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Welcome and the Scientific Method

Learning Objectives
At the end of this unit, you will be able to:

- Describe the nature of science and the scientific method, including its limitations.
- List the stages in the cycle of the scientific method.
- Identify, in a given experiment:
  - The hypothesis
  - The independent variable
  - The dependent variable
  - The control(s)
- Describe some of the methods of dissemination of scientific research.

Scientific Method
The scientific method is a process that scientists use to explore observations and answer questions about the natural world.

The scientific method is best shown as a cycle, indicating that scientists are ________________.

Science and its Limits

<table>
<thead>
<tr>
<th>Science is</th>
<th>Science is not</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Scientific Method
The steps of the scientific method are:

1. **Observation**: a process of noticing things in the world around you.
2. ________________: the “wonder” that this observation has inspired.
3. ________________: your best guess for the answer to your question.
4. ________________: to test your prediction in a controlled experiment.
5. ________________: a look at the data you collected in your experiment from which you have identified trends or relationships.

6. ________________: an informative statement based on your findings.

**Experimental Design**

- The purpose of experimental design in biology is to plan an experiment in which you can reliably answer your biological question.
- Your experimental design must include several components:
  - Background knowledge
  - Hypothesis
  - Variables and method of collecting data
  - Controls to ensure the data collected relates directly to your question
  - A method of analyzing your data to see if your hypothesis is correct
  - A way of spreading the word about your findings

**Terms Relating to the Scientific Method**

**Independent variable:**

**Dependent variable:**

**Control:**

**Theory:** a statement generally accepted by the majority of scientists as a summary for a hypothesis.

**Law:** a statement based in repeated experimental observations, which, with no exceptions, describes some aspect of the universe.

**TRY IT OUT**

These people are in my group with me:

I chose the scenario about:

- Moss on trees.
- Sharks.
- Phones vs. toilet seats.

Hypothesis:
Experimental Design:

Independent variable (what do you get to manipulate?):

Dependent variable (what do you measure or record?):

Controls (how do you keep it “fair”?):

**Cell Biology: Part 1**

**Learning Objectives**

At the end of this unit, you will be able to:

- Explain cell theory and the history of its development.
- Label a diagram of the cell and its organelles.
- Identify the function of each structure in the cell.
- Diagram and define cell division.
- Describe several cell processes.
- Outline the unique role DNA plays in cell theory.
- Outline the unique role DNA plays in natural and artificial selection.

**Cells: the building blocks of life**

- A cell is the smallest unit of life.

- Your body is made up of __________ of cells.

- Some cells live in one single unit.

- If you are ______________, you are made of cells.

In order to be considered a cell, three components are necessary:

1. A _________________ (the barrier of the cell).
2. _________________ (the watery interior).
3. _________________ (DNA or RNA).
Cell Theory
Cell theory consists of three basic tenets:

1. All living things are composed of one or more cells.
2. The cell is the most basic unit of life.
3. All cells arise from pre-existing cells.

Cells have Organelles
- Just as we have _______________ in our bodies that have specific _______________, cells have _______________.
- Each of these organelles has a specific set of tasks, for which they are specialized. When all the organelles are doing their tasks, you have a _______________.

Two main types of cells

<table>
<thead>
<tr>
<th>Prokaryotic</th>
<th>Eukaryotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic material is not enclosed in a membrane</td>
<td>Genetic material is enclosed in a membrane</td>
</tr>
<tr>
<td>Small in size (1-5 um)</td>
<td>Large in size (10-100 um)</td>
</tr>
<tr>
<td>Typically single-celled organisms</td>
<td>Single-celled or multi-celled organisms</td>
</tr>
<tr>
<td>Few organelles</td>
<td>Many organelles</td>
</tr>
</tbody>
</table>

Organelles

Let’s start with the three basic components of the cell:

- Cell membrane
- Genetic Material
- Cytoplasm
Cell Membrane

- The **cell membrane** is the “skin” of the cell, which:
  - Keeps the inside in and the outside out.
  - Helps maintain the __________ of the cell.
  - Is made of a type of molecule called a ____________.
- Certain substances can cross the cell membrane while others cannot.
- Some types of organisms will surround their cell membrane with a protective layer, either a _____________________ or a __________________.

Genetic Material

- **Genetic material** is typically stored in a central location in the cell.
- In the vast majority of cells, this genetic material is ________.
- DNA contains all of the information needed to build and maintain an organism.
- In a eukaryotic cell, the genetic material is DNA, and it is wrapped in a membrane called the nuclear envelope. This membrane together with the DNA, is called the ____________.
- In a prokaryotic cell, the DNA, or in some cases RNA, is stored in an area called the ________________.

Cytoplasm

- The **cytoplasm** is in the interior of the cell.
- Cytoplasm:
  - Makes up approximately _____________ of the cell’s volume (in a typical cell).
  - Has a jelly-like consistency.
  - Provides a place for all the other _________________ to be.
  - Helps maintain the shape of the cell.

Organelles

- Eukaryotic cells, including plant and animal cells, have many types of organelles. Each type of organelle is suited for a specific job.
• The ______________is located inside the nucleus. It is where _____________ are made.

• **Ribosomes** are tiny pieces of cell machinery whose job it is to synthesize ________________.
  
  • Ribosomes can be found attached to the ER, or floating around in the cytoplasm.

• The endoplasmic reticulum (ER) is attached to and surrounds the nucleus.
  
  • It is made of the same type of membrane material as the _____________ and the _________________.
  
  • There are two types of ER, smooth and rough.
  
  • ________________ is studded with ribosomes and helps make proteins.
  
  • ________________ has no attached ribosomes and helps produce fats, steroid hormones, and cell membrane components.

• The **Golgi body** is made of the same materials as the ER and plasma membrane, but is not attached to the _________________.
  
  • The Golgi body prepares products made by the rough and smooth ER for export out of the cell.
  
  • Because the Golgi body needs to modify and package products made by the ER, there are organelles called **vesicles** which transport substances from one place to another in the cell—like taxis.

• The **mitochondria** is the powerhouse of the cell.
  
  • It converts the energy in glucose (sugar) into a more usable currency, called ATP.
  
  • A cell will have several mitochondria.

**Cell Division**

Cell division is used by cells for ________________, ________________, and ________________.

• In cell division, one cell makes a copy of its DNA, and then splits into two halves, each with its own complete set of DNA.
• When your body grows, your cells do not get bigger, they make more of themselves. This is how **growth** occurs in multicellular organisms.

• **Repair** is another use for cell division—Cell division provides cells for healing.

• **Reproduction** is another reason cells undergo division. The process works differently for different reproduction strategies.
  
  • Single celled organisms grow to a certain size and then divide to form two identical but separate organisms. In bacteria, this is called ______________.

  • There are certain types of reproduction that result in ______________: separate organisms with identical genetic material.

  • Plants often undergo **vegetative reproduction**, but they use cell division to create identical, but tinier versions of themselves that will grow to maturity.

• Up to this point, all of the cell division we have discussed in this course has been a type called ____________.

• In mitosis, two **identical** cells are produced from an original parent cell.

• There are pros and cons to reproducing yourself using mitosis (also called ______________).

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• You do not have to find a mate.</td>
<td>• Less genetic variation in the population means that it is harder to adapt to changes in the environment.</td>
</tr>
<tr>
<td>• Your offspring are already adapted for their environment.</td>
<td></td>
</tr>
<tr>
<td>• Cell division occurs quickly.</td>
<td></td>
</tr>
</tbody>
</table>

• Organisms that use **sexual reproduction** use a different type of cell division called ____________.

• Meiosiss is a special type of cell division that results in ________ separate and unique daughter cells, each with only a half set of DNA.

• The idea behind sexual reproduction is that each of the two individuals contribute a cell with a half set of DNA. Once the two cells merge, a new, genetically unique individual is formed.
There are pros and cons to sexual reproduction:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>•</td>
<td>• It requires much more energy.</td>
</tr>
<tr>
<td>•</td>
<td>• Courtship may require time and resources.</td>
</tr>
</tbody>
</table>

**Cell Division: Mitosis**

In **mitosis**, a single cell makes an _______________ of its DNA and divides into __________ _______________ daughter cells.

There are four stages in the process of mitosis:

1. **Prophase:**
   ____________________________________________________________________________________________.

2. **Metaphase:**
   ____________________________________________________________________________________________.

3. **Anaphase:**
   ____________________________________________________________________________________________.

4. **Telophase:**
   ____________________________________________________________________________________________.

Mitosis can be used for:

**Cell Division: Meiosis**

- **Meiosis** is used only to create **gametes** for the purpose of sexual reproduction.
- **Gametes** are cells with half the amount of DNA as a regular cell, for the specific purpose of fusing with another gamete to produce an entirely new organism.
- **Meiosis** follows the same four stages of mitosis (prophase, metaphase, anaphase and telophase) but goes through these stages twice in order to halve the amount of DNA in the cell.
- These two stages are called Meiosis I and Meiosis II.

**Cell Processes**

- The cell is a busy place!
- At any given time, your cells are:
• Taking in nutrients
• Expelling wastes
• Breaking down molecules
• Building molecules
• Replicating DNA
• Growing

and much more!

• These cell processes are often performed in relation to replication, growth, protein synthesis and motility.

Cell Biology: Part 2

Cell Processes

We will be learning about 4 main cell processes:

1. DNA Replication
2. Protein Synthesis
3. Photosynthesis
4. Cellular Replication

For each of these processes you should be able to:

• Write the

______________________________________________________________

___.

• Explain the __________________________________________ and
when/under what circumstances

______________________________________________________________.

• Identify

______________________________________________________________

___.
DNA Replication

- DNA is the __________________________________________ in a cell.

- It carries the instructions for how to create all the different types of ________________________ a cell can make.

- Since all cells arise from pre-existing cells and all cells have genetic material, it follows that DNA must be replicated before a cell goes through ______________________________ so that each new cell has a ________________________ of DNA.

- DNA is a double stranded molecule made of smaller parts called ____________________.

- There are four types of nucleotides: ____________________________.

- The nucleotides form the double stranded molecule by pairing with one another, always in the same way—_________________, and ____________________

- DNA is replicated in the nucleus of the cell.

The formula for DNA replication is:
DRAW IT OUT

Sketch the stages of DNA replication indicated in the table below.

<table>
<thead>
<tr>
<th>In the process of DNA replication, the two strands of the DNA molecules separate.</th>
<th>Then, enzymes called DNA polymerase create a new half to complete each of the strands.</th>
</tr>
</thead>
</table>

- The end result of DNA replication is _______________________ strands of DNA, both containing a half strand of the ______________________.
- The term for this is ____________________________ replication.
- With these two identical sets of DNA, the cell is now ready to go through ________________.

Protein Synthesis

- Many of the chemical reactions that take place in the cell are synthesizing proteins.
- The instructions for how to make proteins are coded in DNA.
- Proteins fulfill many roles, both in the cell and in the overall multi-cellular organism. Proteins make up:
  - Enzymes
  - Cytoskeleton
  - Ribosomes
  - Chemical messengers
  - Hair, skin, fingernails
  - Muscles
  - and much more!
• Making proteins is a multi-step process that occurs in many places within the cell.

• Proteins are made by joining long strands of molecules called amino acids.

• There are 24 different types of amino acids. DNA contains the information about which order these amino acids should be combined to produce each specific protein.

• The formula for protein synthesis is:

________________________________________________________________
___________.

• In order to make proteins, the instructions are copied from the DNA onto a molecule called ________.

• These instructions are sent out into the cell and meet with a ______________.

• The ribosome uses the RNA to determine the ____________ in which the amino acids should be linked together.

• Once the amino acids are linked in the correct order, the protein molecule is folded until it is in the correct shape.

Photosynthesis

• Photosynthesis is one of the most important biochemical reactions to life on earth.

• Photosynthesis is a chemical reaction that occurs in most plants in which carbon dioxide and water are converted to oxygen and glucose, by using energy from sunlight.

• The production of glucose is critical to life on earth—the majority of organisms use glucose as their _____________________.

The formula for photosynthesis is:

________________________________________________________________
___________

• Photosynthesis occurs in the _________________ of the cell.
• Not all cells contain __________________——they are found in plant and algal cells.
• Cells can contain anywhere from one to hundreds of these organelles.

Cellular Respiration
• Cellular respiration is the process a cell uses to break down glucose to access the energy stored in the molecule.
• Cellular respiration reverses the reaction that takes place in photosynthesis.

The formula for cellular respiration is:

___________________________________________________________________.

• Cellular Respiration takes place in the ______________ of a cell.
• Respiration is another word for breathing. It is included in the name of this process because cellular respiration requires ______________ to occur.
• Cellular respiration converts the energy stored in the glucose molecule into a form more easily used by the cell: __________.

Simple Patterns of Inheritance
• We already know that DNA codes for proteins. A section of DNA that codes for an individual protein is called a ____________________.
• These proteins give us many of our characteristics, such as:
  o Hair colour.
  o Eye colour.
  o Height.
  o Metabolism.
  and much more!
• When a sperm meets an egg, each of these _____________ is carrying only half of a set of DNA.
• When these two half sets of DNA meet, a new mix of _____________ is created, making a unique individual.
• Some of these genes will become _________________.
• Traits can be visible (hair or eye colour, for example) or not (metabolic rates, hereditary diseases).
• For each trait, you have genes from your mother, and genes from your father.
• These genes will interact to determine what trait you end up ___________________.
• There are several ways the two sets of genes will _________________.

Match the terms in the table below to the correct definitions:

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Phenotype</th>
<th>Homozygous</th>
<th>Heterozygous</th>
<th>Dominant</th>
<th>Recessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>The genes you got from your mom and dad that code for different things.</td>
<td>A gene that displays itself only if it is the only type of gene available.</td>
<td>The genes you have.</td>
<td>A gene that displays itself regardless of what other genes are present.</td>
<td>The trait you display.</td>
<td>The genes you got from your mom and dad that code for the same thing.</td>
</tr>
</tbody>
</table>

• You have two sets of genes for each trait: one from your ______________________ and one from your ______________________.
• Somehow, using the information contained in these ____________ you end up expressing a ____________.
• There are different ways in which genes interact, and it varies from gene to gene which interaction model is used.
• The interaction models that you will learn about in this course are:
  • Dominant/Recessive
  • Incomplete dominance
  • Codominance

**Dominant/Recessive**

In a dominant/recessive model of inheritance:

___________________________________________________________________________

_________________________
This model often shows up in colouring—darker colouring in eyes, hair and skin are much more likely to be expressed. In a ________________ individual, the ________________ gene will be expressed. Conversely, this means that a ________________ trait is only present if an individual has ________________ than the recessive gene.

**Incomplete Dominance**

In the case of incomplete dominance:

• In the image shown (on the slide), there are _____ genotypes, but ______ phenotypes.

**Codominance**

• We see an example of codominance in blood typing.
• Whichever genes you receive from your parents, you ________________.

**Punnett Squares**

• A Punnett Square is a tool we use to predict the genotype/phenotypes of offspring based on the genotype of their parents.

• Reginald Punnett and his colleague William Bateson developed the Punnett Square in 1905, as they examined the work of Gregor Mendel, who is often referred to as “the father of genetics.”
TRY IT OUT

Choose one of the following scenarios to discuss with a partner or small group.

Scenario 1:
You have discovered a new type of flower deep in the Amazon Jungle. This flower seems to come in three colours: yellow, orange and red. However, you have only been able to isolate two genotypes: one for red and one for yellow.

What type of inheritance model is expressed?
What would be the phenotype of a heterozygous flower?

Scenario 2:
You met a family of aliens on your way to school today. These aliens have cute little antennae on their heads. The mom alien has a pair of antennae with circles at the tops,
and the dad has a pair of antennae with ovals at the tops. The child alien has two pairs of antennae—one set with ovals and one set with circles.

What type of inheritance model is expressed?

If the alien couple had another child, what are some possible phenotypes that could arise?

**Natural Selection**
- **Natural selection** is the different survival/reproduction of living things based on differences in ________________________.
- We now know that certain traits are heritable, so traits that make organisms more likely to ______________________ are passed on to the next generation, often concentrating the successful gene.
- Often, the environment determines which traits will be successful. Since environment is different everywhere, certain organisms become adapted to a certain environment—this is an example of ________________________.
- **Microevolution** is a change in gene frequencies, over time, within a population.
- Natural selection can change a certain population when changes in the environment occur—whether that is a change in ______________-, ______________, ______________, etc.
- You can also use the term **fitness**: an organism’s ability to survive and reproduce based on its genotype.

**Artificial Selection**
- Artificial selection can also be called selective breeding.
- This is the process humans use to selectively develop desired traits in crops and/or livestock.
- Artificial selection is highly used in agriculture.
• When growing crops, genes for high yielding plants are favoured, as well as insect- and pathogen-resistant genes.

• When raising livestock, several genes are often favoured, including:
  • ___________________.
  • ___________________.
  • ___________________.
  • ___________________.
  • ___________________.

**Nutrition**

**Learning Outcomes**
• Describe the energy needs of the body.
• Describe worldwide food needs.
• Identify nutrients needed by the body.
• Identify special foods and diets.
• Plan a healthy diet.

**Diet**

**THINK ABOUT IT**

When you think of the word “diet,” what do you associate with its meaning?

How do you feel about the food you eat on a day-to-day basis?

**Nutrition**

“**Nutrition** is the process by which the body nourishes itself by transforming food into energy and body tissues. The science of **nutrition** concerns everything the body does with food to carry on its functions. Food provides essential substances called **nutrients.**”

~ Encyclopedia Britannica
Vocabulary

• _______________: a substance that provides nourishment essential for the maintenance of life and for growth.

• _______________: the food and drink regularly consumed by a person or a group of people.

• _______________: the amount of calories in food or drink in the form of fats, proteins or carbohydrates.

• _______________: a unit of measurement for energy.

Food as Fuel

• The food we eat provides all the nutrients we need to _________________.

• When our body _________________, these necessary molecules come from our diet.

• These molecules are called nutrients, and include:

• _________________.

• Any extra nutrients have to exit the body or be _________________.

Food Worldwide

TALK IT OUT

What types of food do you see here? Do you see different styles?

Which foods are healthy and which are not? Do you see trends or similarities?

Canada Food Guide

WORK IT OUT

Which category (gender, age) do you fit in to?
How many servings of each should you be eating each day?

- Vegetables and Fruits ________________
- Grain Products _____________________
- Milk and Alternatives __________________
- Meat and Alternatives ____________________

Think about what you ate yesterday, and list it here:

<table>
<thead>
<tr>
<th>Breakfast</th>
<th>Lunch</th>
<th>Dinner</th>
<th>Snacks/Beverages</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

How does yesterday’s meals compare with what is suggested according to the Canada Food Guide?

**Caloric Intake by Country**
Which areas or countries consume the most calories?

Which areas or countries consume the least calories?

Do you notice any trends in this map?

**Food Choices by Country**
Do you see any trends within the high-income countries’ food choices?

Do you see any trends within the low-income countries’ food choices?
Where does Canada fall in this graphic?

Does your food intake match the information given about Canada?

**Meat/Protein Consumption by Country**

What trends do you notice in these two graphs?

How do you think your own protein consumption falls in comparison with the average daily protein requirement?

What factors do you think would affect the accepted levels of the average daily protein requirements?
Assignment (10%)

Your assignment is to research a particular diet, which can be from a geographical region, a particular culture, a weight loss diet, etc.

Prepare an infographic providing:

1. Information about the diet, including:
   - Types of foods eaten
   - Typical daily caloric intake
   - Reasoning behind food choices
2. A list of the pros and cons of eating this way long-term, including:
   - Possible health benefits
   - Possible side effects
3. A 3-day meal plan that follows the diet, but aims to maximize the health benefits and minimize the possible side effects

Grading

Your project will be marked out of 20.

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Possible marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of diet</td>
<td>/7</td>
</tr>
<tr>
<td>Pros and cons of diet</td>
<td>/7</td>
</tr>
<tr>
<td>Meal plan</td>
<td>/6</td>
</tr>
<tr>
<td>Total:</td>
<td>/20</td>
</tr>
</tbody>
</table>