

# Intermediate General and Applied Science

## Biology Module: Lecture Manual

Developed by Christine Miller © 2018

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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

Science is	Science is not

## 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:

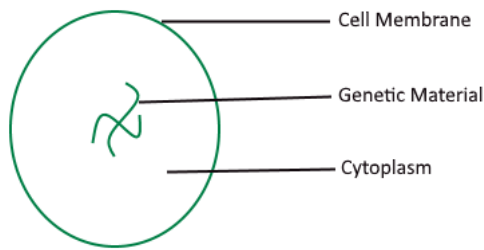
- Explain cell theory and the history of its development.
- Label a diagram of the cell and its organelles.
- Identify the function of each structure in the cell.
- Diagram and define cell division.
- Describe several cell processes.
- Outline the unique role DNA plays in cell theory.
- Outline the unique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

Prokaryotic	Eukaryotic
Genetic material is not enclosed in a membrane	Genetic material is enclosed in a membrane
Small in size (1-5 um)	Large in size (10-100 um)
Typically single-celled organisms	Single-celled or multi-celled organisms
Few organelles	Many organelles

## Organelles

**Organelle:**

**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 \_\_\_\_\_).

Pros	Cons
<ul style="list-style-type: none"> <li>• You do not have to find a mate.</li> <li>• Your offspring are already adapted for their environment.</li> <li>• Cell division occurs quickly.</li> </ul>	<ul style="list-style-type: none"> <li>• Less genetic variation in the population means that it is harder to adapt to changes in the environment.</li> </ul>

- Organisms that use **sexual reproduction** use a different type of cell division called \_\_\_\_\_.
- Meiosis 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:

Pros	Cons
•	<ul style="list-style-type: none"> <li>• It requires much more energy.</li> <li>• Courtship may require time and resources.</li> </ul>

## 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.

**In the process of DNA replication, the two strands of the DNA molecules separate.**

**Then, enzymes called DNA polymerase create a new half to complete each of the strands.**

- 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:

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\_\_\_\_\_

- 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:

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- 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:
  - Hair colour.
  - Eye colour.
  - Height.
  - 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:

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

- 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:

\_\_\_\_\_

\_\_\_\_\_



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\_\_\_\_\_.

- 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

- In the case of 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

	<b>A</b>	<b>A</b>
<b>a</b>		
<b>A</b>		

	<b>A</b>	<b>a</b>
<b>A</b>		
<b>a</b>		

	<b>A</b>	<b>a</b>
<b>a</b>		
<b>a</b>		

## TALK 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:

<b>Breakfast</b>	<b>Lunch</b>	<b>Dinner</b>	<b>Snacks/Beverages</b>

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.

Project Component	Possible marks
<b>Description of diet</b>	<i>/7</i>
<b>Pros and cons of diet</b>	<i>/7</i>
<b>Meal plan</b>	<i>/6</i>
<b>Total:</b>	<b><i>/20</i></b>