BODY WORLDS

ANIMAL INSIDE OUT

EDUCATOR'S **GUIDE**

Grades 8 – 12

TELUS WORLD of SCIENCE Edmonton

CLASSROOM ACTIVITIES

These classroom activities can be used as either pre-visit activities to prepare students for *BODY WORLDS: ANIMAL INSIDE OUT* or as post-visit activities to help with debriefing.

CONTENTS

Thanks to the Perot Museum of Nature and Science for the initial development of these educational materials.

Per[ ]t
Museum of Nature and Science

EXHIBITION OVERVIEW

BODY WORLDS creator and anatomist, Dr. Gunther von Hagens, takes you on an anatomical safari with *ANIMAL INSIDE OUT*. As you explore this captivating exhibition, you will experience the intricate anatomy and physiology of a variety of the world's most spectacular creatures. *ANIMAL INSIDE OUT* contains more than 100 specimens that have been painstakingly preserved by the remarkable process of Plastination, invented by Dr. von Hagens. Students will be able to examine the anatomical intricacies of familiar and exotic animals like giraffes, camels and octopuses.

This exhibition is an unforgettable way for students to learn about animal science.

The exhibition explores:

Skeletons
From tiny insects to full-grown mammals, most animals have a skeleton of some sort. It could be an endoskeleton, which humans have, or an exoskeleton like that of insects and crustaceans.

Muscles, tendons and ligaments
From the large running and leaping muscles of a caribou, to the specialized muscles of a bull's heart that pump the blood and nutrients around its body, *ANIMAL INSIDE OUT* reveals the intricacy and details of the muscles and ligaments that most animals have.

The nervous system
A vast and complex network that connects the brain, spinal cord and all parts of the body. It channels data continuously and transmits commands. The nerve fibres that carry this vital information can be finer than a human hair and invisible to the naked eye.

Reproduction
After feeding, reproduction is the most essential activity of an animal. Evolution has developed a number of ways for animals to reproduce.

Respiration and digestion
By viewing the lungs and digestive tracts of animals, like the caribou, we can see how we share the same intricate details of many major organs.

Wildlife conservation and preservation
By learning how similar animals and humans are, visitors will be able to gain a new appreciation for the importance of animal welfare.

Caution for sensitive viewers:

ANIMAL INSIDE OUT features a few human organs and body parts, as well as a male body plastinate with eyes and genitals. This material is included for the comparison of human anatomy to that of other animals.

CURRICULUM LINKS

While visiting this exhibition, students will be using the processes and skills of science. Young children naturally have an interest in animals and this provides the motivation and inspiration for them to practice thinking like a scientist does. Students will be able to describe and compare their observations and ideas with each other and learn about the nature of science. For older students, direct experiences with the specimens will challenge them to practice important science skills and develop hypotheses and conclusions about animal science, diversity, change over time and the processes of science. Teachers can use student experiences in *ANIMAL INSIDE OUT* to support student learning in life science, as well as providing experiences for contextual reading and writing applications.

- **Science 8 Unit B**
  (Cells and Systems)
- **Science 9 Unit A**
  (Biological Diversity)
- **Biology 20 Unit A**
  (Energy and Matter Exchange in the Biosphere)
- **Biology 20 Unit D**
  (Human Systems)
- **Biology 30 Unit B**
  (Reproduction and Development)

FIELD TRIP INFORMATION

FOR PARENTS/GUARDIANS

What is the purpose of the exhibition?

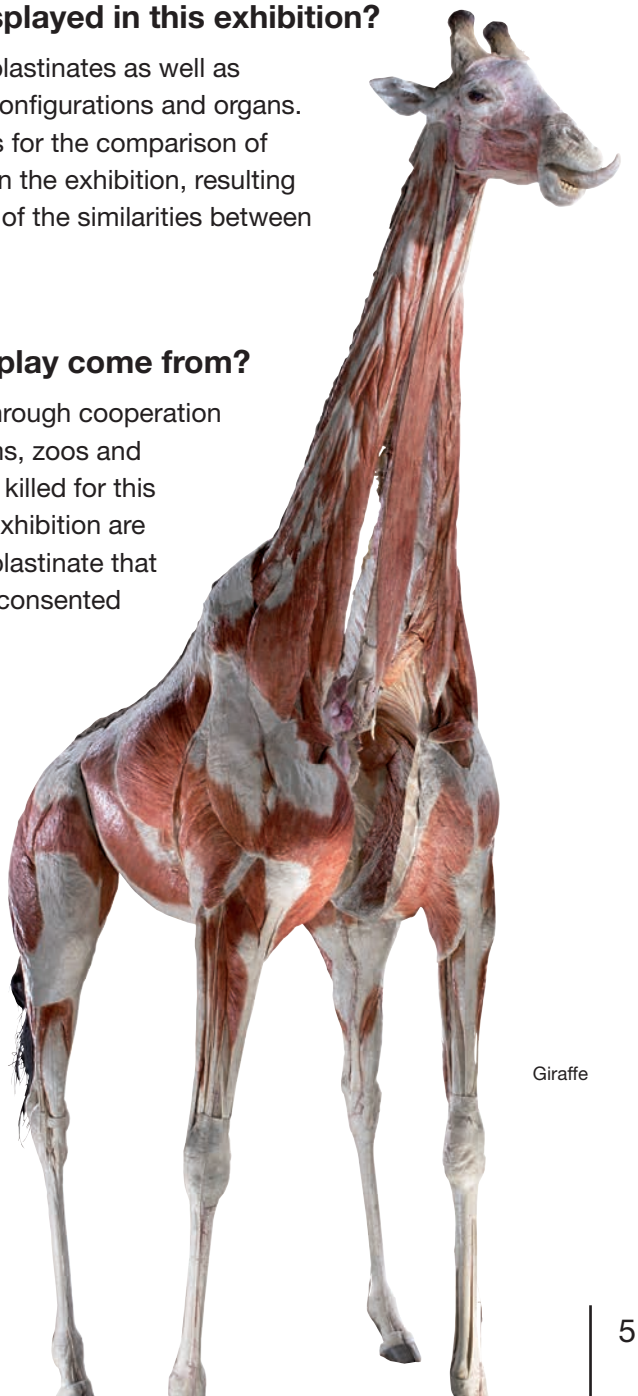
The purpose of *BODY WORLDS*: *ANIMAL INSIDE OUT* is to inspire a deeper appreciation and respect for the animal world. Thanks to the science of Plastination, visitors can examine the intricate anatomy and physiology (blood vessels, muscles, bones, organs and nerves) of some of the world's most spectacular creatures. Visitors will be better able to understand the inner workings of animals and all the systems that enable them to live, thrive and survive (e.g. nervous, muscular, circulatory, respiratory, digestive and reproductive).

What kinds of specimens are displayed in this exhibition?

ANIMAL INSIDE OUT includes full body plastinates as well as cross-sections, skeletons, blood vessel configurations and organs. The inclusion of human plastinates allows for the comparison of human anatomy to that of other animals in the exhibition, resulting in a new understanding and appreciation of the similarities between animals and humans.

Where did the specimens on display come from?

ANIMAL INSIDE OUT is made possible through cooperation with various university veterinary programs, zoos and animal groups. No animal was harmed or killed for this exhibition. Among the plastinates in the exhibition are human specimens, including a full body plastinate that came from the Institute for Plastination's consented body donation program.



Giraffe

Is this exhibition appropriate for children?

ANIMAL INSIDE OUT was designed for visitors of all ages to better understand animal anatomy. The content is factual, instructive and is presented in a non-sensational manner, but some content may require explanation by a parent or teacher. Along with informative displays that show animals' nervous, muscular, digestive, respiratory and circulatory systems, the exhibition also includes reproductive systems. Among the 100 specimens on display, you will see the following:

- A blood vessel configuration of a horse's penis
- A blood vessel configuration of a bull's testicle
- A human placenta
- A male caribou's reproductive organs
- A caribou uterus
- A fetus inside a caribou uterus
- A cross-section of a duck developing an egg

Caution for sensitive viewers:

ANIMAL INSIDE OUT features a few human organs and body parts, as well as a male body plastinate with eyes and genitals. This material is included for the comparison of human anatomy to that of other animals.

Ostrich

INTRODUCTION

TO THE ACTIVITIES

These activities are recommended for use as pre-visit activities, before your class trip to *BODY WORLDS*: *ANIMAL INSIDE OUT*, or as post-visit materials to help debrief your class.

Objectives

- Describe the purpose and function of several organ systems in the human body
- Predict, observe and explain chemical reactions
- Assess various survival pressures present in biomes and speculate on how a population might adapt over generations in response to these particular pressures
- Describe examples of structural, physiological and behavioural adaptations
- Model the breakdown of starch in the digestive system
- Model the process of protein digestion
- Explain the role of bile in the emulsification of fats
- Identify the presence of an acid using an indicator

Curriculum Connections by Grade

- **Science 8 Unit B**
  (Cells and Systems)
- **Science 9 Unit A**
  (Biological Diversity)
- **Science 9 Unit A**
  (Matter and Chemical Change)
- **Biology 20 Unit A**
  (Energy and Matter Exchange in the Biosphere)
- **Biology 20 Unit B**
  (Ecosystems and Population change)
- **Biology 20 Unit D**
  (Human Systems)
- **Biology 30 Unit B**
  (Reproduction and Development)
- **Biology 30 Unit C**
  (Cell Division, Genetics, and Molecular Biology)
- **Chemistry 30 Unit C**
  (Chemical Changes of Organic Compounds)

Vocabulary

- » **biology**
- » **human body**
- » **organ, tissue**
- » **digestive system**
- » **excretory system**
- » **circulatory system**
- » **respiratory system**
- » **immune system**
- » **health**
- » **disease**
- » **physical science**
- » **chemistry**
- » **cell**
- » **biology**
- » **biochemistry**
- » **solution**
- » **solvent**
- » **solute**
- » **organic**
- » **inorganic**
- » **polar**
- » **nonpolar**
- » **plastic**
- » **polymer**
- » **monomer**
- » **molecule**
- » **atom**
- » **dissolve**
- » **life science**
- » **ecology**
- » **adaptation**
- » **biome**
- » **temperate rainforest**
- » **boreal forest**
- » **tundra**
- » **desert**
- » **tropical rainforest**
- » **animal**
- » **evolution**
- » **co-evolution**
- » **biotic**
- » **abiotic**
- » **environment**
- » **taxonomy**
- » **cladogram**

Resources

- » Catalyst for Science | Life Science | Making Biochemistry Meaningful
  catalystforscience.ca/life-science/making-biochemistry-meaningful
- » Catalyst for Science | Physical Science | Reaction in a Bag—Making Silly Putty®
  catalystforscience.ca/physical-science/reaction-in-a-bag
- » Science World Resources | Activities | Polymer Tag
  scienceworld.ca/resources/activities/polymer-tag
- » The Phylomon Project | Biodiversity Card Game
  phylogame.org/game-play
- » Steve Spangler Science | Vanishing Styrofoam
  stevespanglerscience.com/lab/experiments/vanishing-styrofoam
- » Beaty Biodiversity Museum | Educator Resources
  beatymuseum.ubc.ca/educator-resources

ACTIVITY 1

ORGAN SYSTEMS JIGSAW

Activity Length	Activity Type	Topic
1–2 hours	Activity	Human Body

Curriculum Connections

- **Science 8 Unit B**
  (Cells and Systems)
- **Biology 20 Unit D**
  (Human Systems)

Introduction

In teams, become an expert on one organ system and try to convince your classmates that it is the most important in the body.

Organ systems are groups of organs that work together to do a job for the body they live in. For example, they can help with gas exchange, removing waste, obtaining and transporting nutrients and protecting the body from disease.

This exploration is a jigsaw activity with a twist. Students will work in small groups to become experts on the organ system assigned to them. They will then use creative methods to share their knowledge with the rest of the class. This lesson can be used effectively to preview all organ systems before exploring them in more depth and it also serves as an excellent end-of-unit review tool.

Objectives

- Describe the purpose and function of several organ systems in the human body
- Explain a variety of strategies for keeping each organ system as healthy as possible

Materials

- Access to printed and/or online resources for research
- Organ Systems Summary Sheets (5 copies per student)

Preparation

- Print the Organ Systems Summary Sheets for your class or have them copy it into their notes. Each student will need 5 summary sheets—one for each organ system.

What to Do

1. Divide the class into five “Expert Groups” for the systems you are studying: Respiratory, Circulatory, Excretory, Digestive and Immune.
2. The Expert Groups have 20 minutes to learn about their organ system and prepare an explanation about what they learned, for the rest of the class.

   2a) Using the resources available to them, each Expert Group will fill in their summary sheet (see attached).

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

2b) They will try to convince the rest of the class that their organ system is the most important in the body. They will prepare a 5-minute advertisement, debate or election campaign for their organ system. After each group has had a chance to present, hold a class vote. Students are not allowed to vote for their own organ system.

3. Following the presentations, complete the jigsaw. Break the Expert Groups into "Sharing Groups," where each group has at least one member representing each organ system. In the Sharing Groups, students will take turns explaining what they know about their assigned organ system. During sharing, the other students are responsible for taking notes for each organ system. At the end of this time, each student in the class should have a full set of notes for all of the organ systems being studied.

Key Questions

- What are the major functions of each organ system in the human body?
- How do these organ systems carry out their tasks?
- What can be done to help these systems work as effectively as possible?

Extensions

After the jigsaw is complete, have students return to their Expert Groups and try one of the following extensions:

- Use all members of the group to create a "human machine" of their organ system to present to the class and explain how their organ system works. Each member will act as a part of the organ system while explaining that organ function. Student presentations should be brief, no more than 2–3 minutes long. The use of props is encouraged, if they are readily available in the classroom and can be safely used.
- Have groups research a disease of their organ system and explain how that interferes with proper functioning of the system. Have them include examples of treatments that will help ease or eliminate the symptoms of the disease. Ask them to prepare a 5-minute presentation for the class. They can choose from the examples listed below or talk with you about researching a different disease.

System	Disease
Immune	Allergies, HIV/AIDS, juvenile arthritis
Respiratory	Asthma, emphysema, cystic fibrosis
Circulatory	Hemophilia, anemia, hypertension
Digestive	Diabetes, diarrhea/constipation, ulcer
Excretory	Kidney stones, cirrhosis, gout

Resources

- Science World at TELUS World of Science | Online Games | Bodyworks Games
  scienceworld.ca/online-games
- Harvard University Outreach Program | Johnny's Anatomy: From Organ Systems to Injury
  lifesciencesoutreach.fas.harvard.edu/animations-0
- CK-12 Online Textbook | Chapter 35: The Body Systems
  ck12.org/user%3Abiologyepisd/book/EPISD-Biology-Version-1.0/section/35.0

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 1

ORGAN SYSTEMS SUMMARY SHEET

Name: _____

Group Members: _____

_____

Organ System: _____

Overall purpose of organ system: _____

_____

_____

_____

1. In the space provided below, list the major organs and tissues of this system. Provide a brief (one sentence) description of the function of each.

_____

_____

_____

_____

_____

_____

2. How can you help to keep this organ system healthy?

_____

_____

_____

_____

_____

_____

3. Write down 5 interesting facts about your organ system.

_____

_____

_____

_____

_____

_____

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 2

THAT FOOD YOU EAT

Activity Length	Activity Type	Topic
15–20 min.	Activity	Human Body

Curriculum Connections

» **Science 8 Unit B**
(Cells and Systems)

Introduction

Students connect classroom learning with their visit to *ANIMAL INSIDE OUT* as they explore the physical and chemical changes that occur when food is processed in the digestive system.

Objectives

» Distinguish between physical and chemical changes in the digestive system.

Materials

» Access to printed and/or online resources for research
» Data sheet

Background

The body's digestive system converts the food you eat into the energy you need to live. The journey through your digestive system starts in the mouth, where teeth grind and tear the food into small pieces. Saliva then wets and softens the food and begins to dissolve carbohydrates. Once the food is properly mashed and wet, it is pushed by muscle action into the pharynx, or throat, and down the esophagus, which leads to the stomach.

When food reaches the stomach it is mixed and broken down further by acids that the stomach produces. The stomach protects itself from these acids by secreting a layer of mucus that coats the inside lining. Food products, such as water and sugars, can be absorbed right out of the stomach and into the bloodstream. Other foods that need more digestion have further steps ahead of them. When the stomach has made the food a liquid, the food passes through a valve into the small intestine.

The small intestine has a large surface area because it contains villi. Villi are tiny little structures like very short hairs that stick out into the small intestine. Through the walls of the villi nutrients from food pass into the bloodstream. The bloodstream carries the nutrients to your cells so they can live. Once all the useful nutrients have been taken from food in the small intestine, the unusable parts pass into the large intestine, or colon. In the large intestine, water is extracted from the waste and the material condenses into feces. The feces are passed out of the body when you go to the toilet.

The pancreas, liver and gallbladder play an important role in digestion. The pancreas makes enzymes that help digest proteins, fats and carbohydrates. The liver makes bile, which helps the body absorb fat. Bile is stored in the gallbladder until it is needed. Enzymes and bile travel into the small intestine through ducts.

What to Do

1. Arrange students into 6 teams. Each team is responsible for researching a different segment of the digestive system. Students should look for evidence of physical changes or chemical reactions that change the composition of digestible material as it passes through their segment.
2. Hand out the data sheet. Ask students to record their research on the data sheet (it should only take up one row, for the segment they are researching). Have teams present their research to the rest of the class. Students should use their data sheet to take notes to fill in the remainder of the data sheet during the presentations.

Key Questions

» What kinds of molecules are absorbed in each segment of the digestive system?
» Why do physical changes occur in some segments of the digestive system and not in others?

Extensions

» After your visit to *ANIMAL INSIDE OUT*, have students describe how a caribou stomach is different from a human stomach. What would be the purpose of this adaptation?
» Have students investigate the foods that they would eat if they needed energy for sports or active recreation. Have them pick five foods that they think would be good sources of energy and have them conduct research. Were they good choices?

BODY WORLDS
ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 2

DATA SHEET

Digestive System Segment	Physical Changes Occurring	Chemical Changes Occurring

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 3

POLYMERS, POLARITY AND PREDICTING REACTIONS

Activity Length	Activity Type	Topic
Part 1: 40 min.	Exploration	Chemistry

Part 2: 10 min. for set-up, 10 min. for demonstrations, plus overnight for evaporation of acetone.

Curriculum Connections

- **Science 9 Unit A**
  (Matter and chemical change)
- **Chemistry 20 Unit A**
  (The Diversity of Matter and Chemical Bonding)
- **Chemistry 30 Unit C**
  (Chemical changes of organic compounds)
- **Biology 30 Unit C**
  (Cell Division, Genetics, and Molecular Biology)

Introduction

In this demonstration, students will observe interactions between polystyrene, water and acetone and explain the results in terms of their molecular structure. Students can make inferences about the processes involved in Plastination (when biological samples are preserved in plastic). Microorganisms that cause decomposition can't survive in an environment where fats, proteins and water have been replaced with plastic. Plastics vary widely in properties, meaning that some are better suited for tissue preservation.

Molecules with evenly distributed electrons are nonpolar and molecules that have an uneven electron distribution are polar. A common saying in chemistry is "Like dissolves like." In other words, polar molecules can dissolve polar molecules and nonpolar molecules can dissolve nonpolar molecules. A mixture of polar and nonpolar molecules will remain separate unless special molecules with qualities of both are present to help them mix together.

Chemists categorize molecules in a variety of different ways. Organic molecules always contain carbon and hydrogen and may contain other elements such as nitrogen, oxygen, phosphorous and sulphur. They are often found in living systems but could also be synthesized in a laboratory. Some organic molecules are very large. Knowing that a molecule is organic does not help chemists to predict how it will react, but does influence the way these molecules are named and studied.

Some of the largest organic molecules are polymers. Polymers are long chains or webs made of smaller groups of atoms called monomers that are joined together like beads on a string. Common examples of polymers include DNA, proteins, nylon and Silly Putty. Chemical reactions can attach monomers together into polymers and can also break them down again.

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

Objectives

- Predict, observe and explain interactions between water, polystyrene and acetone
- Identify changes as being physical or chemical
- Categorize molecules as polar or nonpolar, organic or inorganic, and identify polymers and their monomers
- Infer how polymer chemistry can be used to preserve biological samples for study

Materials

Per student:

- Background Research sheet
- Molecular Interactions sheet

Per class:

- Goggles, gloves, fume hood
- Polystyrene (Styrofoam® cups or packing peanuts with a #6 recycling code will work best)
- 200ml acetone (**Note**: pure acetone is available at most hardware stores. Most acetone-based nail polish removers do not contain a high enough concentration of acetone to yield good results)
- Three x 250ml glass beakers
- Food colouring
- Glass stirring rod
- Tweezers
- Large watch glass

What to Do

Part 1: Research and Predict

Teacher Tip: Group work and discussion is encouraged for all phases of this demonstration. Depending on the grade level and time of year, this activity will be used to introduce new ideas and/or review and apply previously learned concepts. Questions are designed to be open ended and to demonstrate that sometimes the answers are not direct or obvious. Students should be encouraged to develop and use appropriate research techniques for their grade level as they proceed through the activities.

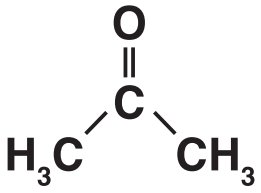
Senior chemistry students should be able to categorise the molecules based on structure alone. Provide them with images or models of the 3 molecules and challenge them to complete the chart without conducting outside research.

1. Have students look at the images of water, acetone and polystyrene on the Background Research sheet. They can supplement their understanding with further research as needed.
2. Ask students to copy and fill in the Venn diagram to describe the similarities and differences between these three molecules. The aim is for them to use as many of the words in the vocabulary list as they can.
3. Have students predict how these chemicals will react by having them fill in the first 2 columns of the Molecular Interactions sheet. Have them record their observations of Reaction as you demonstrate the interactions during Part 2 and then have students fill in their Explanation following the demonstrations.

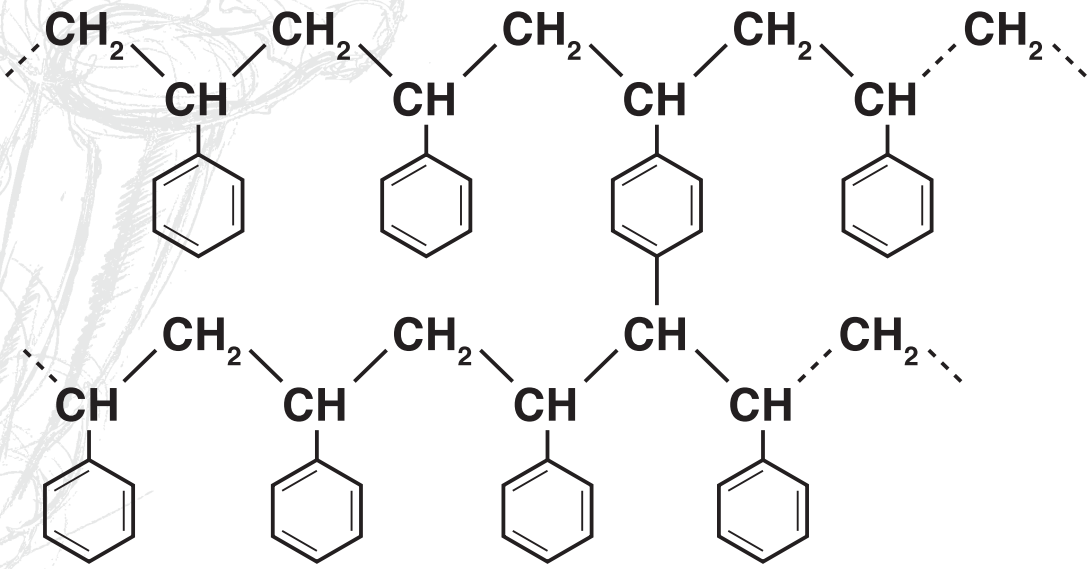
ACTIVITY 3

BACKGROUND RESEARCH

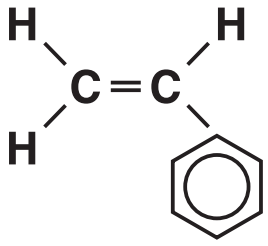
water



acetone



crosslinked polystyrene



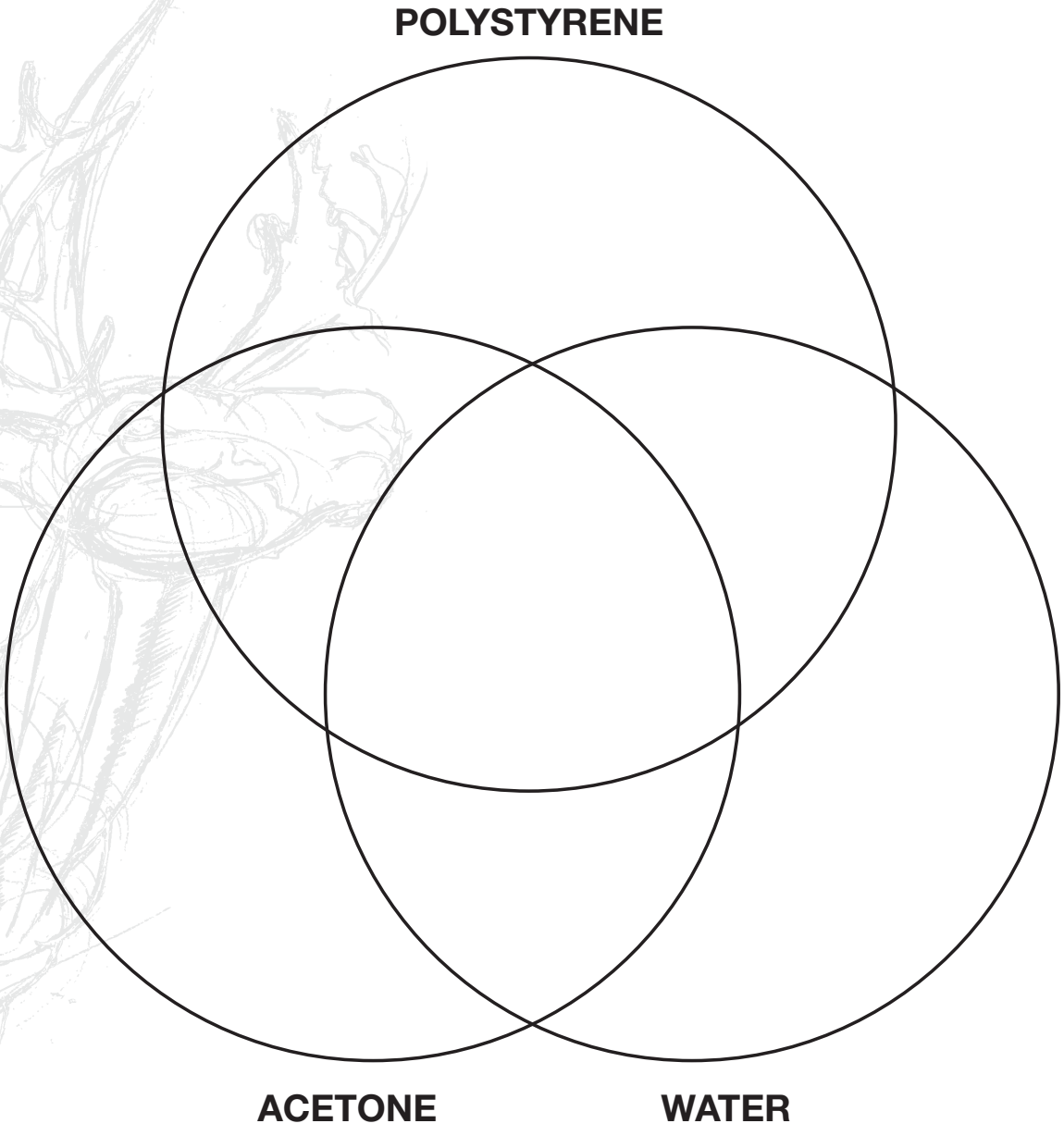
styrene monomer

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 3

VENN DIAGRAM



Vocabulary

- **polymer**
- **monomer**
- **molecule**
- **organic**
- **inorganic**
- **polar**
- **nonpolar**
- **physical**
- **chemical**
- **atom**
- **element**

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 3

MOLECULAR INTERACTIONS

	Prediction of Reaction	Explanation
Water and Polystyrene		
Water and Acetone		
Polystyrene and Acetone		

	Observations of Reaction	Explanation
Water and Polystyrene		
Water and Acetone		
Polystyrene and Acetone		

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 3

POLYMERS, POLARITY AND PREDICTING REACTIONS

Part 2: Molecule investigation (Teacher Demonstration)

Teacher Tip: Acetone is a volatile, flammable substance with some toxic effects. Familiarise yourself with the MSDS information for acetone. Always demonstrate acetone under a fume hood, away from sparks, and follow safe disposal methods.

Preparation

1. Fill up 2 beakers with 100ml of acetone each.
2. Fill the third beaker with 100ml of water and add a drop of food colouring so it is easy to identify.

Demonstration

1. Place a piece of polystyrene into the beaker of water. Use a stirring rod to submerge the plastic into the water. Place as much polystyrene into the beaker as you can safely fit. Ask students to observe and record what happens.
2. Use tweezers to remove the polystyrene from the water.
3. Pour 100ml of water into a beaker containing 100ml of acetone. Ask students to observe and record what happens.
4. Finally, place some polystyrene into the remaining beaker containing 100ml of acetone. Place as much polystyrene into the beaker as you can safely fit. Ask students to observe and record what happens.
5. Remove the polystyrene from the beaker with your tweezers and place it on a watch glass. Allow the acetone to evaporate overnight in the fume hood.

Key Questions

» What are some of the ways of categorizing molecules?
» How can we use our knowledge of molecular structure to predict how molecules will interact?

Extensions

Ask students:

» Were any of the molecules difficult to categorize in any way? Explain.
» To describe the appearance of the polystyrene before and after it is mixed with acetone.
» To identify examples of physical changes and examples of chemical changes observed during the demonstrations. If any of the observations were difficult to categorize as being physical or chemical changes, explain what else you would want to know to help you reach a conclusion.
» Repeat steps 1, 2, 4 and 5 of the demonstration with different types of plastics or biodegradable packing peanuts. Have students look at the chemical structures first and then make predictions about what will happen. Ask them the questions on the following page:

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

- Why can plastic be used to preserve biological samples?
- To list some examples of molecules commonly found in animal bodies that are polar, nonpolar or both.
- Dr. Gunther von Hagens invented a technique called Plastination that replaces a tissue's water and fat with various plastics (elastomers or epoxy resins).
    - What are some of the challenges involved when replacing water and fat with plastic?
    - How can these challenges be addressed?
    - Polystyrene is one example of a variety of plastics and it is typically not used for preserving specimens. Use your research skills to learn about the properties and molecular structure of a different type of plastic. Do you think it would be a good choice for Plastination of animal tissues? Provide some reasons for your opinion.

References

Steve Spangler Science | Vanishing Styrofoam
stevespanglerscience.com/lab/experiments/vanishing-styrofoam

BODY WORLDS
ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 4

EVOLUTION OF THE SASQUATCH

Activity Length	Activity Type	Topic
60 min. (90 with extension)	Activity	Creatures

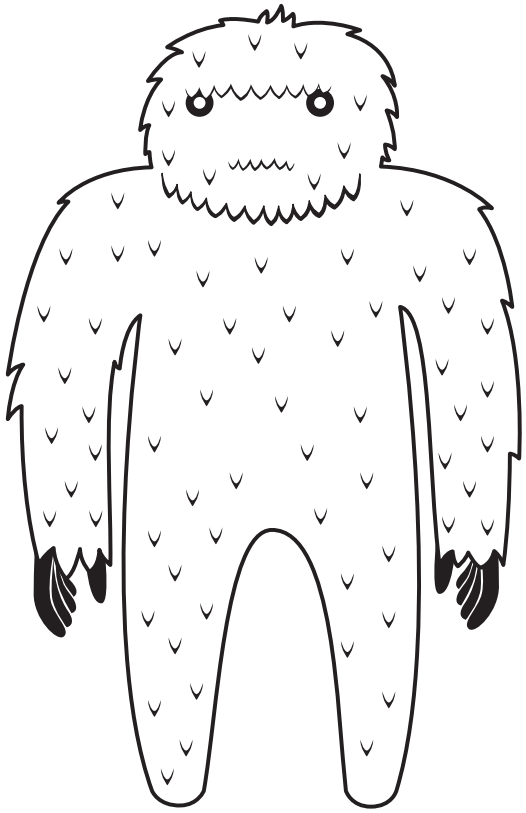
Curriculum Connections

» **Science 9 Unit A**
(Biological Diversity)

Introduction

What will happen when imaginary Sasquatch families need to leave the temperate rainforest of British Columbia and settle in other North American biomes? In this activity students investigate how adaptations ensure that animals survive in their habitat.

This is a Sasquatch (*Sasquatch originalis*). It is a fictional mammal that lives in the mountains of BC in a temperate rainforest biome. The climate is moderate. Here, fresh, flowing water is readily available year-round. An adult Sasquatch is approximately 2 metres tall and has thick, brown fur and padded hands and feet with blunt claws. The Sasquatch is an omnivore, who prefers to eat small mammals, mushrooms and the needles of coniferous trees. The Sasquatch has no major predators, although on rare occasions one will be eaten by a desperately hungry bear. The Sasquatch must hunt quickly and carefully, because the animals they like to eat will run away quickly at any sight or sound of them.



BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

A disaster has destroyed the area where all Sasquatches live. In order to survive, the Sasquatches begin to roam all over North America in search of food and shelter. As they travel farther away from their original home, the food, climate and surrounding life forms slowly change. Sasquatch groups become separated by distance and members can only now mate with those in the same travelling group. As time passes, Sasquatch babies will be born and many sasquatches will also die. Some Sasquatches are not able to stay alive in climates that are much hotter, colder or drier than the temperate rainforest. Many have difficulty finding food and some may get eaten by predators.

Future generations of Sasquatches will find themselves living in very different environments and only those who are well adapted to those environments will be able to survive and reproduce. For the area assigned to you, predict how the Sasquatches may change after 1,000 generations have been born in the new environment.

Objectives

- Describe the biotic and abiotic factors of several biomes
- Assess various survival pressures present in the biomes and speculate how a population might adapt over generations, in response to these particular pressures
- Describe examples of structural, physiological and behavioural adaptations
- Analyze similarities and differences in the new generations of Sasquatch descendants in order to create a cladogram representing possible relationships between the new species

Materials

- Environment cards
- Paper
- Markers or coloured pencils

What to Do

Preparation

1. Print out environment cards and cut paper, so that each card is on a separate piece of paper.
2. Form four groups and hand out a different environmental condition card to each group.

Activity

1. In groups, learn about and describe your environment, by outlining important biotic and abiotic factors that your future Sasquatches will need to live with.
2. Draw and describe your future Sasquatch. How does it compare to its ancestor from the temperate rainforest?
3. Give your new species a name.
4. Provide examples of structural, behavioural and physiological adaptations to the new environment.
5. Be prepared to share your ideas and explain how these adaptations will help the animals to survive.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

Key Questions

- How does the surrounding environment help to shape the life that lives there?
- How can small changes in a population add up to big changes over time?

Extensions

- List the shared and new traits displayed by the Sasquatch originalis and the 4 future populations of Sasquatches. Use these traits to make a cladogram as described in bu.edu/gk12/eric/cladogram.pdf.
- If more than one group creates a cladogram, are they the same? If they are different, discuss various reasons why the cladograms are not the same.
- What else would you want to know about the Sasquatch species to help you construct an accurate cladogram?
- Which future Sasquatch species was most closely related to the Sasquatch originalis? Which one showed the greatest differences? Do these relationships match with the story of how the Sasquatch migrated?

Resources

Tundra Adaptations

umassk12.net/ipy/sess09/Plant%20activity/tundra%20adaptations.pdf

conservationinstitute.org/tundra-animals-6-arctic-animals-perfectly-adapted-for-life-in-the-cold

Desert Adaptations

desertusa.com/survive.html

desertmuseum.org/books/nhsd_adaptations_birds.php

unenvironment.org/resources/report/global-deserts-outlook

Boreal Forest

borealforest.org/index.php?category=world_boreal_forest

nrdc.org/save-canadian-boreal

Tropical Rainforest

tropical-rainforest-facts.com/Tropical-Rainforest-Animal-Facts/Tropical-Rainforest-Animal-Facts.shtml

pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/world-biomes/characteristics-of-bioclimatic/tropical-rain-forest

The Phylomon Project—Biodiversity Card Game

phylogame.org/game-play

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 4

ENVIRONMENT CARDS

ENVIRONMENT A

Some Sasquatch families slowly move northeast into the boreal forest. This area has many small lakes dotting a much flatter landscape than the original environment. The forest is home to large populations of songbirds that migrate south in the winter and contains fewer small mammals than the original environment. Bears still live in the area and compete with Sasquatches for food. In the summertime, biting insects are a major annoyance.

ENVIRONMENT B

Another group ends up far north in the tundra. Plant life grows slowly and mushrooms are no longer abundant in the permafrost. The ocean holds more appealing food than a Sasquatch can find on land here, but it is more difficult to access. Over time, local polar bears start to think of the Sasquatch as a tasty treat and begin to actively hunt them.

ENVIRONMENT C

One Sasquatch group travels south and after several generations, they end up in the desert of the Southwestern United States. They do not have any predators here, but must be careful to avoid getting accidental bites from smaller venomous animals that can be deadly to the Sasquatch.

ENVIRONMENT D

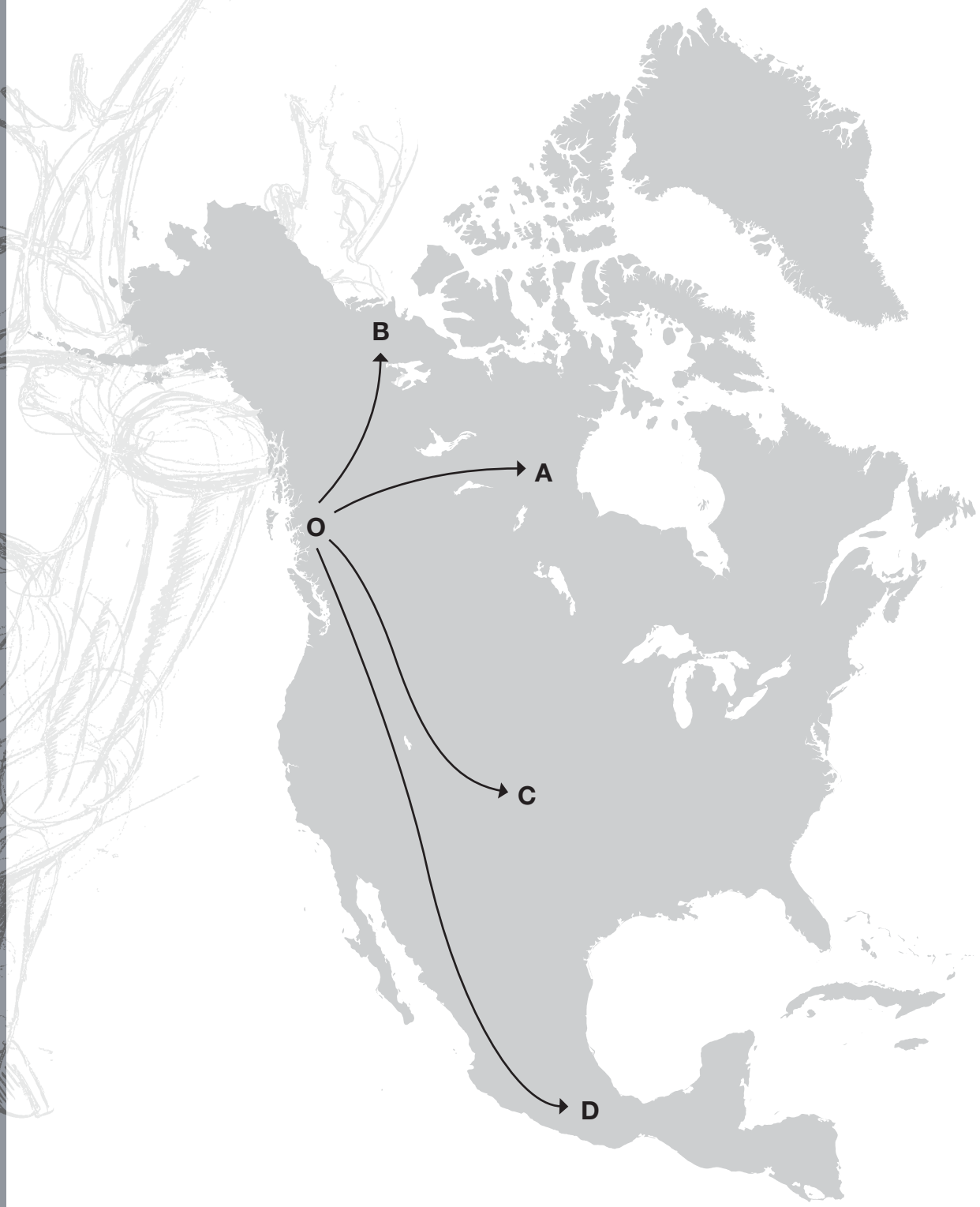
Other Sasquatches end up even further south in a tropical rainforest of Central America. Food is abundant, though many animals are hunting for the same meals. Bites from venomous animals are still possible and jungle cats begin to hunt the Sasquatch as a source of food.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 4

MIGRATION MAP



BODY WORLDS
ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 5

I WILL SURVIVE (THROUGH NATURAL SELECTION)

Activity Length	Activity Type	Topic
10 min.	Activity	Creatures

Curriculum Connections

» **Biology 20 Unit B**
(Ecosystems and Population change)

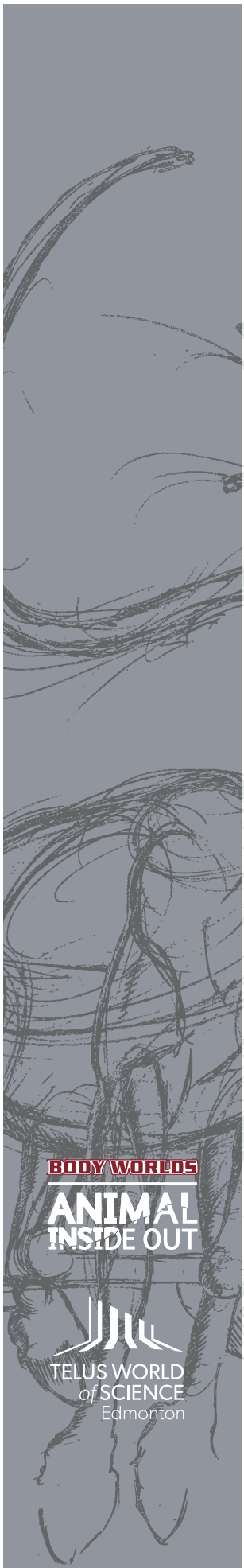
What to Do

1. Using the tune “I Will Survive,” by Gloria Gaynor, sing the song on the following page with your students.

Extension

» Use this song as an example for students. Ask them to find appropriate songs and create their own lyrics throughout various units.

BODY WORLDS
ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton



I WILL SURVIVE (THROUGH NATURAL SELECTION)

Life began as prokaryotic cells.
These bacterial life forms still do very well.
But the need for food and space
And other pressures in the sea
Influenced life
To achieve more complexity.

The ones who lived could reproduce,
Soon the study of taxonomy was introduced.
Now we can name all living things
By their phylum and their class.
Then it's order, family, genus
And the species name comes last.

CHORUS
Environments
Don't stay the same.
Always rewriting
The rules of the survival game.
Life forms all need water, shelter,
food and oxygen,
Ways to reproduce
And grow without getting eaten.

Oh and I, I will survive.
There are qualities about me
That will help my children thrive.
Got variation in our genes.
Yeah, you know just what it means.
I will survive. I will survive!

<Instrumental Break>

The fossils of life forms that are now extinct
Inspired many scientists to stop and think
That all these little changes
Happening through history
Have added up to make a great diversity.
And now we have fungus and plants
And animals that are well made for
their environments.
Some structures are homologous and
some formed separately.
Some are no longer needed.
That's vestigiality!

CHORUS (x2)
Environments
Don't stay the same.
Always rewriting
The rules of the survival game.
Life forms all need water, shelter, food
and oxygen,
Ways to reproduce
And grow without getting eaten.

Oh and I, I will survive.
There are qualities about me
That will help my children thrive.
Got variation in our genes.
Yeah, you know just what it means.
I will survive. I will survive!
I WILL SURVIVE!!!

Lyrics credit: Samsara Marriott

ACTIVITY 6

ARE YOU MY CARBOHYDRATE?

Curriculum Connections

» **Science 8 Unit B**
(Cells and Systems)

Introduction

The average person eats about 1.4kg of food per day, with roughly 50% coming from carbohydrates. The following activities test for the presence of starch and glucose and demonstrate the process by which carbohydrates (a large proportion of what we eat) are broken down into starch and its building blocks.

Objectives

Students will be able to:

» Identify the presence of glucose and starch using common indicators
» Describe the role of α-amylase in carbohydrate digestion

Background

We eat carbohydrates in most meals. Carbohydrates are foods rich in sugars. Starch is a complex carbohydrate made up of chains of sugars. Glucose is a simple sugar that is the basis for most sugar chains. When we eat complex carbohydrates, our body uses chemicals called enzymes to break them down into their chains and then further into their simple sugars.

Carbohydrates are first broken down by salivary amylase, an enzyme released in saliva. As the partially broken down food enters the stomach, another enzyme called pancreatic amylase is secreted by the pancreas. Pancreatic amylase breaks down starch into its smaller chains (disaccharides). As the meal continues into the small intestine, more enzymes (lactase, maltase and sucrase) are released to break down the disaccharides into glucose and fructose.

List of Activities

» Testing for starch and glucose
» Starch breakdown using α-amylase AMYLASE
» Test for the by-products of starch

References

» *BODY WORLDS Educators Guide*

Other Resources

» Wisc Online Learning Object | Carbohydrate Digestion
wisc-online.com/objects/ViewObject.aspx?ID=AP15806

» Biology Experiments |DG Makean
biology-resources.com/biology-experiments2.html

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6A

TESTING FOR STARCH AND GLUCOSE

Activity Length
45 min.

Activity Type
Activity

Introduction

Lugol's solution (an iodine-potassium iodide solution) can be used to test for the presence of starch in an unknown compound. Starch molecules have a helix-shaped secondary structure. Inside the helix, substances such as iodine can get lodged (forming an inclusion compound). The resulting substance turns blue or blackish in colour. The compound is unstable when heated, thus the colour should disappear when it is warmed and reappear when it is cooled.

Benedict's solution is a general test for monosaccharides, e.g. glucose. It contains blue Copper(II) ions that are reduced to Copper(I) ions. Glucose contains an aldehyde group that reduces the blue Copper(II) ions to red Cu_20. The same reaction is shown by fructose, maltose and lactose, but not by sucrose (cane sugar).

Materials (per lab group)

- Starch (maltose powder or potato powder)
- Glucose Lugol's solution (iodine-potassium iodide solution)
- Benedict's solution
- 4 test tubes
- Hot water bath (hot plate and beaker filled half with water) or spirit burner
- Observation sheet
- Spoon

(All chemicals and solutions are readily available from science supply stores)

What to do

Preparation

1. Prepare a starch solution by filling a test tube to about a third full with water and adding a spoon tip's worth (approx. 100mg) of starch. Warm the suspension in a hot water bath or carefully over a spirit flame until the solution turns clear. Then cool the solution again under running water.
2. Preparation of glucose solution: Fill a test tube to about a third full with water and dissolve about 2 spoon tips' worth of glucose in it.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

Activity

Lab 1: Starch (Lugol's solution test)

1. Add a few drops of Lugol's solution to half of the starch solution and mix.
2. Note any colour changes.
3. Warm the solution in the hot water bath or over the spirit burner and then cool it again.
4. Note any colour changes.

Lab 2: Glucose (Benedict's solution test)

1. Add 2ml–3ml of the Benedict's solution to half the glucose solution and mix.
2. Then warm the sample in the hot water bath or over a spirit burner (slowly and while agitating) for 3–5 minutes.
3. Note any colour changes.

Control Experiments

1. Carry out the starch test with the remaining glucose solution and the glucose test with the leftover starch solution.

Key Questions

» Lab 1: Why is there a difference when it is heated?
» Lab 2: What is the range of colours that you observed in the glucose test?

Extensions

» Manipulate the range of heat. Does that affect the speed of colour change in the starch test?
» Does a change of pH affect the indicators?
» Can you detect the presence of starch in food? Try a range of fruits and vegetables.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6B

STARCH BREAKDOWN USING αα-AMYLASE

Activity Length
45 min.

Activity Type
Activity

Introduction

Amylase breaks down starch. Salivary amylase is the enzyme released in your mouth as part of saliva. Pancreatin is produced by your pancreas and contains amylase, which is released in your stomach as part of the gastric juices. Each of these works to break down complex chains of carbohydrates into their simpler forms.

As in the previous experiment, the colour change when in the presence of Lugol's solution, indicates the presence of starch.

Materials (per lab group)

- Lugol's solution
- Starch (Maltose powder or potato powder)
- α-amylase
- Pancreatin
- 2 x 250mL beakers
- Hot water bath (hot plate and beaker filled half with water) or spirit burner
- Glass rod
- Shallow dish (e.g. petri dish)
- Cotton ball
- Writing paper (3 pieces, preferably large, e.g. 10cm x 5cm)
- Observation sheet
- Spoon

(All chemicals and solutions are readily available from science supply stores)

What to do

Preparation

1. Starch solution: add 1 spoon-tip's worth (approx. 100mg) starch to approx. 10ml water and heat in hot water bath until a clear solution is formed.
2. Amylase solution: add 1 spoon-tip's worth (approx. 100mg) αamylase to approx. 5ml water and shake.
3. Pancreatin solution: dissolve 1 spoon-tip's worth (approx. 60mg) pancreatin in 5ml water and shake.
4. Dilute Lugol's solution: dilute 1–2ml Lugol's solution with approx. 10ml water and pour out into a shallow dish.

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

Lab

1. Moisten a cotton ball with starch solution and coat 3 pieces of writing paper on one side with the starch solution. Leave the starch solution to dry slowly. Transfer a drop of amylase solution onto the surface of one piece of the prepared paper with a glass rod (wooden rod, paintbrush) and spread it out into a design of your choice.
2. After the amylase solution has had a few seconds to soak in, dip the paper briefly into the dilute Lugol's solution.
3. Repeat the experiment, but use the pancreatin solution in place of amylase solution on a second piece of prepared paper
4. To perform a control experiment, dip the third piece of prepared paper briefly in the Lugol's solution.
5. Record your observations.

Key Questions

» How can you determine the presence of amylase?
» How can you determine the presence of starch?
» Did you see the same colour change as in the previous test for starch experiment?

Extensions

» Test for the presence of amylase in your saliva (replace amylase solution with a few drops of saliva).

BODY WORLDS
ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6C

TEST FOR THE BY-PRODUCTS OF STARCH

Activity Length
45 min.

Activity Type
Activity

Introduction

Pure starch solution does not react with Benedict's solution. When starch is broken down by amylase into maltose, the typical Benedict's reaction may be observed.

Materials (per lab group)

- Starch α-amylase
- Pancreatin
- Benedict's solution
- Test tubes
- Hot water bath (hot plate and beaker filled half with water) or spirit burner
- Spoon

(All chemicals and solutions are readily available from science supply stores)

What to do

Preparation

1. Starch solution: add 1 spoon-tip's worth (approx. 100mg) starch to approx. 10ml water and heat in a hot water bath until a clear solution is formed.
2. Pancreatin solution: dissolve 1 spoon-tip's worth of pancreatin in approx. 5ml water.
3. Amylase solution: add 1 spoon-tip's worth (approx. 100mg) α-amylase to approx. 5ml water and shake.

Lab

1. Mix the starch solution with 1–2ml of pancreatin solution in one test tube and leave for a few minutes to react.
2. Mix the starch solution with 1–2ml of the amylase solution in a second test tube and leave for a few minutes to react.
3. Carry out the Benedict's solution test (see glucose test above) on each mixture.
4. To demonstrate that the pancreatin preparation is sugar-free, carry out the Benedict's solution test with the remainder of the pancreatin solution.

Key Questions

- What is the control?
- What was the result of mixing starch with the pancreatin or amylase?

Extensions

- Can you repeat this experiment to break down starch in food? Try a range of fruits and vegetables (mash them up to replicate the mechanical digestion by your teeth).

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6A

OBSERVATION SHEET

Test Tube	Contents	Test	Results before heating (colour)	Results after heating (colour)	Results after cooling (colour)
1	Starch solution	Lugol's solution			
2	Glucose solution	Benedict's solution			
3	Starch solution	Glucose solution			
4	Glucose solution	Starch solution			

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6B

OBSERVATION SHEET

Paper	Contents	Test	Colour of design
1	Starch solution + amylase	Lugol's solution	
2	Starch solution + pancreatin	Lugol's solution	
3	Starch solution	Lugol's solution	

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 6C

OBSERVATION SHEET

Test Tube	Contents	Test	Results after heating (colour)	Results after cooling (colour)
1	Starch solution + amylase	Benedict's solution		
2	Starch solution + pancreatin	Benedict's solution		
3	Pancreatin	Benedict's solution		

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 7

UNPACKING PROTEINS

Curriculum Connections

- **Science 8 Unit B**
  (Cells and Systems)
- **Biology 20 Unit D**
  (Human Systems)

Introduction

When we eat foods like cheese, meats and dairy products, we consume a variety of proteins. How do these complex, three-dimensional molecules get from our food into our bloodstream?

Background

Digestion occurs when three-dimensional structures have been reduced to their building blocks. Proteins are extremely complex, three-dimensional structures that are first broken down in the stomach and further broken down in the small intestine.

In our stomach, proteins are broken down from three-dimensional structures into chains of amino acids. Pepsin is the enzyme released by the gastric gland that facilitates this first reaction. The pH of the stomach is low due to the presence of hydrochloric acid.

As these chains move into the intestine, pancreatic juices containing proteases and peptidases (protein-specific enzymes) break the protein chains down further into individual amino acids. The pH of the small intestine is higher (more alkaline) than it is in the stomach.

Digestive enzymes operate within an optimal pH and temperature range. By modelling the environment within the stomach and within the small intestine, we can observe the activity of these enzymes on their substrates.

List of Activities

- Protein digestion in the stomach
- Protein digestion in the small intestine

Vocabulary

- **acid**
- **amino acid**
- **peptide bond**
- **pH**
- **polypeptide**
- **protein**
- **chemical digestion**
- **digestive system**

References

- *BODY WORLDS Educators Guide*
- Protein Digestion
  study.com/academy/lesson/protein-digestion-and-absorption-process.html

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 7A

PROTEIN DIGESTION IN THE STOMACH

Activity Length
45 min.
plus 2 days for observation

Activity Type
Activity

Introduction

This activity models the environment of the stomach—a low pH due to the presence of hydrochloric acid.

Although food is mechanically broken down in the mouth by the teeth, it isn't until the food reaches the stomach that chemical digestion of the proteins begins. The gastric gland releases several enzymes that contribute to the gastric juices which work to break down food. In particular, pepsinogen is a chemical released in the gastric juices that in the presence of hydrochloric acid is reduced to pepsin, which digests proteins.

The temperature within the stomach is 37°C the same as body temperature. This is the optimal temperature for pepsin activity. If the temperature is manipulated, pepsin changes shape and can no longer effectively digest complex proteins.

» **Note:** always add acid **to** water and not vice versa.

Materials (per lab group)

» Hard-boiled egg whites (protein) (can also use casein powder or gelatin)
» Pepsin (may be purchased from science supply stores)
» Dilute hydrochloric acid
» 7 test tubes
» Small beaker
» Measuring pipette
» Hot water bath (hot plate and beaker filled half with water)
» Spoon

What to do

Preparation

1. Put 10ml water into a test tube, add 3 spoon-tips' worth (approx. 150mg) of pepsin and dissolve by shaking gently. The result is an approximately 1%–2% pepsin solution.
2. Repeat step 1 preparing a second test tube of pepsin solution. Using a hot water bath, boil the pepsin solution for 5 minutes then cool.
3. Fill a small beaker with 30ml of water. Pipette 3ml of dilute hydrochloric acid into the beaker (hydrochloric acid is corrosive, so use a pipette bulb). The result is a dilute hydrochloric acid. This has a concentration roughly the same as that of human gastric acid.

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

Lab

1. Set up the five test tubes in the following way:
    i. 10ml water + 2ml water
    ii. 2ml water + 10ml dilute hydrochloric acid
    iii. 10ml water + 2ml pepsin solution
    iv. 2ml pepsin solution + 10ml dilute hydrochloric acid
    v. 2ml previously BOILED pepsin solution + 10ml dilute hydrochloric acid
2. Put a pea-sized piece of hard-boiled egg white into each of the five test tubes.
3. It will take approximately 1–2 days before the pepsin's digestive effects can be clearly seen. Placing the test tubes in a chemical oven or a water bath (37°C) will speed up the egg protein digestion.
4. Compare rates of digestion quantitatively and qualitatively in a chart.

Key Questions

- Which test tube is the control?
- Which test tube contents cause the protein to digest faster? Why?
- Which test tube did you see no change in? Why?
- What is the difference between digestion and decomposition? Which is happening in which test tube?
- What was the effect of boiling the pepsin solution?

Extensions

- Repeat the experiment, but manipulate the effective temperature range of pepsin using a series of water baths (e.g. 27°C, 37°C, 47°C).
- This lab can be replicated using gelatin (protein derived from bones) or casein (protein derived from milk) instead of egg white.
- **Note:** if using gelatin or casein as a replacement for egg white:
- Gelatin is a protein extracted from the collagen in bones.
- Casein is the most important protein component in milk. It is composed of a number of different proteins.
- Replace egg white with either 1 rectangular piece of gelatin (approx. 1cm x 3cm) or 2 spoon-tips' worth of casein per test tube.
- The final step of the lab procedure (heating up the solutions to speed up digestion) is not appropriate for gelatin digestion as gelatin dissolves in warm water.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 7B

PROTEIN DIGESTION IN THE SMALL INTESTINE

Activity Length
20 min.
plus 60 min. to 2 days for observation

Activity Type
Activity

Introduction

Pancreatin contains the enzymes in the pancreatic juices, whose optimal pH condition is neutral to weakly alkaline. Amongst other substances, pancreatin contains proteases, protein-busting enzymes that become active in the neutral or mildly acidic conditions of the small intestine.

Materials (per lab group)

- Pancreatin (may be purchased from science supply stores)
- Hard-boiled egg whites (protein) (can also use casein powder or gelatin)
- Dilute sodium hydroxide (caution: caustic!)
- Three test tubes
- Pipette
- Spoon

What to do

Preparation

1. Pancreatin solution: In a test tube, Mix 10ml water with 1 spoon-tip's worth (approx. 60mg) of pancreatin and dissolve, shaking gently.
2. Cut two pieces of hard-boiled egg white to the size of a pea.

Activity

1. Set up the two test tubes in the following way:
    i. 1st test tube: Mix 10ml pancreatin solution with one drop of dilute sodium hydroxide and add one pea-sized piece of egg white.
    ii. 2nd test tube: Mix 10ml water with 1 drop of dilute sodium hydroxide and add one pea-sized piece of egg white
2. At room temperature, these can be analyzed after 1–2 days. The rate of the experiment can be sped up by placing test tubes in a water bath and raising the temperature to 37°C.

Key Questions

- Which test tube is the control?
- Which test tube contents caused the protein to digest faster? Why?
- Which test tube did you see no change in? Why?

Extensions

- Repeat the experiment, but manipulate the effective temperature range of pancreatin using a series of water baths (e.g. 27°C, 37°C, 47°C).

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 8

BREAKIN' DOWN WITH BILE

Curriculum Connections

» **Biology 20 Unit D**
(Human Systems)

Could also work for:

» **Science 8 Unit B**
(Cells and Systems)

Introduction

Fats are tricky to break down and don't dissolve in water. The following activities demonstrate the process by which fats are broken down into compounds that are largely water soluble.

Objectives

Students will be able to:

» Explain the role of bile in the emulsification of fats
» Identify the presence of an acid using an indicator
» Explain the significance of the pH scale with reference to the digestion of fats

Background

Small, water-soluble molecules can pass through the intestinal wall and be transported through the body.

Solid fats are chewed and broken down mechanically before they pass into the stomach. As they leave the stomach, bile salts are added to fats by the gall bladder. The bile salts help emulsify fats that are not water soluble; that is, they help these fats disperse in water. The fats are broken down into many tiny fat droplets.

Small fat droplets are then broken down by an enzyme called lipase, into their building blocks: fatty acids and glycerine. The greater surface area that results from emulsification gives lipase a larger target area to work on.

These experiments investigate the role of digestive enzymes produced by the pancreas, in the process of breaking down fats.

List of Activities

» Digestion of Fat
» How Bile Works
» Fat Digestion with the Aid of Bile

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

Vocabulary

- **fat**
- **bile**
- **acids**
- **digestive system**
- **neutralization**
- **phenolphthalein**
- **lipid**
- **pH**
- **pancreatic amylase**
- **chemical digestion**

References

- *BODY WORLDS Educators Guide*

Other Resources

- National Institutes of Health | The Visible Human Project
  nlm.nih.gov/research/visible/visible_human.html
- BBC Science and Nature | The Human Body and Mind
  bbc.co.uk/science/humanbody/body/index_interactivebody.shtml
- Kids' Health Organization
  kidshealth.org

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 8A

DIGESTION OF FAT

Activity Length
20 min.

Activity Type
Demonstration

Introduction

Pancreatin contains the enzyme lipase, which breaks up fat. The free fatty acids that result from the process neutralise the sodium hydroxide. In neutral and acidic conditions, phenolphthalein is colourless.

Pancreatin contains enzymes in the pancreatic juices whose optimal pH condition is neutral to weakly alkaline.

Materials (per lab group)

- Cooking oil
- Pancreatin
- Dilute sodium hydroxide
- Phenolphthalein solution (acid-base indicator)
- Test tubes
- Beakers
- 1 Erlenmeyer flask 300ml or larger with airtight stopper
- Measuring pipette (e.g. 5ml)
- Spoon

(All chemicals and solutions are readily available from science supply stores)

Instructions for storing the enzymes:

- If left in a dry place in the fridge (+4°C), the enzyme preparations will keep for several years without any significant decrease in activity.

What to do

Preparation

1. Fat emulsion: put approx. 200ml of water and approx. 2ml of cooking oil into an Erlenmeyer flask. Seal the flask and shake it vigorously until an opaque, milky liquid forms. Add 5 drops of dilute sodium hydroxide and 5 drops of phenolphthalein solution to this emulsion, while swirling the flask. The liquid is now a pink colour.
2. Pancreatin solution: fill each of 2 test tubes with the same amount of water (approx. 5ml). Put 1 spoon-tip's worth (approx. 50mg) of pancreatin into one of these test tubes and shake into a suspension.

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

Demonstration

1. Divide the fat emulsion equally between 2 beakers.
2. Add the pancreatin solution to one of the beakers.
3. For comparison, add only an equivalent amount of water to the second beaker.
4. After a short time the contents of the first beaker will become colourless, whereas no change can be seen in the second beaker.

Key Questions

» Which beaker is the control? Why?

BODY WORLDS
ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

ACTIVITY 8B

HOW BILE WORKS

Activity Length
10 min.

Activity Type
Activity

Introduction

Bile emulsifies fats. It makes fats that are not water soluble, disperse better in water. This leads to a larger number of fat droplets. The resulting increase in surface area gives lipase a larger target area to work on.

Materials (per lab group)

- Cooking oil
- Dried ox bile/bile salts (can be ordered through a science supply store or from a natural health pharmacy)
- 2 test tubes
- 2 shallow dishes (e.g. petri dishes)
- Pipette
- Spoon

What to do

1. Half fill 2 test tubes with water and add 3 drops of cooking oil to each.
2. Add 1 spoon-tip's worth (approx. 50mg) of ox bile into one of the test tubes.
3. Seal the test tubes, shake and pour the contents of each into a shallow dish.
4. Observe the difference in size of the fat globules forming in the dishes. The addition of the ox bile causes smaller globules of fat to form.

Key Questions

- Which test tube is the control? Why?
- Why is there a difference in size?

Extensions

- How does this demonstration compare to what happens in the small intestine?
- How do we use emulsifiers in daily life?

BODY WORLDS ANIMAL INSIDE OUT

TELUS WORLD of SCIENCE Edmonton

ACTIVITY 8C

FAT DIGESTION WITH THE AID OF BILE

Activity Length
20 min.

Activity Type
Activity

Introduction

Pancreatin contains the enzyme lipase that breaks down fat. The free fatty acids that are created in this process neutralise the sodium hydroxide. With the aid of bile, dispersion of the fat in the water increased compared to when no bile is added. Therefore, bile causes the oil droplets to take on a greater surface area, which aids in the enzyme action and thereby speeds up the reaction.

Materials (per lab group)

- Cooking oil
- Pancreatin
- Dried ox bile/bile salts (can be ordered through a science supply store or from a natural pharmacy)
- Dilute sodium hydroxide
- Phenolphthalein solution
- 3 test tubes
- Measuring pipette
- Spoon

(All chemicals and solutions are readily available from science supply stores)

What to do

Preparation

1. Bile: dissolve 5 spoon-tips' worth (approx. 250mg) of dried ox bile in 10ml of water. Divide solution into two equal portions.
2. Pancreatin solution: dissolve 5 spoon-tips' worth (approx. 300mg) of pancreatin in 10ml of water. Divide solution into two equal portions.

Lab

1. Put 1ml of cooking oil and 5 drops of phenolphthalein solution into each of the 3 test tubes.
2. Then add the following:
   1st test tube: 5ml pancreatin solution + 5ml water
   2nd test tube: 5ml bile + 5ml water
   3rd test tube: 5ml bile + 5ml pancreatin solution
3. Mix the contents of each test tube by shaking them gently.
4. Add dilute sodium hydroxide, drop by drop, to each test tube in turn, until the contents of all the test tubes are largely the same colour.

BODY WORLDS ANIMAL INSIDE OUT
TELUS WORLD of SCIENCE Edmonton

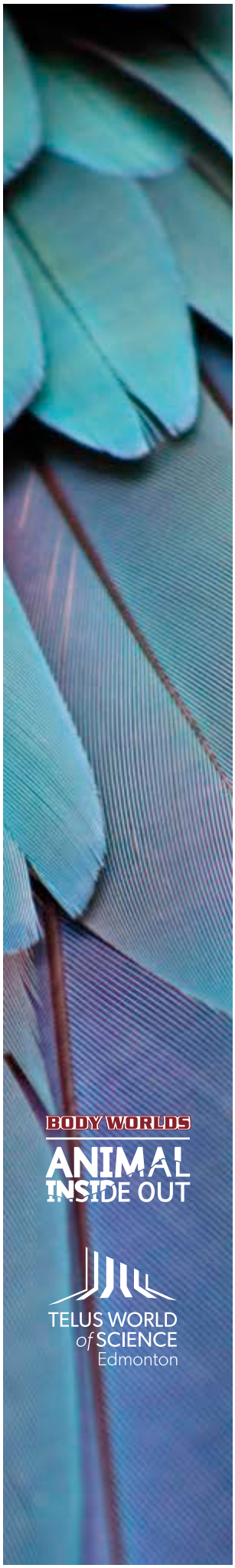
» **Note:** as bile has a strong colour of its own, it is not possible to get exactly the same colour in each test tube, but the results of the experiment are still clear. If necessary, the reactions can be sped up by putting the test tubes in a water bath (40°C).

Key Questions

» Which test tube is the control? Why?

» In alkaline (basic) conditions, phenolphthalein is red, but in neutral and acidic conditions it is colourless. Using this information, explain why the colour changes occurred.

» Which test tube took the longest to neutralize?



AMAZING FACTS

Human intestines
are at least 7.5 metres long in an adult.
Be glad you're not a full-grown horse—
their coiled-up intestines are 27 metres long!
Digestion from mouth to anus takes about 72
hours compared to 6 to 8 hours for humans.

Horses don't have
gall bladders, bile from the liver flows
directly into the small intestine.

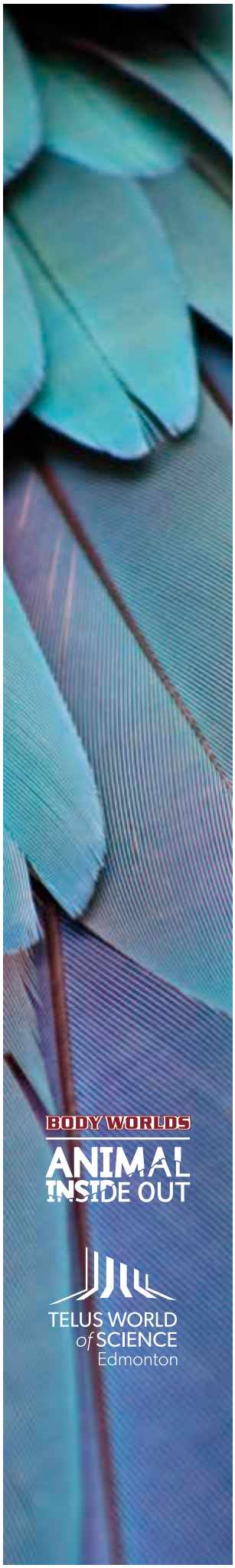
Some animals like
seahorses, lungfishes and platypuses
have no stomach. Their food goes from
the esophagus straight to the intestines.

Chickens and other birds
don't have teeth.
They have a gizzard that stores small stones
which are used to grind hard foods like seeds.

The owl swallows its prey whole,
including the bones. When it has digested the
edible parts of its food, the bones and the other
non-digestible parts are pushed out through its
mouth in a small ball called a pellet.

Horses can't throw up.
This is because the esophagus in
a horse has a one-way movement.
It prevents feed from coming back up.

Horse



Giant squid
can snatch prey
up to 10 metres away by
shooting out their two feeding tentacles,
which are tipped with hundreds of
powerful sharp-toothed suckers.

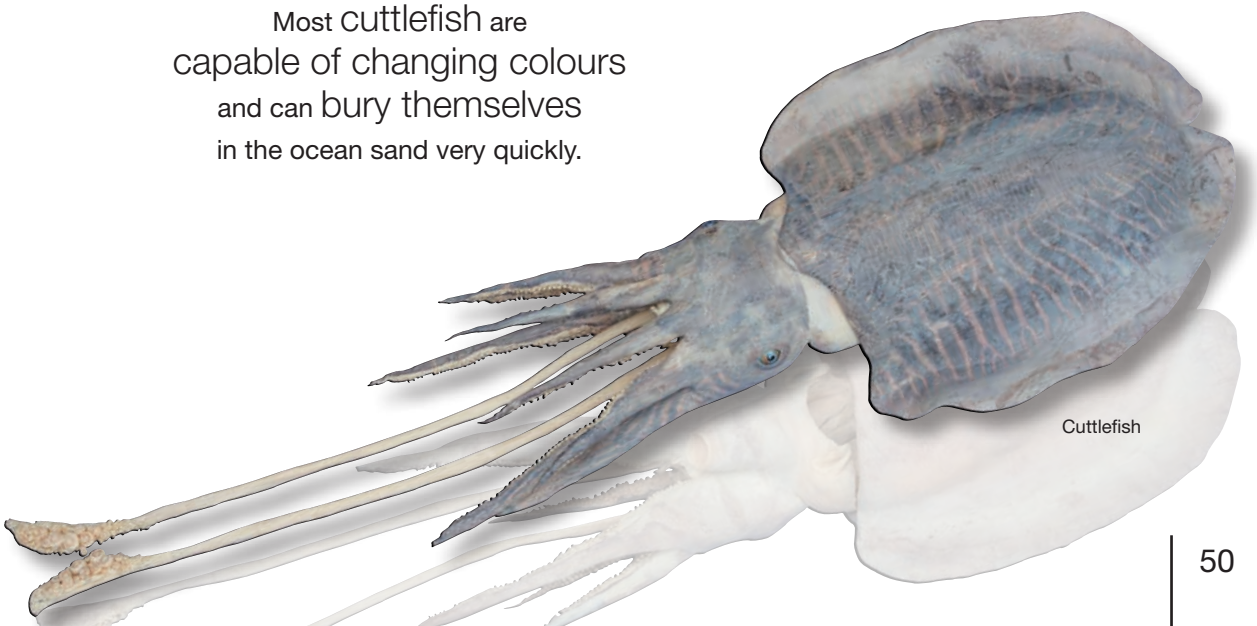
Sharks
have been swimming the seas
for 400 million years—
that's longer than the
dinosaurs walked the Earth.

Sea scallops
grow rapidly during the early years of life.
Between the ages of 3 and 5, they commonly increase
50% to 80% in shell height
and quadruple their meat weight.

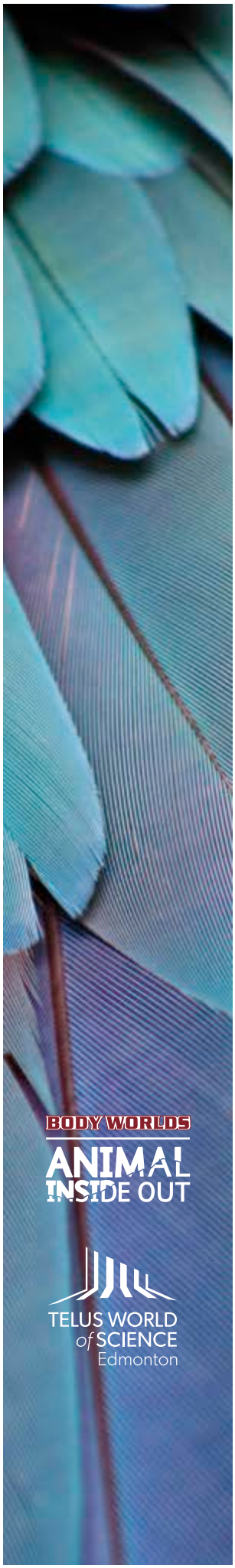
The maximum speed of a snail
is 100 metres per hour.

Mackerel,
unlike any other species, are likely to die if their
incredibly thin and specialized skin is
touched by human hands. It is theorized that this
might be due to the oils in human hands.

Most cuttlefish are
capable of changing colours
and can bury themselves
in the ocean sand very quickly.



Cuttlefish



Frogs don't need to drink the way humans do—they absorb water through their permeable skin!

Giraffes are the tallest mammals on Earth, ranging in height from 4.3 to 5.5 metres. An adult bull giraffe can feed on the leaves of trees over 5.8 metres above the ground!

Mallards can travel up to 105 kilometres per hour.

The combination of the cat's inner ear (vestibular apparatus) and tail gives the cat its incredible balance and acrobatic prowess.

Caribou have long, coarse hair with hollow cores, which keeps them insulated in colder climates. Caribou are very strong swimmers and can travel across wide, rapid and frigid rivers.

A bull's heart is around 5 times heavier than a human heart.

Caribou