

The Canada Science and Technology Museum  
presents

**Cycle-ology:  
A Virtual Exploration  
of the Bicycle**

**Section 3: Cycling Science**



## Introduction

This module investigates the scientific principles behind the bicycle. Through these activities, students will explore the various parts and systems of this human powered vehicle and gain a better understanding of the scientific concepts behind this amazing invention.

Teachers may request an answer package for more detailed Activity Sheets by e-mailing [virt\\_prog@technomuses.ca](mailto:virt_prog@technomuses.ca). Please allow at least a week for us to reply.



# Activity 3.1: Bike Anatomy

Suitable for Grades 4 – 6



Purpose: Students will identify basic bicycle parts, their utility and how they contribute to the proper function of the bicycle.

## Individual Activity

Using the school library and internet resources, have your students identify the parts of a bicycle, using Activity Sheet 3.1a

Then, using Activity Sheet 3.1b, have students pair each bicycle part to their appropriate function.



These websites provide excellent resources for this activity:

How Stuff Works

<http://science.howstuffworks.com/bicycle1.htm>

The Bicycle Doctor

<http://www.bicycledoctor.co.uk/parts.html>

Think Quest – Cycling

[http://library.thinkquest.org/11569/html\\_home/html\\_rbiking/parts.html](http://library.thinkquest.org/11569/html_home/html_rbiking/parts.html)

## Group Activity

Once students have identified the principal bicycle parts and their functions, divide the classroom into smaller groups. Taking into consideration the function of each bicycle part, teams must now rank the bicycle parts from the most important part of the bicycle to the least important. Students will debate over which parts are the most important and come to a consensus. After 15 minutes, have a speaker from each group read their list out loud to the class and justify the reasons for their ranking. While students share their answers, the teacher is invited to play devil's advocate.



## Class Discussion

After completing these activities, discuss the following questions with your class:

- Can you name a part of the bicycle that is not important?
- Can each part of the bicycle work independently?
- Is one bicycle part more important than another?
- How do bicycles work? Why are they so effective?



Through this class debate, students will realize that no specific part of the bicycle is more important than another. They all contribute in the proper function of the machine. The frame holds the handlebars, seat, and the wheels; the handlebars help the bicycle turn, the wheels enables the bicycle to move forward, etc. The individual components of a bicycle cannot work independently and, if you remove a part, the bicycle cannot work efficiently. Only accessories are independent, for example the bell, basket, etc.

In fact, the bicycle is a complex machine — a point we'll examine in Activity 3.2.

# Activity 3.2: Simple Machines

Suitable for Grades 4 – 6

Purpose: Students will identify and describe the functions of the simple machines found on a bicycle.

## Class Discussion

Discuss the importance of simple machines with the class. Why are simple machines so important? How do they improve our lives on a daily basis?

Simple machines help us do our work. They maximize our use of our muscle power to assist in everyday tasks. Simple machines improve our lives as they are tools that make work easier.

Ask students to name the six different types of simple machines and review their definitions as a class.

These websites are valuable for information on simple machines:

Canada Science and Technology Museum's website:

[http://www.sciencetech.technomuses.ca/english/schoolzone/Info\\_Simple\\_Machines2.cfm#simple](http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Simple_Machines2.cfm#simple)

Edheads — Simple Machines

<http://www.edheads.org/activities/simple-machines/>



## The Hunt for Simple Machines

Distribute copies of Activity Sheet 3.2a. Have the students search the classroom and school grounds for as many simple machines as they can find within a given time period. Once they have identified a simple machine, have them place it in the proper category.

### Tips for Teachers

It is important that you add several objects in the classroom prior to the lesson in order to have objects that represent all six categories of simple machines. See the answer sheet for examples of objects.

Once the students return from their hunt, list their answers on the board.

## The Complex Machines

To expand on the *Hunt for Simple Machines* activity, ask students if they found any objects that could fit into more than one category — that is an object that has two or more simple machines working together (a complex machine). Inform the students that the bicycle is a complex machine as it has more than one simple machine working together to have it run efficiently. Distribute Activity Sheet 3.2b to the students and have them identify the simple machines found on a bicycle and describe how they work together to make the bicycle work.

## Student Essay

Conclude this activity by having the students write a short essay or story about the practicality of simple machines and how they make our lives easier. Have them imagine a world without simple machines. What impact would that have on their daily lives?



Name: \_\_\_\_\_

**Activity 3.2a**  
**A Hunt for Simple Machines**


Search your classroom and school grounds for as many simple machines as possible. Once you have identified a simple machine, list it in the appropriate category.

Simple Machine	Object
	
	
	
	
	
	

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Name: \_\_\_\_\_



**Activity 3.2b**  
**Complex Machines**

A bicycle is a complex machine — it's made of many simple machines.

1. Can you find the simple machines on a bicycle?
2. How do these simple machines work together to make the bicycle function?
3. What do you think would happen to the bicycle if we removed one of its simple machines?
4. Can you list other objects that contain simple machines?

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## Activity 3.3: Gearing Up!

Purpose: Students will learn the purpose of gears and determine gear ratio advantage.

### Class Discussion

Suitable for Grades 4 – 6

Discuss the importance of bicycle gears with the class. You will find information on these websites:

Canada Science and Technology Museum

[http://www.sciencetech.technomuses.ca/english/schoolzone/Info\\_Simple\\_Machines2.cfm#gear](http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Simple_Machines2.cfm#gear).

Exploratorium – Science of Cycling

<http://www.exploratorium.edu/cycling/gears1.html>

How Stuff Works – Bicycle Gears

<http://www.howstuffworks.com/bicycle3.htm>



Ask the class the following questions:

- What purpose do gears serve on a bicycle? What are the benefits of gears?
- What would happen to a bicycle if its gears were removed?
- Other than the bicycle, where else are gears found?



### What Are Gear Ratios?

Suitable for Grades 5 – 6

Explain to the class that gear ratios are calculated by dividing the number of teeth on the front sprocket by the number of teeth on the rear sprocket. This ratio determines how many revolutions the back wheel will make for every complete turn of the front chain wheel. Gear ratios also help in calculating the distances travelled by multiplying the gear ratio by the circumference of the bicycle wheel.



For instance, if the front sprocket of the bicycle has 50 teeth and the back sprocket has 25 teeth, its gear ratio is 2:1 (i.e. for every front chain wheel revolution, the back wheel will turn twice). If the wheel's circumference is 1.5 metres, the distance travelled would be 3 metres per pedal revolution. ( $1.5 \times 2 = 3$ )

Have students visit the following websites to learn more about gear ratios:

The Exploratorium

<http://www.exploratorium.edu/cycling/gears1.html>

How Stuff Works

<http://www.howstuffworks.com/bicycle4.htm>



### Demonstration of Gear Ratios

Suitable for Grades 5 – 6

The best way to explain gear ratios is by demonstrating this using a bicycle. Turn a bicycle upside down in order for the students to see the chain gear. Set the bicycle to its largest gear ratio. Invite the students to count the number of teeth on the front and back sprockets. Using this information to calculate the gear ratio, ask the class how many revolutions the back wheel will make for every complete turn of the front sprocket. To verify the answer, use masking tape or chalk to make a reference mark of the wheel and turn the pedals. Have the class count the number of revolutions made by the back wheel. Was the class correct? Did they have the appropriate gear ratio?



To calculate the distance of travel for each pedal revolution, remind the class of the mathematical calculation (gear ratio multiplied by the circumference of the wheel). Using chalk or masking tape,

identify the distance travelled by the bicycle at the beginning and end of one pedal revolution. It should match the students' answer.

## Gear Ratio Exercises

### Suitable for Grades 5 – 6

To close the lesson, have students solve the gear ratio problems found in Activity Sheet 3.3.



Name: \_\_\_\_\_

#### Activity 3.3 Gear Ratios



Can you solve these gear ratio problems?

- If the front sprocket of your bicycle has 48 teeth and the back sprocket has 20 teeth, how many revolutions will the back sprocket make for every complete revolution of the front sprocket? \_\_\_\_\_
  - If the chain length of your bicycle is 1.5 metres, how far would you travel in one complete revolution of the pedals? \_\_\_\_\_
  - If you are pedalling at a constant speed of 60 revolutions a minute on the back, what distance will you have travelled if you cycle 10 minutes? \_\_\_\_\_
- If the front sprocket of your bicycle has 48 teeth and the back sprocket has 15 teeth, how many revolutions will the back sprocket make for every complete revolution of the front sprocket? \_\_\_\_\_
  - If the chain length of your bicycle is 1.5 metres, how far would you travel in one complete revolution of the pedals? \_\_\_\_\_
  - If you are pedalling at a constant speed of 60 revolutions a minute on the back, how many kilometres will you have travelled in 10 minutes? \_\_\_\_\_
- If the front sprocket of your bicycle has 48 teeth and the back sprocket has 11 teeth, how many revolutions will the back sprocket make for every complete turn of the front sprocket? \_\_\_\_\_
  - If the chain length of your bicycle is 1.5 metres, how far would you travel in one complete revolution of the pedals? \_\_\_\_\_
  - If you changed gears so that the back sprocket now had 12 teeth, how far would you travel in one complete turn of the pedals? \_\_\_\_\_

## Activity 3.4: The Wheel Story

Purpose: Students will recognize that the wheel and axle has been incorporated in the design of many structures throughout history in order to make work easier.

### The Wheel Invention Timeline

Suitable for Grades 4 – 6



The wheel is one of the world's greatest mechanical devices. The earliest wheel documented dates back to about 3500 BC. With time inventors incorporated the wheel and axle in the fabrication of simple machines and simplified the lives of many people as it made work much easier. Using the school's library resources and the internet, have students investigate the history of the wheel and axle and its many functions. What early and modern inventions have incorporated the wheel and axle into their structure? Who used these inventions and why?

Invite the class to create a large wheel invention timeline. Using brown craft paper posted to the wall of a hallway, have students decide on the year increments in order to draw a timeline. Using magazines, catalogues, newspapers and personal drawings, have students locate images of inventions that have incorporated the wheel and axle in its design. Have students place the image of the inventions they have found on the timeline under the year it was first introduced.

### Student Essay

Suitable for Grades 6 +

Complete the lesson by having students write an essay on how a historical group of people used a wheeled device to help them work.



## Activity 3.5: Archimedes and the Number $\pi$

Suitable for grades 5-6

*Adapted from Jeux de vélos with the permission of the Société pour la promotion de la science et de la technologie.*



**Purpose:** Students will discover the number pi and learn that the diameter of a wheel has an influence on a cyclist's performance.

Ask students if they cycled with their parents when they were young. Perhaps they noticed that, even though the adults were pedalling slowly, the children had to work a lot harder just to keep up. Here's why: the adults were riding on large wheels, while the children were riding on small wheels.

To understand why wheel size makes a difference, we need to look at the number  $\pi$  (pi), discovered by Archimedes in ancient Greece. This number expresses the ratio of the circumference of a circle to the diameter of the circle: in other words, the distance a wheel travels in one turn, divided by the wheel's diameter.



Ask students to write down the value of  $\pi$ . The number  $\pi$  is, to an accuracy of 64 decimal places: 3.1415926535897932384626433832795028841971693993751058209749445923

### Did You Know?

$\pi$  was the first discovered member of a class known as *irrational numbers*. These are numbers that can't be represented by a ratio of two integers. The decimal part of  $\pi$  never ends; it can be calculated to as many decimal places as desired. The digits do not repeat or form any recognizable pattern.  $\pi$  has been calculated to literally billions of decimal places.

For most purposes, an accuracy of 6 or 7 decimal places is more than adequate: 3.1415926



Since the  $\pi$  is a constant, the larger the diameter of a bicycle wheel, the greater the distance the wheel travels in one turn of the pedals. In fact, the 1880s *High-Wheel* bicycle could attain considerable speed because it had a very large front wheel and a small rear wheel. Since the front wheel diameter could be as large as 2.5 metres, one turn of the pedals went a long way!

### Experiment: Following in Archimedes' Footsteps

#### Materials:

For each team:

- One or more bicycles
- A piece of chalk
- A measuring tape

#### Preparation

Divide the class into small teams.

#### Procedure

1. Measure the diameter of a wheel of the bicycle.
2. Make a chalk mark on the sidewall of the tire and another chalk mark on the ground. Be sure the two marks are lined up together.

3. Push the bicycle forward until the wheel has completed exactly one turn, and then make a second chalk mark on the ground.
4. Measure the distance between the first and second chalk marks and record the result.
5. Repeat Steps 3 and 4 at least three times to minimize any error.

### Extra Challenges

- Repeat the experiment using a bicycle with wheels of a smaller diameter. Write down these new results.
- Repeat the experiment while making measurements as accurately as possible. Use the distance between the marks and the wheel diameter to calculate  $\pi$  to as many decimal places as possible. Which team will obtain the longest series of correct figures for the number pi ( $\pi$ )?



## Experiment: Tied Strings

### Materials:

Materials required:

- A two-litre plastic bottle
- String
- Sticky tape
- Two light weights
- A measuring tape

### Preparation:

**Note:** Complete the preparation before your class arrives.

1. Tie a string around the body of the bottle and another around the neck of the bottle. Use sticky tape to make sure the strings adhere to the bottle.
2. By holding the bottle horizontally and rotating it, roll the strings around the bottle several times.
3. Still holding the bottle horizontally, cut both strings evenly at the bottom. Attach a small weight to each string. Unroll the strings to their full length.

### Procedure

1. Hold the bottle horizontally with the weighted strings dangling. Explain that you are going to rotate the bottle, wrapping the strings around it.
2. Ask the students which string will win the race and be wound up first.
3. Rotate the bottle to wind up the strings. Which string won the race?

### Discussion

Many people might think that the shorter string would win. But no! The two strings will be “tied” — they will be wound up at the same time, every time.

Why are the strings “tied?”

It’s  $\pi$ ’s fault! Whatever the radius (“ $r$ ”) of a circle, the circumference is always equal to  $2\pi r$ . So, each turn of the bottle winds up each of the strings one turn (one turn being equal to the circumference of the bottle, wherever the string is tied). And, because the number of turns is the same for each string, they both finish being wound up at the same time.

# Activity 3.6: Bicycle Frames

Suitable for Grades 3 – 6

Purpose: Students will discover that the diamond (or triangular) shape is the most effective in making bicycle frames and that its design is so successful it hasn't changed for more than a century.

## Web Exploration

A bicycle frame is an important part of a bike as it supports and distributes the cyclist's weight and holds together all its various components

Have students visit this Exploratorium website:

<http://www.exploratorium.edu/cycling/frames4.html> to learn more about the bicycle frame and have them answer the following questions:

- What are the functions of the frame? (*Holds all the bicycle parts together, positions and supports the rider, makes pedalling efficient due to light weight, gives strength but is light in weight*)
- What geometric shape is commonly used to design the bicycle frame? (*The diamond shape which is divided by two back to back triangles*)
- Why is this shape so effective for a bicycle frame? (*The triangle shape is very strong and can support the weight of the frame and the cyclist*)

Have students locate and draw other examples of objects that rely on this shape for strength and stability. You may find these objects simply by observing your surroundings or by surfing the internet for ideas.

Have students visit the Canada Science and Technology Museum's website on structures to learn more: [http://www.sciencetech.technomuses.ca/english/schoolzone/Info\\_Structures.cfm#bridge3](http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Structures.cfm#bridge3)

## The History of Bicycle Frames

Invite students to explore the Canada Science and Technology Museum's web pages on the history of bicycles:

<http://www.sciencetech.technomuses.ca/english/collection/cycles.cfm>.

Have students illustrate the various frames of these historical bicycles and encourage them to compare and examine the different shapes and designs. Ask students to identify the cycle which incorporated the triangle or diamond shape for the first time. How did bicycle makers arrive at this shape? How has this shape influenced the design of the modern bicycle?



# Activity 3.7: Bicycle Materials

Purpose: Students will determine which materials are the most suitable for the fabrication of bicycle frames.

## Materials used in the Past

### Suitable for Grades 4 – 6

Throughout history, inventors, makers and mechanics have used various materials to fabricate their bicycles. Have students explore the Canada Science and Technology Museum’s web pages at:

<http://www.sciencetech.technomuses.ca/english/collection/cycles.cfm>

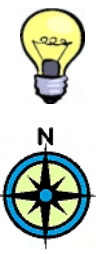
and list the different materials used in the construction of the wheels and frames of these bicycles. For each material listed, have students write the advantages and disadvantages of the material. Students can record their answers on Activity Sheet 3.7a.

Name: \_\_\_\_\_

**Activity 3.7a  
Bicycle Materials**  
Identify the materials used to make the following historical bicycles. Indicate the advantages and disadvantages of the material used in its construction.

Bicycle	Material Used	Advantages	Disadvantages
			
			
			
			

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## Selecting Materials

### Suitable for Grades 4 – 6

The addition of materials such as steel tube frames and pneumatic tires revolutionized the bicycle in the late 19<sup>th</sup> century by increasing its speed, stability and comfort substantially. The bicycle improved furthermore well into the 20<sup>th</sup> century as inventors and makers began fabricating bicycle frames using new materials.

Invite students to consult the Exploratorium website on frames and materials at:

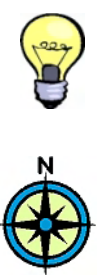
<http://www.exploratorium.edu/cycling/frames1.html>

and the Bike Frames website at:

<http://www.bikeframes.co.uk/>

Using the school’s library resources as well as the internet, have students answer the following questions:

- Name the principal materials used in the fabrication of bicycle frames today.
- Why are these materials popular with bicycle makers?



## Yield Strength, Ultimate Strength, and Elasticity

### Suitable for Grades 5 – 6

Test students knowledge of materials by completing the science experiment “Yield Strength, Ultimate Strength, and Elasticity Activity” found on the Exploratorium’s website at:

<http://www.exploratorium.edu/cycling/frames3.html>

Prior to the activity, gather the objects required to complete the experiment. Divide the class into groups and have them list their observations on the Activity Sheet 3.7b.

Name: \_\_\_\_\_

**Activity 3.7b  
Yield Strength, Ultimate Strength and Elasticity**  
Use the following materials and do the following experiment. Record your observations and complete the table through Yield Strength and Elasticity of these materials. Write your team's observations in the grid below.

Material	Elasticity	Yield Strength	Ultimate Strength
			
			
			
			
			

Which of these materials is the most appropriate for the fabrication of a bicycle frame? Be specific, name and describe the object you name.

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# Activity 3.8: Aerodynamics of Cycling

Suitable for Grades 6 – 7

Purpose: Students will learn about aerodynamic forces that affect cyclists' performance.

## Class Discussion

Ask the class what happens when they ride their bicycle against the wind. Why does this problem occur?



This problem is due to drag. Drag is the resistance that a cyclist encounters when he or she is moving through air. This resistance occurs because the human's shape is not designed to slice through the air. Ask the class to name a shape that cuts through air; such a shape is known as an *aerodynamic shape*. (Examples: domes, ovals, cones, spheres)

Drag or wind resistance is an important issue to cyclists who wish to increase their speed and conserve their energy. Unfortunately, wind resistance increases as you cycle faster. To demonstrate that wind resistance increases with speed, ask the class if they have ever placed their hand outside a window of a moving car. What happens to your hand when the vehicle increases its speed?

These websites have extra information on cycling and aerodynamics:

Exploratorium — Science of Cycling  
<http://www.exploratorium.edu/cycling/aerodynamics1.html>

Society of Women Engineers — Aerodynamics of Cycling  
[http://www.swe.org/iac/lp/cycling\\_03.html](http://www.swe.org/iac/lp/cycling_03.html)



## Drag Demonstration

To demonstrate the effects of drag on the cyclist invite the students to try this outdoor experiment. Have students descend a hill on their bicycles. They must push off and let the bicycle go down the hill without using their pedals. For the first part of the experiment the participant should sit up straight. Have another student record the time that it took for his classmate to cycle from the top of the hill to the bottom. Repeat the experiment using a more aerodynamic posture, that is the student crouches his or her back into a rounded position. Was there a time difference? Why?



## Aerodynamic Improvements

To decrease drag bicycle makers, as well as cyclists, have adapted not only the design of the bicycle but also the riding position of the cyclist.

Have students describe the aerodynamic improvements in the sport of cycling that has contributed to improving the cyclist's performance by reducing drag and wind resistance. Include aerodynamic modifications in the design of wheels, frames, riding techniques, body position and clothing and equipment. Have students list their answers in Activity Sheet 3.8.

Name: \_\_\_\_\_

**Activity 3.8**  
**Aerodynamic Improvements**

Can you describe the aerodynamic improvements in the sport of cycling that have contributed to improving the cyclist's performance by reducing drag and wind resistance? Include aerodynamic modifications in the design of wheels, frames, riding techniques, body position and clothing and equipment.

Features	Aerodynamic Improvements
Wheels	
Frames	
Riding Techniques	
Body Position	
Clothing and Equipment	



## Student Essay

Ask students to list other sports where aerodynamics may affect an athlete's performance. Have each student write an essay on a specific sport that has modified its equipment and design in order to reduce wind resistance.



## Drafting

Has anyone ever watched the *Tour de France* or other cycling races on television or in person? Have you ever noticed that cyclists ride close behind each other in a pack? Why do cyclists do this?



When cyclists pull up close behind each other they are drafting. The advantage of drafting is to conserve energy as the rider in front of you is doing the work of pushing the air in front of them, while the others behind him are riding the draft and conserving their energy. This is why cyclists racing in teams take turns at being the leader, each member is taking turns at preserving their energy.

Ask students to name other sports, where athletes use drafting in order to conserve energy. (*Examples: speed skating, car racing*)

# Activity 3.9: Forms of Energy found in Transportation

Suitable for Grades 4 – 6

Purpose: Students will recognize the forms and sources of energy used by various modes of transportation.

## Web Exploration

Different modes of transportation use different forms of energy. From food to fossil fuels, there are many sources of energy that allow you to travel from point A to point B.

Have students explore the Canada Science and Technology Museum's web pages on the theme of energy at:

[http://www.sciencetech.technomuses.ca/english/schoolzone/Info\\_Energy.cfm#transportation](http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Energy.cfm#transportation).

Using this site, invite students to complete Activity Sheet 3.9 and identify the form and source of energy used in various modes of transportation.



Name: \_\_\_\_\_

**Activity 3.9**  
**Forms of Energy Found in Transportation**  
What form and source of energy are used by the following modes of transportation?

Mode of Transportation	Form of Energy	Source of Energy
 Bicycle		
 Boat		
 Bus		
 Train		
 Car		
 Motorcycle		
 Plane		

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# Activity 3.10: Energy Transformations

Suitable for Grades 5 – 7

*Adapted from Jeux de vélos with the permission of the Société pour la promotion de la science et de la technologie.*

**Purpose:** Students will identify a series of energy transformations explaining that bicycles work on solar energy.

When you're cycling, you make a large number of energy transformations. You can't see energy, but you can see its effects — for example, when things move. You can't create or destroy energy, but you can convert it from one form to another.

When you want to set an inanimate object in motion, you have to push or pull it; when you want your bicycle to move forward, you have to push the pedals. That takes energy.

The energy that moves your bicycle forward comes from the work done by the muscles of your body. Those muscles obtain energy from the food you have eaten. If you ask yourself where the energy comes from, at each step farther back along the energy chain, you end up with a long series of energy transformations. Eventually, all energy transformations lead back to the sun. So it's not hard to figure out that bicycles actually work on solar energy!

## The Energy Chain

Have the students cut out the boxes from Activity Sheet 3.10. Have them place the energy transformations in the correct order to demonstrate how bicycles actually work on solar energy.



# Activity 3.11 Bicycles and Energy Efficiency

Suitable for Grades 5 – 7

*Adapted from Jeux de vélos with the permission of the Société pour la promotion de la science et de la technologie.*

Purpose: Students will compare the energy consumption of various modes of transportation and will discover that the bicycle is the most energy efficient.

The energy efficiency of a means of transportation is the amount of energy required for a person using that means of transportation to move its own weight over a given distance. To understand the concept of energy efficiency, ask students this question: using a given means of transportation, how much energy does it take to move one person one kilometre?

## Who Consumes the Least Energy to Move the Same Distance?

Discuss the following with the class.

A good cyclist will consume about 15 kilocalories (kcal) of food energy in order to move one kilometre. If you compare the quantity of energy consumed (in terms of food calories) with the quantity of work produced (in terms of movement), the human body on a bicycle is more energy-efficient than all other means of transportation, including motor vehicles.



As well, the quantity of energy required for movement may be influenced by the weight of the load to be moved and the type of vehicle used.

For a given means of transportation, energy efficiency is always calculated in terms of one person.

To understand the concept of energy consumption, have students consider these facts.

- When you move, air resistance causes some loss of energy. The faster you move, the greater the resistance.
- Water creates greater resistance than air.
- Motor vehicles take nearly as much energy to move one person as they take to move a number of persons.
- Lifting an arm or leg requires energy because each movement must overcome gravity.

Have students cut out the boxes in Activity Sheet 3.11. Instruct students to arrange the means of transportation in order, starting with the one with the greatest energy efficiency.

Which means of transportation uses the least energy to move one person one kilometre?



Name: \_\_\_\_\_

**Activity 3.11**  
**Energy Efficiency**

Use the following means of transportation to order, starting with the one with the greatest energy efficiency.

One driver and four passengers

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# Activity 3.12 Speed Record

Suitable for Grades 4 – 6

*Adapted from Jeux de vélos with the permission of the Société pour la promotion de la science et de la technologie.*

Purpose: Students will learn that the bicycle is the fastest mode of transportation working on human power.

Did you know that cycling is the fastest of all human-powered means of transportation?

Discuss the following questions with the class.

- Why is cycling so fast?
- What makes bicycles such a speedy way to get around?



Wheels are what make bicycles so fast. Wheels allow humans to move faster, over longer distances, and with less fatigue. By using bicycles, humans can attain speeds three or four times greater than by walking or running.

## Who is the Fastest?







Ask the students to cut out the boxes in Activity Sheet 3.12 and have them associate each sport to its corresponding speed record.

**Note:** If you want to complete this activity more than once, you can glue the two sets of boxes to a piece of cardboard before cutting out the boxes. Then arrange the corresponding “sport” and “speed” boxes side-by-side.

Name: \_\_\_\_\_

**Activity 3.12**  
**Who's the Fastest?**

Can you find the fastest and slowest mode of transport for each sport?

6 kilometres per hour	13 kilometres per hour	92 kilometres per hour
25 kilometres per hour	42 kilometres per hour	48 kilometres per hour
70 kilometres per hour		

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## Bar Graph

Have students create a bar graph comparing the energy efficiency of various means of transportation.

# Activity 3.13: Science of the Bicycle Word Search

Suitable for Grades 4 – 6



Purpose: Students will familiarize themselves with bicycle vocabulary.

Can you find the hidden words in the word search grid? They might appear across, backwards, diagonally, up or down. Once you've found all the words in the list, assemble the unused letters to spell a secret word.

For your own reference, the vocabulary words are included here.

Name \_\_\_\_\_

**Activity 3.13**  
**Science of the Bicycle Word Search**

You can find the hidden words in the grid. They might appear across, backwards, diagonally, up or down. Once you've found all the words in the list, assemble the unused letters to spell a secret word!

```
C N A R Y N E M S
M S E K I D I R R I
S U A P H A C A I T
T L S O H R B E Y T
R A C E R I D D R
S D N G L I X S G O
L A N D S E E I R P
W I N D P S A M S
R A C E S R U T E
H W H E E L P O T S
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**WORD LIST**

Words	Handlebars	Spin	Race
Body	Land	Steel	Rim
Chain	Road	Stop	Tire
Energy	Seat	Muscles	Turn
Frame	Sit	Pedals	Wheel
Gear	Speed		Wind

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"SCIENCE  
YOUNG PEOPLE'S  
MUSEUM" Carroll

## Word List

<b>Bikes</b>	<b>Handlebars</b>	<b>Spin</b>	<b>Race</b>
<b>Body</b>	<b>Land</b>	<b>Sport</b>	<b>Rim</b>
<b>Chain</b>	<b>Road</b>	<b>Steel</b>	<b>Tire</b>
<b>Energy</b>	<b>Seat</b>	<b>Stop</b>	<b>Turn</b>
<b>Frame</b>	<b>Sit</b>	<b>Muscles</b>	<b>Wheel</b>
<b>Gear</b>	<b>Speed</b>	<b>Pedals</b>	<b>Wind</b>

## Activity 3.14: Gyroscopic Inertia

Suitable for Grades 4 – 6

Purpose: To discover and experience the concept of gyroscopic inertia that contributes to keeping the rider upright on his or her bicycle.

To begin this activity, ask students the following questions.

Have you ever tried to sit down on a bicycle without it moving? Was it difficult to balance? Why is it far easier to maintain your balance on a moving bicycle than on a motionless bicycle? What's the difference? (*The wheels are spinning*)

To explore this concept have students complete the following experiment.

### Experiment: Spinning Records

Divide the class into groups and hand each team an LP record, which can easily be purchased in second hand stores or flea markets, one meter of string and a pencil. Explain the procedure as outlined below.



#### FIRST PART

- Invite the groups to tie one end of the piece of string to the centre of the pencil.
- Have the students pull the other end of the string through the hole of the record.
- Have students hold the record by the string and swing it back and forth like a pendulum.
- Ask the teams to write down their observations. What happens to the record? Does it tilt or stay level when you swing it? (*it should tilt or wobble*)

#### SECOND PART

- For the second part of the experiment, tell the students to hold the record level and spin it as fast as possible.
- Using the string, have them swing the record back and forth.
- Ask the teams to write down their observations. What happens to the record? Does it tilt or stay level when it is spinning and swung? (*the record stays level*)

The LP record stays level as it spins because the spinning motion resists any force that tries to make it tilt. “Gyroscopic inertia is the property of a rotating object to resist any force which would change its axis of rotation. Once the record is set spinning at an angle perpendicular to the string, it will resist any forces (such as gravity) that try to change that angle.”

(Source:<http://www.spartechsoftware.com/reeko/Experiments/ExpRecordSpin.htm>)

This action happens on a bicycle —you have to be moving to keep it upright. The spinning wheel resists the tilting that happens when the bicycle begins to slow down and then fall over. The faster you go on a bike, the greater the resistance to tipping. The shape of the wheel plus the speed at which it travels are keys to balancing upright.

To learn more about gyroscopes and gyroscopic inertia, visit the Canada Science and Technology Museum's website: [http://www.sciencetech.technomuses.ca/english/schoolzone/Info\\_Science.cfm#5](http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Science.cfm#5)



## Activity 3.15: Bicycle Graphs

Suitable for Grades 4 – 5



Purpose: Students will use their math skills to create graphs and solve problems.

### Graph Making

Have students create charts surrounding the theme of the bicycle. Provide each student a class list and have them survey their classmates to find the answers to their questions.

Examples of survey questions:

- What colour is your bicycle?
- Do you ride your bike to school?
- How many cycles have you ever owned? (Have students specify the number of tricycles and bicycles they have owned)
- What is the distance you would need to travel by bike to ride to school? (Have students consult Map Quest or Google Maps to obtain this answer by entering their school and home addresses)

Have students incorporate the results of their survey into a graph. Use the class results to create math problems that students will solve. For instance, students can calculate:

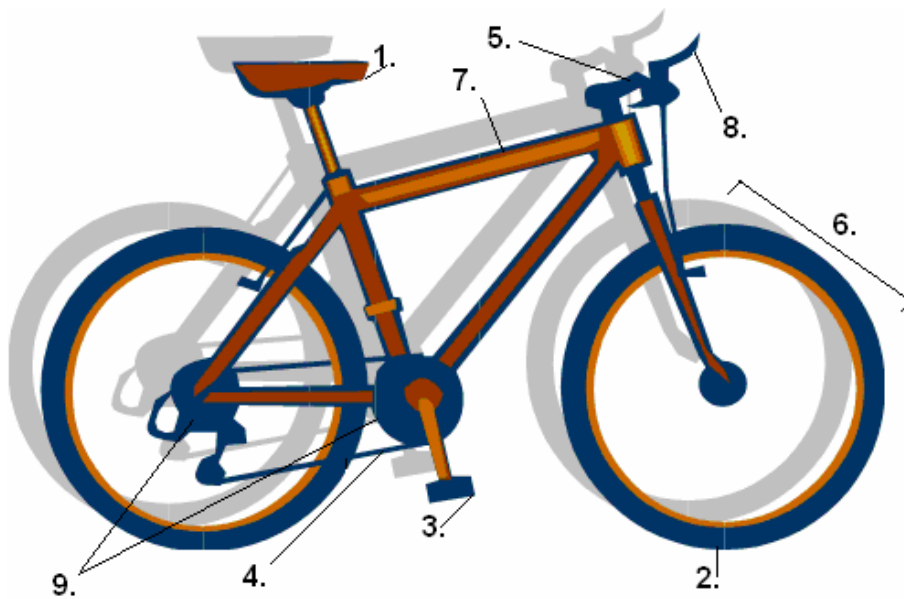
- the percentage of the class who own a red bicycle
- the percentage of girls who ride a bicycle to school
- the sum of the cycles ever owned by the students in the class
- the sum of wheels of the cycles ever owned by the students in the class
- the mean, mode and median of the distance travelled by the students to ride their bicycles to school

Name: \_\_\_\_\_

## Activity 3.1a Bike Anatomy

Can you identify the following parts of this bicycle?

- |        |        |            |
|--------|--------|------------|
| Frame  | Gears  | Chain      |
| Tires  | Wheel  | Handlebars |
| Pedals | Brakes | Seat       |



1 \_\_\_\_\_  
2 \_\_\_\_\_  
3 \_\_\_\_\_  
4 \_\_\_\_\_  
5 \_\_\_\_\_  
6 \_\_\_\_\_  
7 \_\_\_\_\_  
8 \_\_\_\_\_  
9 \_\_\_\_\_

Name: \_\_\_\_\_

## Activity 3.1b Bike Anatomy







What am I? Draw lines to link each bicycle part to its function.

Frame	Allows the rider to propel the bicycle by transferring power to the wheel.
Pedals	Increases the comfort of the bicycle ride by absorbing ground shocks.
Tires	Allows the bicycle to roll over the ground and move the cyclist from point A to point B.
Wheel	Makes pedalling easier, allows the cyclist to go faster and makes it easier to ride up-hill.
Handlebars	Connects the pedals to the rear wheel. It allows the power applied to the pedals to be transferred to the rear wheel, moving the bicycle forward.
Gears	Ensures the comfort of the cyclist and acts as one of the body's principal contact point to the bicycle.
Brakes	Holds all the parts together and positions and supports the rider.
Chain	Allows the rider to steer the bicycle.
Seat	Allows the rider to slow down and stop.

Name: \_\_\_\_\_

## Activity 3.2a A Hunt for Simple Machines

Search your classroom and school grounds to find as many simple machines as possible. Once you have identified a simple machine, list it in its appropriate category.

Simple Machine	Objects
<b>Inclined Plane</b> 	
<b>Wedge</b> 	
<b>Screw</b> 	
<b>Lever</b> 	
<b>Wheel and Axle</b> 	
<b>Pulley</b> 	

Name: \_\_\_\_\_



## Activity 3.2b Complex Machines

A bicycle is a complex machine — it is made of many simple machines.

1. Can you find the simple machines used in this bicycle?

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2. How do these simple machines work together to make the bicycle function?

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3. What do you think would happen to the bicycle if we removed one of its simple machines?

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4. Can you list other objects that combine simple machines?

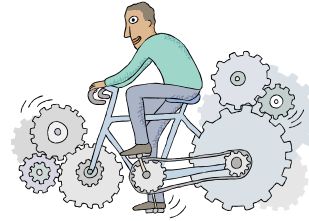
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Name: \_\_\_\_\_

## Activity 3.3 Gear Ratios

Can you solve these gear ratio problems?







- 1
  - If the front sprocket of your bicycle has 60 teeth and the back sprocket has 20 teeth, how many revolutions will the back sprocket make for every complete revolution of the front sprocket? \_\_\_\_\_
  - If the circumference of your bicycle wheels is 1.5 metres, how far would you travel in one complete revolution of the pedals? \_\_\_\_\_
  - If you are pedalling at a consistent speed of 40 revolutions a minute on flat land, what distance will you have travelled if you cycle 10 minutes?  
\_\_\_\_\_
  
- 2
  - If the front sprocket of your bicycle has 45 teeth and the back sprocket has 15 teeth, how many revolutions will the back sprocket make for every complete revolution of the front sprocket? \_\_\_\_\_
  - If the circumference of your bicycle wheels is 180 centimetres, how far would you travel in one complete revolution of the pedals? \_\_\_\_\_
  - If you are racing at a consistent speed of on 70 revolutions a minute on flat land, how many kilometres will you have travelled in 20 minutes?  
\_\_\_\_\_
  
- 3
  - If the front sprocket of your bicycle has 44 teeth and the back sprocket has 11 teeth, how many revolutions will the back sprocket make for every complete turn of the front sprocket? \_\_\_\_\_
  - If the radius of your bicycle wheels is 250 millimetres, how far would you travel in one complete turn of the pedals? \_\_\_\_\_
  - If you changed gears so that the back sprocket now had 22 teeth, how far would you travel in one complete turn of the pedals? \_\_\_\_\_

Name: \_\_\_\_\_

## Activity 3.7a Bicycle Materials

Identify the materials used to make the following historical bicycles. Indicate the advantages and disadvantages of the materials used in its fabrication.



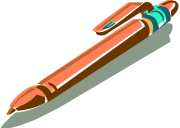


Bicycle	<b>Hobbyhorse</b> 	<b>Velocipede</b> 	<b>High-Wheel</b> 	<b>Safety Bicycle</b> 
Year Introduced				
Materials Used				
Advantages				
Disadvantages				

Name: \_\_\_\_\_

## Activity 3.7b

### Yield Strength, Ultimate Strength and Elasticity

Visit the Exploratorium's website at: <http://www.exploratorium.edu/cycling/frames3.html> and complete the Yield Strength, Ultimate Strength and Elasticity experiment. Write your team's observations in the grid below.

Material	Elasticity	Yield Strength	Ultimate Strength
 plastic comb			
 rubber band			
 ball point pen			
 pencil			
 paper clip			

Which of these materials is the most appropriate for the fabrication of a bicycle frame?  
Use specific reasons and details to support your answer.

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**Name:** \_\_\_\_\_

## **Activity 3.8**

### **Aerodynamic Improvements**

Can you describe the aerodynamic improvements in the sport of cycling that have contributed to improving the cyclist's performance by reducing drag and wind resistance? Include aerodynamic modifications in the design of wheels, frames, riding techniques, body position and clothing and equipment.

<b>Features</b>	<b>Aerodynamic Improvements</b>
<b>Wheels</b>	
<b>Frames</b>	
<b>Riding Techniques</b>	
<b>Body Position</b>	
<b>Clothing and Equipment</b>	

Name: \_\_\_\_\_

## Activity 3.9

### Forms of Energy Found in Transportation






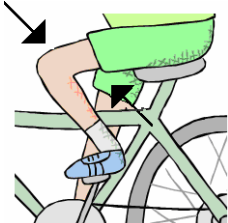


What form and source of energy are used by the following modes of transportation?

Mode of Transportation	Form of Energy	Source of Energy
 Bicycle		
 Sailboat		
 Steam Train		
 Car		
 Horse and Buggy		
 Canoe		
 Airplane		

Name: \_\_\_\_\_

## Activity 3.10 The Energy Chain




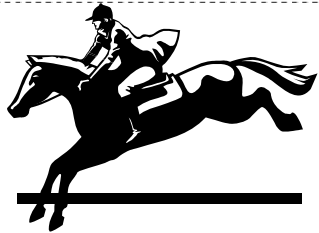





Cut out the boxes. Place the energy transfers in the correct order to explain how bicycles actually work on solar energy.

 A	 B	 C	 D
 E	 F	 G	 H

Name: \_\_\_\_\_

## Activity 3.11 Energy Efficiency

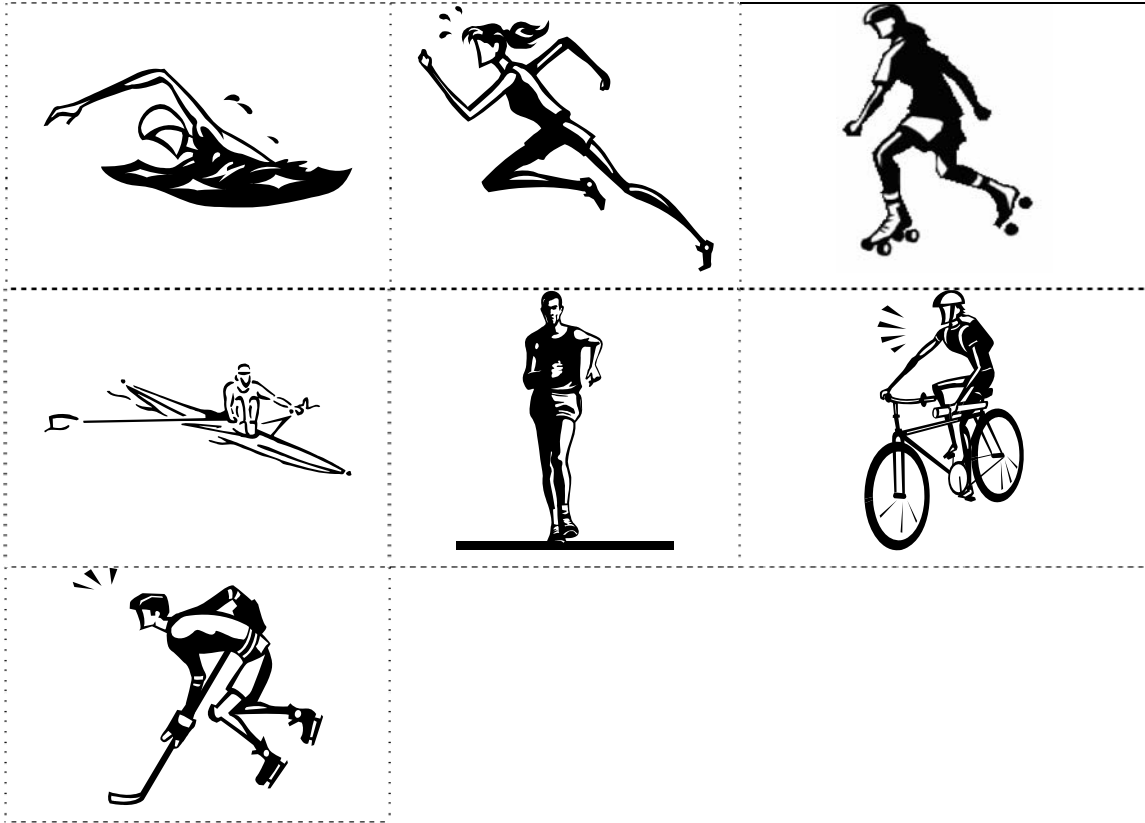
Which means of transportation uses the least energy to move one person one kilometre?  
Cut out the boxes and arrange the means of transportation in order, starting with the one with the greatest energy efficiency.

		
	 A car with one driver	
 A car with one driver and four passengers		

Name: \_\_\_\_\_

## Activity 3.12 Who's the Fastest?

Cut out the boxes and associate each sport to its corresponding speed record.



6 kilometres per hour	13 kilometres per hour	19 kilometres per hour
35 kilometres per hour	42 kilometres per hour	48 kilometres per hour
76 kilometres per hour		

Name: \_\_\_\_\_

## Activity 3.13

### Science of the Bicycle Word Search

Can you find the hidden words in this grid? They might appear across, backwards, diagonally, up or down. Once you've found all the words in the list, assemble the unused letters to spell a secret word.

E	M	A	R	F	N	E	N	M	S
M	S	E	K	I	B	I	R	R	I
S	U	A	P	R	A	C	A	I	T
T	L	S	O	H	H	B	E	Y	T
E	R	A	C	E	E	I	G	D	R
E	D	N	D	L	S	R	E	O	O
L	A	N	D	E	E	E	I	B	P
W	I	N	D	N	P	S	A	M	S
R	A	C	E	S	N	R	U	T	E
H	W	H	E	E	L	P	O	T	S

#### Word List

Bikes	Handlebars	Spin	Race
Body	Land	Sport	Rim
Chain	Road	Steel	Tire
Energy	Seat	Stop	Turn
Frame	Sit	Muscles	Wheel
Gear	Speed	Pedals	Wind

SECRET WORD: \_\_\_\_\_