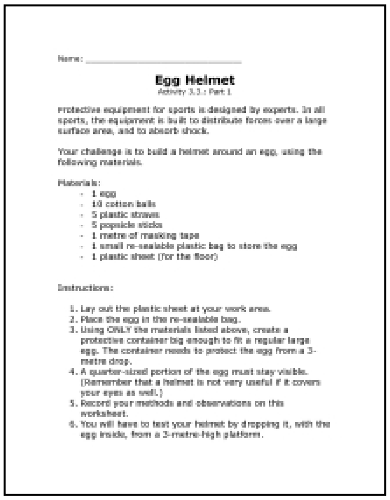
These three demonstrations can be done in the classroom or the gymnasium. If the latter is chosen, there will be enough room for all students to try each activity.

1. Have all students in the class compete in a tug-of-war. Afterwards, ask what kind of force was applied to the rope (tension).
2. Have a couple of students fill their backpacks with books, and have them put these on in front of the class. Ask the class what kind of force is at work in the student's spine (compression).
3. Have two students stand back to back. Give a medicine ball (or other heavy object) to one of the students. Ask them to give the ball to the other person without moving his/her feet. The student will have to rotate their body. Ask the rest of your students what kind of force is at work on the student's spine and muscles (torsion).

Part 1: Distribution of Force

Objective: To discover how distributing a force over a large area can reduce the potential damage of its impact.

Ask students why they think hockey goalies wear more padding and a larger helmet than other players. Explain that protective equipment is built to distribute force over a large surface area. By distributing the force, no single area of the structure reaches the limit of its material's strength and flexibility. This helps prevent injuries such as broken bones and muscle tears.


Name: ______________________

Egg Helmet
Activity 3.3.: Part 1

Protective equipment for sports is designed by experts. In all sports, the equipment is built to distribute forces over a large surface area, and to absorb shock.

Your challenge is to build a helmet around an egg, using the following materials.

Materials:
- 1 egg
- 10 cotton balls
- 5 plastic straws
- 5 popsicle sticks
- 1 metre of masking tape
- 1 small re-sealable plastic bag to store the egg
- 1 plastic sheet (for the floor)

Instructions:
1. Lay out the plastic sheet at your work area.
2. Place the egg in the re-sealable bag.
3. Using ONLY the materials listed above, create a protective container big enough to fit a regular large egg. The container needs to protect the egg from a 3-metre drop.
4. A quarter-sized portion of the egg must stay visible. (Remember that a helmet is not very useful if it covers your eyes as well.)
5. Record your methods and observations on this worksheet.
6. You will have to test your helmet by dropping it, with the egg inside, from a 3-metre-high platform.

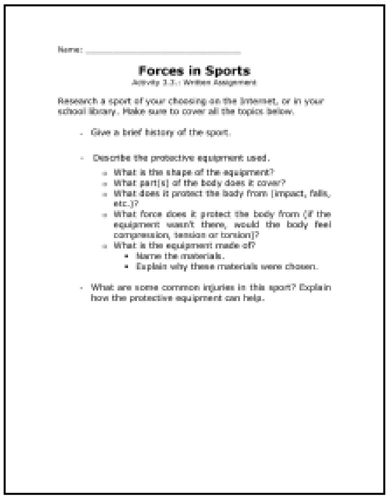
1. Ask students to create a helmet for an egg that will be dropped from a height of three metres. Divide the class into groups, so that students can work collaboratively on this task. Each group will need:
    - An egg
    - 10 cotton balls
    - Five straws
    - Five craft sticks
    - A metre of masking tape
    - A small re-sealable plastic bag to store the egg

- A plastic sheet
- A marker

2. Tell students that they must follow the directions and specifications outlined on their activity sheet.
3. Have all students test their helmets on the same day. Remember to test at least one unprotected egg.

Written Assignment

Ask students to research the protective equipment used in a sport of their choice. Students will follow the instructions on the activity sheet, and will be asked to comment on the types of forces that are felt by an athlete's body while practising this sport.


Name: ______________

Forces in Sports

Activity 3.3.: Written Assignment

Research a sport of your choosing on the Internet, or in your school library. Make sure to cover all the topics below.

- Give a brief history of the sport.
- Describe the protective equipment used.
  - What is the shape of the equipment?
  - What part(s) of the body does it cover?
  - What does it protect the body from (impact, falls, etc.)?
  - What force does it protect the body from (if the equipment wasn't there, would the body feel compression, tension or torsion)?
  - What is the equipment made of?
    - Name the materials.
    - Explain why these materials were chosen.
- What are some common injuries in this sport? Explain how the protective equipment can help.

Extension Activity (Grade 7): Sports have been around for thousands of years. Ask students to research forgotten or perhaps lesser-known sports, and present these to the class.

Some examples of lesser-known sports can be found in the list below. However, you may also wish to allow students to choose any sport they like for this assignment.

Lesser-known sports:

- Octopush (underwater hockey)
- Koppball
- Disc golf
- Harpastum
- Pitz
- Follis
- Marn Grook

Topics to research:

- Country of origin
- Brief history
- Object of the game (rules)
- Type of equipment used. Can include the types of structures these represent (solid, frame, or shell)
- Forces acting on the body, and the equipment used to protect it from these forces.

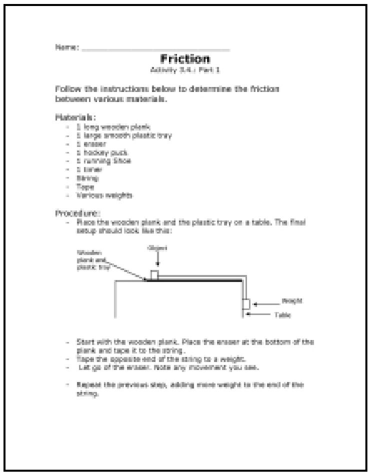
If possible, you can pick one or two new sports to try out in the next gym class.

ACTIVITY 3.4: FRICTION

(Suitable for Grades 4 to 7)

Friction is a force present whenever an object is moving against another solid, or through a liquid or a gas. Friction will always act in the opposite direction of the movement, and can act on matter in all three states: solid, liquid, and gas. In this section, students will learn that friction can work to the advantage or disadvantage of an athlete. For example, it is important that a running shoe create enough friction against the track to keep the runner from slipping. It is equally important that the runner not wear excessively loose clothing, which can increase the friction between clothing and the surrounding air (air resistance).

Part 1: Friction


Name: ________________

Friction

Activity 3.4.: Part 1

Follow the instructions below to determine the friction between various materials.

Materials:
- 1 long wooden plank
- 1 large smooth plastic tray
- 1 eraser
- 1 hockey puck
- 1 running Shoe
- 1 timer
- String
- Tape
- Various weights

Procedure:
- Place the wooden plank and the plastic tray on a table. The final setup should look like this:

- Start with the wooden plank. Place the eraser at the bottom of the plank and tape it to the string.
- Tape the opposite end of the string to a weight.
- Let go of the eraser. Note any movement you see.
- Repeat the previous step, adding more weight to the end of the string.

Objective: To define friction and understand that this force is dependent on the materials that come into contact with one another.

Ask students to test how much friction exists between various materials, by following the instructions on the activity sheet. Explain that there is friction between any two objects that rub against one another. The amount of friction between them will depend on their materials.

Each student or group of students will need:

- A long unfinished wooden plank
- A large, smooth plastic tray (e.g., a cafeteria tray)
- An eraser
- A hockey puck
- A running shoe
- A timer
- String
- Tape
- Various weights

Idea for extension: ask students to choose a different surface, and predict how this will affect the movement of the eraser.

Classroom Demonstration: This demonstration is a great way to illustrate that friction is a powerful force. You will need:

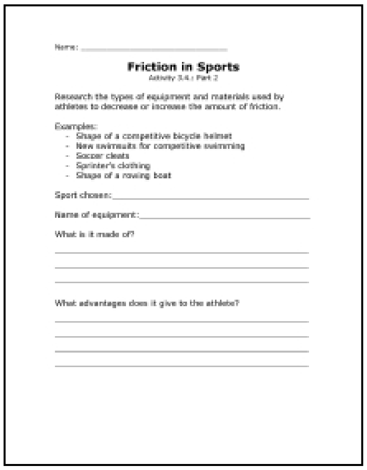
- 170 sheets of paper (this is a good opportunity to empty your recycling bin)
- Stapler
- Tape

Preparation:
1. Prepare six booklets, two with 10 sheets of paper, two with 25 sheets of paper and two with 50 sheets of paper each. Staple the long edge and put tape over the staples to protect your students' hands.
2. Interleave each pair of booklets page by page.

Demonstration:
1. Ask two students to pull the 10-page booklets apart. Ask if they felt any friction.
2. Repeat with the 25- and 50-page booklets.
3. What did they observe?

Go further: If you can find a pair of phone books or large catalogues, this demonstration can be scaled up for a real tug of war; you could drill holes through the pages and thread rope through the books.

Part 2: Friction in Sports


Name: ____________

Friction in Sports
Activity 3.4.: Part 2

Research the types of equipment and materials used by athletes to decrease or increase the amount of friction.

Examples:
- Shape of a competitive bicycle helmet
- New swimsuits for competitive swimming
- Soccer cleats
- Sprinter's clothing
- Shape of a rowing boat

Sport chosen: ____________

Name of equipment: ____________

What is it made of?

What advantages does it give to the athlete?

Objective: To understand that athletes sometimes want increased friction and sometimes want decreased friction, depending on the sport.

Have your students research the ways in which athletes work to increase or decrease friction. Specialized sports equipment can utilize materials that maximize or minimize friction. For example, skis are smooth and thin to minimize friction with the snow, and to increase speed. On the other hand, rock-climbing shoes are made of very soft rubber, increasing friction to minimize the chance of slipping. Students can complete their research by filling in the activity sheet.

Other examples:

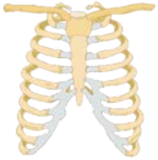
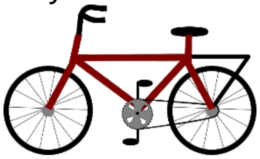
- Ice skates (lower friction with the ice).
- Swimmers can wear specialized swimsuits to minimize friction between their bodies and the water. (Some full-body suits have been banned from the Olympic Games, because they gave the athletes wearing them an unfair advantage.)
- Tires for mountain bikes are thick and rough to increase friction with friable terrains (such as loose rock that can easily break apart), whereas tires for road biking are smooth to maximize friction with a smooth surface and increase speed.

Name: ________________________________

Classify the Structure

Activity 3.1: Part 4

Classify each structure as a solid, frame, or shell structure.

Helmet 	Hockey stick 
Baseball bat 	Human ribcage 
Goalie net 	Human skull 
Bicycle 	Stadium wall 

Name: ________________________________

Target

Activity 3.2.: Part 2

Kneel on the floor with your elbows touching your knees, and your forearms flat on the floor. Place the centre of the target at the tips of your fingers. Now place both arms behind your back, and try to touch the centre of the target with your nose.

Name: ________________________________

Running with Your Arms Behind Your Back

Activity 3.2.: Part 3

With the data collected by your teacher, please answer the questions below.

1. Determine the average run time of runners using their arms, and those not using their arms.

Note: The average is calculated by adding all the run times together, then dividing that number by how many run times there were.

Average run time for normal runners:

Average run time for runners not using their arms:

Which group has the lower average?

____

2. Please give a few reasons why you think it is important to use your arms while you run.

____

____

____

Name: ________________________________

Egg Helmet

Activity 3.3: Part 1

Protective equipment for sports is designed by experts. All protective sports equipment is built to distribute forces over a large surface area, and to absorb shock.

Your challenge is to build a helmet for an egg, using the following materials.

Materials:

- An egg
- 10 cotton balls
- Five straws
- Five craft sticks
- One metre of masking tape
- A small, re-sealable plastic bag to store the egg
- A plastic sheet (for the floor)
- A marker

Instructions:

1. Lay out the plastic sheet in your work area.
2. Draw small eyes on your egg.
3. Place the egg in the re-sealable bag.
4. Using ONLY the materials listed above, create a protective container big enough to fit a regular large egg. The container needs to protect the egg from a three-metre drop.
5. A quarter-sized portion of the egg where the eyes have been drawn must stay visible. (Remember that a helmet is not very useful if it covers your eyes.)
6. Record your methods and observations on this worksheet.
7. You will test your helmet by dropping it, with the egg inside, from a three-metre-high platform.

Name: ________________________________

Egg Helmet

Activity 3.3: Part 1

Method:

Note the exact amount of each material used:

____

____

Explain the function of each material used:

____

____

Results:

Did you egg break after the three-metre drop?

____

Analysis:

Explain why your helmet did, or did not, prevent the egg from breaking.

____

____

What could you do to improve your helmet?

____

____

What materials would you have used if you were not limited to the list included in the instructions?

____

____

Name: ________________________________

Forces in Sports

Activity 3.3: Written Assignment

Research a sport of your choosing on the Internet or in your school library. Write a report, making sure to cover all of the points below.

- Give a brief history of the sport.

- Describe the protective equipment used.
  - What is the shape of the equipment?
  - What part(s) of the body does it cover?
  - What does it protect the body from (impact, falls, etc.)?
  - What force does it protect the body from (if the equipment wasn't there, would the body feel compression, tension, or torsion)?
  - What is the equipment made of? Name the materials and explain why these materials were chosen.

- What are some common injuries in this sport? Explain how the protective equipment can help.

Name: ______________________________

Friction

Activity 3.4: Part 1

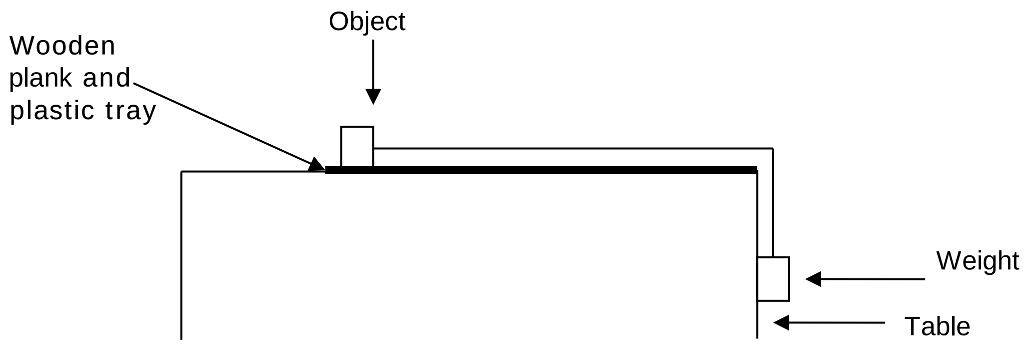
Follow the instructions below to determine the friction between various materials.

Materials:

- A long, unfinished wooden plank
- A large, smooth plastic tray
- An eraser
- A hockey puck
- A running shoe
- A timer
- String
- Tape
- Various weights

Procedure:

- Place the wooden plank and the plastic tray on a table. The final setup should look like this:



- Start with the wooden plank. Place the eraser at the bottom of the plank, and tape it to the string.
- Tape the opposite end of the string to a weight.
- Let go of the eraser. Note any movement you see.
- Repeat the previous step, adding more weight to the end of the string.
- Note how much weight (or force) is necessary to pull the object along the plank.
- Repeat the previous steps, substituting the eraser for the hockey puck and running shoe.
- Repeat all previous steps with the plastic tray.

Observations:

	Weight necessary to move object			
	Eraser	Hockey Puck	Running Shoe	Other:
Wood				
Plastic				

Which surface causes the most friction?

____

____

____

Which object causes the most friction?

____

____

____

Which combination of surface and object produced the most friction?

____

____

____

Which combination of surface and object produced the least friction?

____

____

____

Name: ________________________________

FRICTION IN SPORTS

Activity 3.4: Part 2

Research the types of equipment and materials athletes use to increase or decrease friction.

Examples:

- Shape of a competitive bicycle helmet
- New swimsuits for competitive swimming
- Soccer cleats
- Sprinter’s clothing
- Shape of a rowing boat

Sport chosen: ____

Name of equipment: ____

What is it made of?

____

____

____

What advantages does it give to the athlete?

____

____

____

Section 4: Energy

INTRODUCTION

Energy, or the ability to do work, is an essential concept in understanding sports. It is not only an important consideration when deciding how to power the next big stadium, but also when deciding what food to eat right before a tournament, or how hard to kick a soccer ball to complete a pass.

In this section, students will explore different forms of energy, and will learn how and why energy is transformed from one form to another. Through experiments, students will observe that energy transformation is not a completely efficient process, and that some energy will always be transformed into a less desirable form. Students will learn that energy cannot be created or destroyed — it can only be transformed.

This section contains the following components:

4.1. Forms of Energy
4.2. Energy Transformation

Worksheets for all activities are included at the end of this section. They can also be found by clicking on the image to the right of the activity description.

ACTIVITY 4.1. FORMS OF ENERGY

(Suitable for Grades 4 to 7)

Energy is the ability to do work. The term work is defined as a force, acting over a certain distance. It can manifest itself in various forms: heat energy from the Sun warming our atmosphere and creating wind, chemical energy stored in a battery that powers a pacemaker, or light energy that allows plants to grow. By investigating sports and physical activity, students will explore the various forms that energy can take.

Classroom Discussion: Ask students what they think energy is. Write their ideas on the board, and direct them to the conclusion that energy is the ability to exert a force over a distance. Ask students if they can name different forms of energy. Write these on the board as well. Make sure they provide examples of each form.

For example:

- **Potential Energy**: Energy that can be stored in order to do work at a later time. For example, if a ball is lifted off the ground, it has potential energy. Gravity is an example of potential energy (called "gravitational potential").
- **Kinetic Energy**: The energy of motion. The faster an object moves, the more kinetic energy it is said to possess.
- **Chemical Energy**: Energy derived from a chemical reaction (for example, the food we eat undergoes a chemical reaction to provide our bodies with heat, nutrients, etc.).
- **Muscular Energy**: Our muscles can move thanks to the energy stored in them.
- **Light Energy**: Plants can use this energy due to a process called photosynthesis.
- **Electrical Energy**: This is the movement of charges, such as the movement of electrons inside a copper wire.

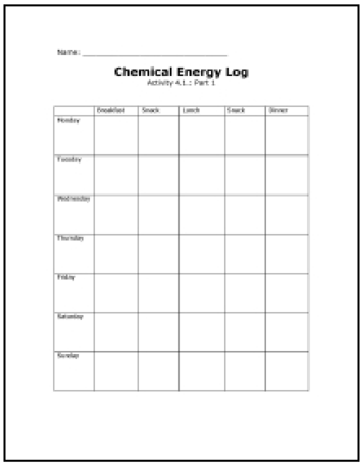
Deeper Study (for older students):

Other forms of energy could also be discussed. For example, solar, thermal (heat radiation), nuclear, wind, water, and fossil fuels are sources of energy that we often consider when discussing how to power our cities, houses, or cars.

These sources of energy are an important consideration when planning large sporting events, such as the 2010 Vancouver Olympic Games. Athletes from all over the world lived in the Olympic Village for the duration of the Games. The Vancouver Olympic Village was built with energy efficiency in mind. For example, heat from sewer lines was captured and used in close proximity to its source, in order to heat buildings and tap water.

Students can also research the types of energy-saving initiatives undertaken at major sport stadiums.

Part 1: Chemical Energy

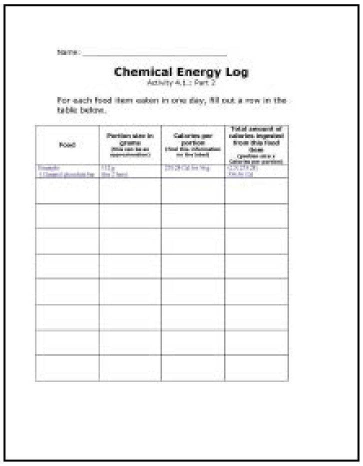


Objective: To identify food as a source of chemical energy, necessary for animal life.

Chemical energy is found in the bonds between the atoms that form a molecule. We store this kind of energy inside our bodies, and use it when we move or exercise. Animals acquire chemical energy through the foods they eat. Energy can be derived from molecules such as the carbohydrates found in fruit, bread, pasta, beans, potatoes, grains, and cereal. Fat molecules that are ingested can be stored in our bodies as a long-term energy source. When the body needs to use these molecules, it converts them into sugars that can be used by the muscles. Proteins are also found in our diet; although they are usually used as building blocks for muscles and organs, they can also be converted into sugars and used as a source of energy, if needed.

1. Ask students where they get their chemical energy by instructing them to fill out a log listing the food that they consume in a week. They can complete the activity sheet as the week goes by, and analyze it the following Monday.
2. Afterwards, ask students what they think about their eating habits. Are they healthy? Is anything missing from their diet? Students should consult Canada's Food Guide made by the Government of Canada.

Most food items that are bought at a grocery store are labelled with nutritional information. These labels contain information about the Calories (energy) contained in one portion of a particular food. The size of the portion is indicated on the label.



3. Ask students to calculate how many calories they consume in one day. This is an activity best done on a weekend, when students will be able to look at the labels on each product they consume. Enlisting the help of the parents would be a good idea, as some nutritional information labels are difficult to read or even find.

4. Have each student fill out the activity sheet and make a list of everything that was consumed in one day. This list should include portion size, calories per portion, and the total amount of calories ingested from each food item.

Although it might seem interesting to do a comparison of each student's caloric intake during one day, please bear in mind that this may be a sensitive subject for many students in your class. The goal of the exercise is simply to understand that animals (humans) get energy from food, and that different food items provide us with different amounts of energy.

Alternatively, each student can do this analysis with one pre-packaged snack that they bring to school.

Background Information: calories vs. Calories

The calorie is a measure of energy. There are two different kinds of calories: small calories (cal) with a lowercase “c" and large Calories (Cal) with an uppercase “C” (also known as kilocalories or Kcal). Small calories represent the energy needed to heat 1 gram of water by 1 degree Celsius, or approximately 4.2 Joules (Joules are another unit of energy). Large Calories are equal to 1,000 small calories, or 4.2 Kilojoules. When talking about the energy content of food, it is more useful to use large Calories (or Kilocalories) or Kilojoules — this is the measurement used on nutritional information labels.

Part 2: Potential and Kinetic Energy

Objective: To understand the difference between potential and kinetic energy.

Concepts

Potential energy is the energy stored in an object. In other words, it is the capacity to do work at a later time. For example, if you lift a ball off the ground, it has the potential to fall. The higher the ball is off the ground, the more potential energy it has. As the ball falls to the ground, its potential energy decreases.

Kinetic energy is the energy an object has when it is in motion. The faster the object travels, the more kinetic energy it has.

When a ball is held in the air, it is not moving, and has no kinetic energy; but it does have a lot of potential energy. As the ball falls to the ground, the kinetic energy increases as the speed of the ball increases, but the potential energy decreases.

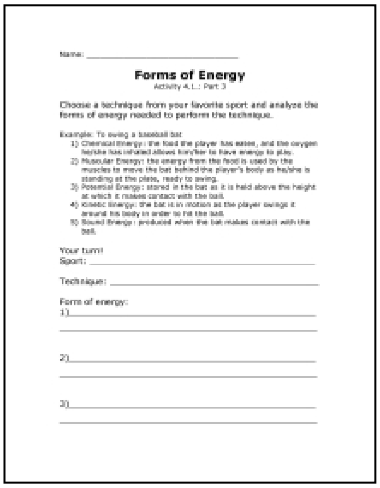
Classroom Demonstration: Take a tennis ball and raise it above your head. Ask students if the ball is moving. No — so it does not have any kinetic energy. Ask students if the ball has the potential to move. It has — towards the ground. Thus, the ball has potential energy.

Just before the ball hits the ground, it will be moving very fast, which means it has a lot of kinetic energy. However, since it is so close to the ground, it will not have much potential energy.

To demonstrate this further, you can organize a game of volleyball. You can explain that, when a player sets the ball or makes a pass, the ball is propelled through the air in an arched trajectory. The ball is said to possess kinetic energy because it is in motion. However, whenever the ball is thrown in the air either straight up, or following an arched trajectory, there is a very brief moment just after the ball stops travelling upwards — but before it starts falling back to the ground — when the ball possesses very little vertical kinetic energy, but a lot of potential energy.

This discussion is only an introduction to the concept of potential and kinetic energy. Your class will have a chance to explore the transfer of potential and kinetic energy with hands-on activities in the next section.

Part 3: Energy in Sports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Forms of Energy

Activity 4.1.: Part 3

Choose a technique from your favorite sport and analyze the forms of energy needed to perform the technique.

Example: To swing a baseball bat

1) Chemical Energy: the food the player has eaten, and the oxygen he/she has inhaled allows him/her to have energy to play.
2) Muscular Energy: the energy from the food is used by the muscles to move the bat behind the player's body as he/she is standing at the plate, ready to swing.
3) Potential Energy: stored in the bat as it is held above the height at which it makes contact with the ball.
4) Kinetic Energy: the bat is in motion as the player swings it around his body in order to hit the ball.
5) Sound Energy: produced when the bat makes contact with the ball.

Your turn!

Sport: ____________________

Technique: ____________________

Form of energy:

1)____________________

2)____________________

3)____________________

Objective: To understand that any movement is a combination of different forms of energy.

Have students pick a specific technique in the sport of their choice. Ask them to analyze the technique and report on the different forms of energy needed to successfully perform the technique.

Examples of techniques include:

- Baseball pitch
- Slapshot
- Tennis backhand
- Volleyball spike
- Three-metre dive

Take your students to the gym and have them try a few techniques, analyzing the different forms of energy at work. You can ask students to research the techniques online.

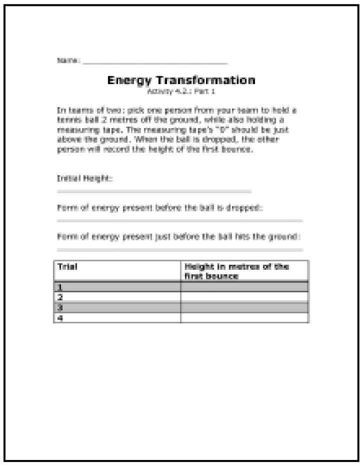
ACTIVITY 4.2: ENERGY TRANSFORMATION

(Suitable for Grades 4 to7)

Energy can be transformed from one form to another, but it can never be lost. If a battery is linked to a light bulb with copper wires, the light bulb will light up. In this simple example, the chemical energy stored in the battery is transformed into electrical energy, which travels through the wires to the bulb where it was transformed again into light and heat energy. Energy is sometimes transformed into less-desirable forms, such as heat in the case of a light bulb. By using a more efficient light bulb, more electrical energy will be converted into light, and less into heat.

These concepts also apply to sports. In this section, students will learn about energy transfer by observing and measuring the bounces of various balls, and by determining how different materials can affect the efficiency of energy transfer.

Part 1: Energy Transformation Efficiency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Energy Transformation

Activity 4.2.: Part 1

In teams of two: pick one person from your team to hold a tennis ball 2 metres off the ground, while also holding a measuring tape. The measuring tape's "0" should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Initial Height:

Form of energy present before the ball is dropped:

Form of energy present just before the ball hits the ground:

Trial	Height in metres of the first bounce
1	
2	
3	
4	

Objective: To observe that energy transformation is almost never 100% efficient.

Bring students outside, or into the gymnasium. Give each team of two students the following:

- A tennis ball
- A measuring tape (at least 2 metres in length)

1. Ask one student to stand on a chair and hold the ball 2 metres from the ground. That same student will hold a measuring tape next to the ball. The tape should be long enough to touch the ground.
2. Have the other student stand next to their classmate, and measure how high the ball bounces after it hits the floor.
3. Students should try this 3 or 4 times, and record their findings on the activity sheet.

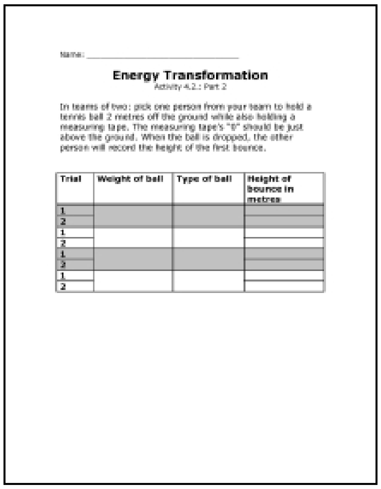
After the activity, discuss with students why the ball did not bounce back to its original height of two metres. Ask them to speculate how this energy was lost, and what type of energy it was transformed into.

When the ball is held two metres above the ground, it does not have any kinetic energy (it is not moving), but it does have potential energy (stored energy). When the ball is let go, the potential energy is transformed into kinetic energy. When the ball hits the ground, it gets slightly squished and deformed. It thus acquires another form of potential energy, called elastic potential energy, as the rubber from the ball tries to regain its original shape. This is equivalent to pushing down on a spring. As soon as the spring is released, it will regain its original shape.

The fact that the rubber molecules rub against one another during this squishing phase causes friction between them. This causes the ball to heat up, meaning that some of the energy has been transformed into thermal energy. This is one of the reasons why the ball will not bounce back up to its original height, and why a ball that is bounced frequently will feel slightly warm.

The sound that is heard when a ball bounces is also due to energy transformation; the kinetic energy of the ball is transformed into sound energy when the ball hits the ground.

Part 2: Influence of Materials on Energy Transfer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Energy Transformation

Activity 4.2.: Part 2

In teams of two: pick one person from your team to hold a tennis ball 2 metres off the ground while also holding a measuring tape. The measuring tape's "0" should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Trial	Weight of ball	Type of ball	Height of bounce in metres
1			
2			
1			
2			
1			
2			
1			
2			

Objective: To observe that material composition will influence how well energy is transferred.

Have students repeat the same experiment, but with different kinds of balls. Have them record their findings on the activity sheet.

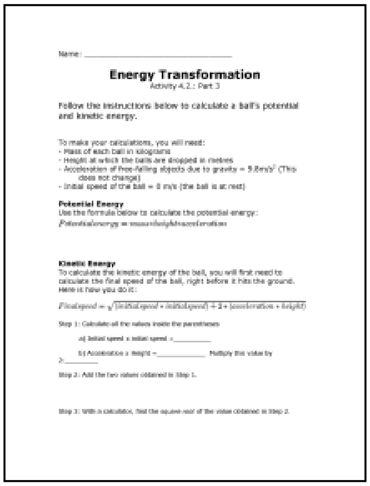
After the activity, discuss the influence that the different ball materials had on the height of the rebound.

Many balls are made of molecule chains called polymers. When the ball hits the ground, the molecules get squished and deformed. Some molecules are very quick to regain their original shapes, while others are not. It is the elastic properties of the molecule chains that determine whether or not a ball will be 'bouncy.'

Note: Temperature affects the way that molecules regain their original shape after being squished. Try freezing a tennis ball, and compare its bounce to that of a room-temperature ball.

Classroom Discussion: Using a relatively accurate infrared thermometer (a reasonably-priced tool available at most hardware stores), ask students to take the temperature of the ball before bouncing it, and again after bouncing it for a few minutes. Students will find that the temperature has increased — a sign that energy has been lost in the form of heat.

Part 3: Potential and Kinetic Energy (Grade 7)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Energy Transformation

Activity 4.2.: Part 3

Follow the instructions below to calculate a ball's potential and kinetic energy.

To make your calculations, you will need:
- Mass of each ball in kilograms
- Height at which the balls are dropped in metres
- Acceleration of free-falling objects due to gravity = 9.8m/s² (This does not change)
- Initial speed of the ball = 0 m/s (the ball is at rest)

Potential Energy

Use the formula below to calculate the potential energy:

Kinetic Energy

To calculate the kinetic energy of the ball, you will first need to calculate the final speed of the ball, right before it hits the ground. Here is how you do it:

Step 1: Calculate all the values inside the parentheses

Step 2: Add the two values obtained in Step 1.

Step 3: With a calculator, find the square root of the value obtained in Step 2.

Objectives: To understand the difference between potential and kinetic energy. To observe the transformation between the two forms. To introduce mathematical equations for the calculation of kinetic and potential energy.

Have students calculate each ball's potential energy before it begins to fall to the ground, and each ball's kinetic energy right before it hits the ground. Students will realize that the potential energy before the ball falls is equal to the kinetic energy right before the ball hits the ground.

This activity will allow students to visualize how energy is transformed.

Group Assignment: Building an Energy-Transforming Device

Motorsports are events and competitions that involve motorized vehicles such as car racing, motorcycle racing, air racing (airplane racing), boat racing, or even lawnmower racing. Although the success of the participants is not necessarily dependent on their physical fitness, as in more traditional sports, their understanding of energy transformation is just as important.

In an internal combustion engine, the chemical energy stored in the gasoline and the oxygen will, after being ignited, release thermal energy (heat). This thermal energy will expand the gases within the cylinders and apply pressure to the pistons, moving them over a certain distance. The pistons will therefore have kinetic energy. This kinetic energy is then transferred to various parts of the vehicle.

Ask your students to design, build, and test a device that transforms one form of energy into another. Have them work in groups of three or four. You can ask the whole class to build the same device, or ask each group to choose the device they would like to build.

Deeper Study: Electrical Signals in the Human Body

(Suitable for Grade 6 and 7)

Electrical energy is not only found in lightning and circuits; it can also be found in the bodies of animals such as humans.

A group of cells in the heart is responsible for creating electrical impulses that maintain the steady rhythm of our heartbeats. We can measure the electrical activity in our heart with a device called an electrocardiograph (also known as an ECG or EKG).

Students can research topics related to irregular heartbeat, such as:

- The pacemaker: a medical device that delivers electrical pulses to heart muscles in order to regulate the heartbeat.
- Arrhythmia: a broad medical condition in which the heart's natural electrical pulses are abnormal, causing an abnormal heartbeat.
- Tachycardia: a type of arrhythmia in which the heart beats too fast.
- Bradycardia: a type of arrhythmia in which the heart beats too slowly.
- Electrocardiograph: a device that measures the electrical activity in the heart.

Name: ________________________________

Chemical Energy Log

Activity 4.1: Part 1

	Breakfast	Snack	Lunch	Snack	Dinner
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					

Name: ________________________________

Chemical Energy Log

Activity 4.1: Part 2

For each food item eaten in one day, fill out a row in the table below.

Food	**Portion size in grams** **(this can be an approximation)**	**Calories per portion** **(find this information on the label)**	**Total amount of calories ingested from this food item** **(portion size x Calories per portion)**
Example: 2 Caramel chocolate bars	*56 g*	*273.28 Cal for 56 g*	*(2 X 273.28) 556.56 Cal*

Name: ________________________________

Forms of Energy

Activity 4.1: Part 3

Choose a technique from your favourite sport and analyze the forms of energy needed to perform that technique.

Example: Swinging a baseball bat

1) Chemical Energy: the food that the player has eaten, and the oxygen they have inhaled allows them to have energy to play.
2) Muscular Energy: the energy from the food is used by the muscles to move the bat behind the player's body as he is standing at the plate, ready to swing.
3) Potential Energy: stored in the bat as it is held above the height at which it will make contact with the ball.
4) Kinetic Energy: the bat is in motion as the player swings it around his body in order to hit the ball.
5) Sound Energy: produced when the bat makes contact with the ball.

Your turn!

Sport: ____

Technique: ____

Form of energy:

1) ____

____

2) ____

____

3) ____

____

Name: ________________________________

Energy Transformation

Activity 4.2.: Part 1

Form a team of two. Pick one person from your team to hold a tennis ball two metres off the ground, while also holding a measuring tape. The measuring tape's '0' should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Initial height: _____________________________________

Form of energy present before the ball is dropped:

____

Form of energy present just before the ball hits the ground:

____

Trial	**Height in metres of the first bounce**
1	
2	
3	
4	

Name: ___________________________________

Energy Transformation

Activity 4.2: Part 2

Form a team of two. Pick one person from your team to hold a tennis ball two metres off the ground, while also holding a measuring tape. The measuring tape's '0' should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Trial	Type of ball	Height of bounce in metres
1		
2		
1		
2		
1		
2		
1		
2		

Name: ________________________________

Energy Transformation

Activity 4.2: Part 3

Follow the instructions below to calculate a ball's potential and kinetic energy.

To make your calculations, you will need:

- Mass of each ball, in kilograms
- Height from which the balls are dropped, in metres
- Acceleration of free-falling objects due to gravity = 9.8 m/s^2 (This does not change)
- Velocity: Initial speed of the ball = 0 m/s (the ball is at rest)

Potential Energy (PE):
Use the formula below to calculate the potential energy:

$$Potential\ energy\ (j) = mass(kg) \times height(m) \times acceleration(\frac{m}{s^2})$$

Example: if the ball is 0.5 kilogram and it raised 1 meter, what is the PE?

PE= 0.5 kg x 9.8 m/s^2 x 1 m

= 4.9 kg m/s^2

= 4.9 j

Kinetic Energy:
To calculate the kinetic energy of the ball, you will first need to calculate the final speed of the ball, right before it hits the ground. Here is how you do it:

$$Final\ speed = \sqrt{((\ initial\ speed \times initial\ speed) + 2 \times (acceleration \times height))}$$

Step 1: Calculate all the values inside the parentheses

a) Initial speed x initial speed =__________

b) Acceleration x Height =_____________ Multiply this value by 2:_________

Step 2: Add the two values obtained in Step 1.

Step 3: With a calculator, find the square root of the value obtained in Step 2.

The answer for Step 3 will give you the final speed of the ball.
To calculate the kinetic energy, use the following formula:

$$Kinetic\ energy\ (j) = \frac{1}{2} \times mass\ (kg) \times final\ speed\ \left(\frac{m}{s}\right) \times final\ speed(\frac{m}{s})$$

Type of ball	Mass	Height	Potential energy	Final Speed	Kinetic energy

Compare the potential energy before the fall, and the kinetic energy at the end of the fall. What do you notice?

____

____

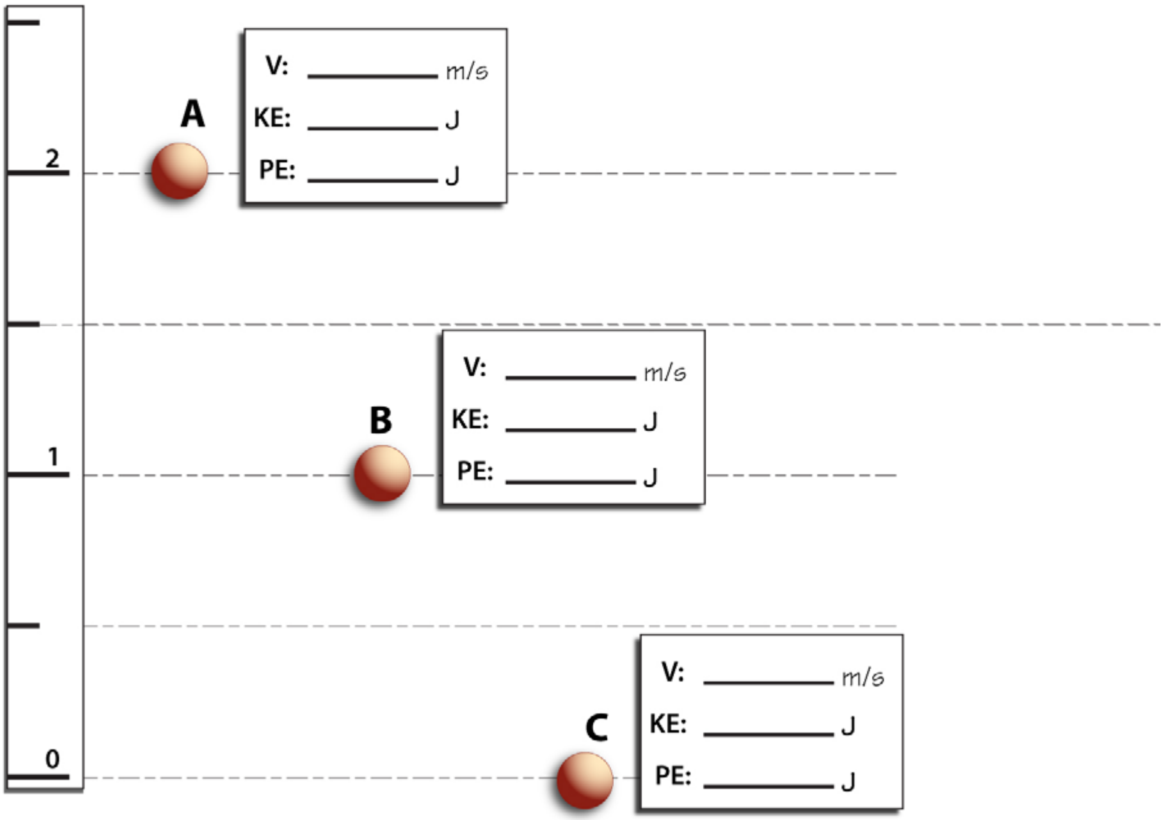
Calculate the kinetic energy of a ball at rest (The final speed is equal to zero, because the ball is not moving). To calculate this, use the formula below.

$$Kinetic\ energy = \frac{1}{2} \times mass\ \times final\ speed \times final\ speed$$

Calculate the potential energy of the ball right before it hits the ground (the height will be equal to zero). To calculate this, use the formula below.

$$Potential\ energy\ (j) = mass(kg) \times height(m) \times acceleration(\frac{m}{s^2})$$

In this diagram, insert the correct amount of potential energy and kinetic energy at each stage of the fall. Use the values you have calculated for the tennis ball in the above exercises.

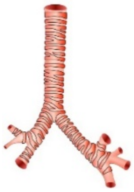


The Science of Sports: Answer Sheets

Please note that answers to questions based on students' observations and reflections are not provided.

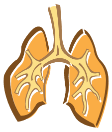
Activity 2.1: Part 1: Organs of the Respiratory System

Answers may vary but should include: The nose (and mouth) is the organ responsible for getting oxygen into the body, and carbon dioxide out of the body. (In addition: The nose contains hairs and mucus that trap airborne particles.)

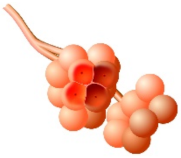


Answers may vary but should include: The trachea is the long tube that links the nose and mouth to the lungs. The trachea will separate into two tubes, called bronchi.

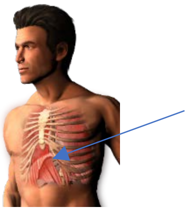
(In addition: The air travels from the nose, down the trachea and through the bronchi. Inside the lungs, the bronchi divide into many smaller tubes, ending in small air sacs called alveoli.



Answers may vary but should include: The lungs are organs that allow oxygen from the air to enter the bloodstream, and carbon dioxide from the blood to seep out of the blood and exit the body through the nose and mouth.



Answers may vary but should include: Alveoli are small air sacs. They are located at the very end of a series of tubes. It is in the alveoli that oxygen from the air enters the bloodstream, and carbon dioxide exits.



Answers may vary but should include: The diaphragm is a muscle located inside the ribcage which contracts to allow air to enter the nose and mouth. (In addition: When it contracts, the diaphragm increases the space inside the ribcage, allowing air to flow in. When it expands, the diaphragm decreases the space inside the ribcage, forcing air out.)

Activity 2.1.: Part 2: Breathing Simulator

Describe what happens when you pull down on the elastic material: *The balloon inside the bottle will inflate.*

Can you explain why this happens? *Pulling down on the elastic material increases the space inside the bottle. The air from the outside tries to fill that space, but gets caught inside the balloon. The balloon then inflates.*

Describe how this breathing simulator represents the human respiratory system:

- What part of the respiratory system is represented by the elastic material? *The diaphragm*
- What part of the body is represented by the plastic bottle? *The ribcage*
- What part of the respiratory system is represented by the balloon? *The lungs*
- What part of the respiratory system is represented by the opening of the bottle? *The nose and mouth*

Activity 2.1.: Part 4: The Effects of Exercise

Have a friend record how many breaths you take during a span of 20 seconds. Complete the table below. *Various Answers*

After making your graph, what can you say happens to the number of breaths per minute when you exercise? *The number of breaths should increase.*

Why do you think this happens? *Muscles need more oxygen, and need to get rid of carbon dioxide faster, when we exercise.*

Activity 2.2.: Part 3: Pulse meter

On a separate sheet of paper, graph the beats per minute (b) over time. You can use the example below as a guide. *Various Answers*

What happens to the heart rate (beats per minute) as you increase the amount of exercise time? *The heart rate should increase.*

Why do you think this happens? *Muscles need more oxygen, and need to get rid of carbon dioxide faster when we exercise. The blood needs to circulate faster for this to happen.*

Activity 2.3.: Part 3: Levers in Sports

Possible Example: Sport: *Rowing*

Describe at least one way in which a player uses a lever: *The oar is used as a lever to push the boat forward.*

Is this lever part of the player's body? *No, but the force on the lever is applied by the arms of the rower.*

Describe where the fulcrum, the rod, the force and the weight are in relation to one another:
The rod is the oar itself. The force is applied at the edge of the rod, where the rower's hands connect with the oar. The weight is the weight of the whole boat. The fulcrum in this example is the water.

How does this lever increase the ability of the player to perform? *The oar allows the boat to go much faster than if the rower used only their hands.*

What would happen if the players could no longer use the lever? Would they still be able to play?
The rowers could use only their arms and hands to propel the boat, but this would take much longer.

Activity 2.4: Part 1: What is Sweat?

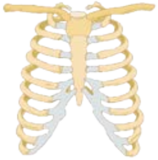
	Distilled water	Distilled water + salt	Distilled water + sugar	Sport drink	Other liquid
Did the LED light up?	*NO*	*YES*	*NO*	*YES*	*NO*

When did the LED light up? What substance had to be present? *The LED only lit up in the presence of salt. The LED also lit up for the sports drink because it also contains salt.*

Why do you think this substance is present in sports drinks? *Salt is necessary for the body to function. It regulates how much water can enter cells, where it is needed.*

Activity 3.1: Part 1: Classify the Structure

Classify each structure as a solid, frame or shell structure.

Helmet  Shell	Hockey stick  Solid
Baseball bat  Solid	Human ribcage  Frame
Goalie net  Frame	Human skull  Shell
Bicycle  Frame	Stadium wall  Answers may vary