MINISTRY OF EDUCATION
SECONDARY ENGAGEMENT PROGRAMME
BIOLOGY
TERM 3
GRADE 10

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CONTENT

Resources are features of the environment that can be used by human society. As the population of the world increases, more raw materials are being used up. Raw materials fall into two main categories: renewable and non-renewable resources.

Renewable resources may be defined as resources that have the potential to be replaced over time by natural processes. The renewal process may be relatively quick, as with sunshine which comes daily or, the renewal process may be very slow, as in the formation of soil which may take hundreds of years. Examples of renewable resources include timber, fish, forms of energy such as solar power, wind energy, hydroelectricity, and ethanol-based fuels.

Non-renewables include energy sources such as fossil fuel and minerals, such as copper, nickel, zinc, and lead. When we have used these resources, they are gone forever.

Human Effects on Natural Resources

Humans impact the physical environment in many ways: overpopulation, pollution, burning fossil fuels, and deforestation. Changes like these have triggered climate change, soil erosion, poor air quality, and undrinkable water.

- Fossil fuels – most of our energy comes from the combustion of fossil fuels, which will run out eventually. Human activities have caused numerous oil spills both on land and water. These have detrimental effects on the organisms. Oil on ocean surfaces is harmful to many forms of aquatic life because it prevents enough sunlight from penetrating the surface, and it also reduces the level of dissolved oxygen. Crude oil ruins the insulating
and waterproofing properties of feathers and fur, and thus oil-coated birds and marine mammals may die from hypothermia.

![Image of oil-spilled birds](image1.png)

**Figs. 1 & 2** Consequences of oil spills
(Image taken from: treehugger.com)

- Fisheries – catches from the local stocks have declined due to overfishing and habitat destruction. Coral reefs, the habitat of fishes, are blown up with dynamite to catch fish.

![Graph showing decline in soft coral cover](image2.png)

**Fig. 3** Decline in soft coral % cover
(Image taken from: medium.com)

The image above shows the decline in the percentage of soft corals in the Caribbean, which are habitats to many fishes.

- Minerals are non-renewable resources and have shown to have several effects on the environment, for example, the red lake at Mount Rosser is known to be polluted heavily.
with alkali; nickel is extracted in Cuba and has led to severe degradation of the environment where deposits have destroyed large areas of coastal vegetation.

- Forest resources – humans have been clearing forests for thousands of years. Timber is used for building materials, paper for newsprint and other forms of paper, lands for farms, roads, factories and towns, and firewood and charcoal as fuel. Deforestation has caused many environmental problems such as flooding, soil erosion, habitat destruction and more carbon dioxide in the atmosphere since the trees that were cut down cannot absorb carbon dioxide any longer.

**Homework**

Identify ways how we can minimise human effects on natural resources.

**References**


Week: One
Lesson: One
Topic: The Impact of Human Activities on Natural Resources

**Instructions** – Answer questions 1 to 10 by CIRCLING the LETTER next to the correct answer.

1. Which of the following resources listed below is a non-renewable resource?
   A) Coal  B) Water  C) Solar  D) Wind

2. Which of the following is a renewable resource?
   A) Coal  B) Oil  C) Wind  D) Natural gas

3. Energy from burning organic or living matter is called?
   A) Wind  B) Nuclear  C) Solar  D) Biomass

4. Energy obtained from water flow is called ___________.
   A) solar  B) hydroelectric  C) geothermal  D) wind

5. What is a natural resource?
   A) Something you do for a living  B) A summer camp
   C) Something found in nature that people use  D) A way to cook camp food

6. Minerals are an important natural resource that comes from the Earth. Which of the following is not a mineral?
   A) Salt  B) Iron  C) Coal  D) Chlorophyll

7. Which of the following is a way to protect our natural resources?
   A) Pollution  B) Overpopulation  C) Recycling  D) Deforestation

8. The process of using resources wisely is called ___________.
   A) sustainability  B) pollution  C) overuse  D) burning
9. Which of the following is NOT an example of how your community uses natural resources?
   A) Chips and dip for watching a football game
   B) Water for a community swimming pool
   C) Gasoline for public transportation
   D) Trees to build furniture and house

10. Which type of natural resource can be replaced or replenished?
    A) Zero resources  
    B) Everything  
    C) Non-renewable resources  
    D) Renewable
MINISTRY OF EDUCATION
SECONDARY ENGAGEMENT PROGRAMME
GRADE 10
BIOLOGY

WEEK 1

TOPIC: Resources

Sub-topic: Pollution

CONTENT

Pollution is the contamination of land, water, or air by the discharge of harmful contaminants. Any harmful substance released into the environment is called a pollutant. The table below summarises some of the effects of pollutants and how they can be controlled.

Table 1: Summary of pollutants, effects, and control.

<table>
<thead>
<tr>
<th>Pollution</th>
<th>Effects</th>
<th>Control of Pollutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution from Agriculture, for example, fertilisers</td>
<td>Accumulate in organisms through food chains, even killing top consumers. May cause mutation. May cause eutrophication in rivers and lakes. May upset the balance of food chains.</td>
<td>Replacement with less toxic alternatives. Replacement with biological control.</td>
</tr>
<tr>
<td>Pollution from Industries, for example, lead from car batteries, mercury used in gold mining, cadmium used in industrial paints</td>
<td>It may be toxic to aquatic organisms. Concentrated in organisms as they move up food chains. May change the behaviour of aquatic organisms.</td>
<td>Screen all wastes from industrial processes to remove toxic materials before releasing them to the environment.</td>
</tr>
<tr>
<td>Pollution from Improper Garbage Disposal, for example, household wastes such as untreated sewage</td>
<td>Bacteria multiply and use up oxygen. Can lead to eutrophication of water. Can cause disease.</td>
<td>Treat all sewage to remove the biological risk before releasing it into the environment.</td>
</tr>
</tbody>
</table>
Pollution and the Marine and Wetland Environments

Water is important to us. Living organisms depend on water. Our planet can sustain life because of the presence of water. Yet, human activities have led to a hotter and drier Earth and the pollution and destruction of aquatic environments. Some effects of human activities in the Caribbean are:

- Destruction of mangrove swamps – mangrove trees protect the coastline and estuaries throughout the tropics. Shrimp fishing, pollution, deforestation, storms, and coastal building development have damaged them, causing nursery grounds for all kinds of fish to be affected, money generated from eco-tourism reduced, eutrophication, etc.

![Fig. 1 Mangroves destroyed for construction purposes.](Image taken from medium.com)

- Destruction of coral reefs – coral reefs are among the most biodiverse places globally, with over a million different species. They provide fish for human consumption, protection for coastlines, and a tourist attraction. Coral reefs are destroyed by dynamiting for fish, pollution, collecting coral for sale, removal to allow the building of harbours, and smothering with red bauxite waste, dust, and cement from construction.
Fig. 2 Coral reefs before and after human activities.

(Image taken from awesomeocean.com)

- Damage to wetland environments – A wetland is where the land is covered by water, either salt, fresh or somewhere in between. Marshes and ponds, the edge of a lake or ocean, the delta at the mouth of a river, low-lying areas that frequently flood are all wetlands. The destruction of wetlands is a concern because they are some of the most productive habitats on the planet. Wetlands also support rice cultivation, a staple in the diet of half the world’s population. They provide a range of ecosystem services that benefit humanity, including water filtration, storm protection, flood control and recreation.

Fig. 3 Wetlands destroyed due to pollution.

(Image taken from: ramsar.org)
Homework
Identify marine and wetland environments in Guyana that have been affected by pollution and indicate what measures are or should be in place to remedy the situation.

References
https://medium.com/environmental-issue-profile-database/the-destruction-of-mangroves-b8f45fde59b0
http://awesomeocean.com/tag/coral-reefs/
Unknown. (2018) 75% of Earth’s land areas are degraded; wetlands have been hit hardest, with 87% lost globally in the last 300 years. Retrieved from ramsar.org
https://www.ramsar.org/news/75-of-earths-land-areas-are-degraded-wetlands-have-been-hit-hardest-with-87-lost-globally-in
1. In many Caribbean countries, wetland ecosystems (swamps) are classified as nature reserves and are protected by special laws that restrict human activities in these areas.

a) State FOUR reasons why wetlands are of great importance.

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b) Suggest FOUR ways in which human activity could affect a wetland ecosystem.

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Instructions: Answer all questions in the spaces provided.
2. a) Outline TWO ways in which the improper disposal of household waste contributes to land pollution or water pollution.

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b) Suggest TWO ways by which people could dispose of their household waste in an environmentally friendly manner.

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3. The adverse effects of human activity can also be observed in urban areas. For example, although ‘No Dumping’ signs are placed at strategic locations throughout most cities, the indiscriminate garbage disposal is still a universal problem.

a) Suggest FOUR reasons why indiscriminate garbage disposal should be discouraged.

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b) Apart from posting signs, suggest TWO OTHER ways to encourage proper garbage disposal.

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4. Environmentalists urge against the use of inorganic fertilisers, while farmers argue in favour of it. Present an argument in support of the environmentalists, giving THREE clear points.

5. A growing concern of many Caribbean governments is the growth of squatter communities since, among other issues, they can pollute watercourses. Identify TWO reasons why the governments may be concerned.
WEEK 1

TOPIC: Resources

Sub-topic: Conservation and Restoration of the Environment

CONTENT

Environmental conservation is the practice of us humans saving the environment from the loss of species, and the destruction of the ecosystem, primarily due to pollution and human activities. Conservation is vital in protecting and helping both animals and trees as we are all dependent on one another for survival. We need to manage the environments that we live in and the resources we use in a sustainable way. Ecosystems, habitats, and species should be conserved for the following reasons:

- Ecosystems provide us with services such as food and fuel.
- Ecosystems help to maintain the balance of life on the planet, for example, nutrient cycles.
- Habitats support a wide variety of organisms that interact in ways we do not fully understand but is vital for the continuation of life on this planet, for example, by keeping pests and diseases in check.

Ecosystems and habitats can be conserved in the following ways:

- Developing National parks
- Protecting areas of the sea from damage from fishing and pollution
- Rescuing endangered animals, breeding them in captivity and releasing them back into the wild.
- Growing endangered plants in a botanical garden and re-establishing them in the wild.
- Reducing habitat destruction
• Encouraging sustainable management of ecosystems
• Having seed banks
• Removing alien species

Fig. 1 The endangered golden rocket frog that is protected at the Kaieteur National Park.
(Image taken from: newsmongabay.com)

Restoration
Restoring habitats that have been degraded or destroyed by human activities and natural catastrophes are essential components of conservation. The following are examples:

• Re-establishing ecosystems where the land has become degraded, for example, establishing dry forest in Guanacaste National Park in Costa Rica.
• Tree planting day in Jamaica and schemes in Haiti to reforest degraded land to reduce the severe effects of heavy rain.
• Restoring land degraded by mining and waste disposal, for example, the Soda lake at Mount Rosser in Jamaica.
• Restoring mangroves to protect the coasts that are at risk, for example, the Guyana Mangrove Restoration Project that was executed during 2010-2013.
Fig. 2 Mangroves planted under the Guyana Mangrove Restoration Programme.  
(Image taken from: kaieteurnewsonline.com)

**Homework**

Identify protected areas in Guyana and the Caribbean

**References**


Haley, M. (2016) *Over 500,000 mangroves planted under the Guyana Mangrove Restoration Programme.* Retrieved from kaieteurnewsonline.com:  

Instructions: Complete ALL questions in the spaces provided.

1. Wildlife reserves have become popular tourist destinations in several Caribbean territories. Wildlife authorities must protect plants and animals while providing an opportunity for people to benefit from the natural beauty of the reserves. Suggest THREE biological factors that wildlife authorities should consider before giving the public access to a wetland (swamp) reserve. For EACH factor, you identify and suggest what precautions the authorities may take in allowing public access.

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2. A forest population has been decimated. Discuss what restorers might do to change this situation.

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3. Discuss the needs for protected areas in your country, including two specific examples.
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4. Discuss the THREE benefits of tree planting.
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5. Suggest ways in which the success of conservation and habitat restoration can be monitored.
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WEEK 2        LESSON 1

TOPIC: Breathing

Sub-topic: Inspiration and Expiration

CONTENT

Breathing is the movement of air in and out of the lungs. Inspired air enters the nose or mouth, passes through the throat and then the larynx, which contains the vocal cords. The air passes through the trachea, bronchi, and bronchioles to the alveoli, where gas exchange occurs. Breathing in is called inspiration, and breathing out is called expired. The following image compares the constituents of inspired and expired air.

![Fig. 1 A comparison of inspired and expired air](Image taken from: Biology for CSEC® Examinations)
Inspiration occurs when the diaphragm and the external intercostal muscles contract. Contraction of the diaphragm (the skeletal muscle below the lungs) causes an increase in the size of the thoracic cavity, while contraction of the external intercostal muscles elevates the ribs and sternum. Thus, both muscles cause the lungs to expand, increasing the volume of their internal air passages. In response, the air pressure inside the lungs decreases below that of air outside the body, and air rushes into the lungs.
Expiration occurs when the diaphragm and external intercostal muscles relax. In response, the elastic fibres in lung tissue cause the lungs to recoil to their original volume. The air pressure inside the lungs then increases above the air pressure outside the body, and air rushes out. During high rates of ventilation, expiration is facilitated by contraction of the expiratory muscles (the intercostal muscles and the abdominal muscles).

**Homework**

State the importance of gaseous exchange in humans.

**References**


Instructions: Answer the following questions in the spaces provided.

1. Breathing involves inspiration and expiration. Figure 1 shows the position of the rib cage during breathing.

   ![Diagram](image)

   **Figure 1.** Position of the rib cage during breathing.

   a) Which of the drawings in Figure 1, A or B, shows the rib cage during inspiration?

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   b) With the aid of Figure 3, outline the activities that occur during the process of inspiration.

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2. Inspired air contains 21% of oxygen and 0.04% carbon dioxide, while expired air contains 16% oxygen and 4% carbon dioxide. Account for the changes in the amount of oxygen and carbon dioxide in inspired and expired air.

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3. Nitrogen gas remains at 78% in inspired and expired air. Suggest why there is no difference in nitrogen for inspired air and expired air.

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4. Differentiate between breathing and gaseous exchange.

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5. A boa constrictor kills its prey by squeezing it to death. This is termed ‘asphyxiation’. Explain how asphyxiation results in death.

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WEEK 2

TOPIC: Breathing

Sub-topic: Smoking

CONTENT

Tobacco may be the cause of over 3 million deaths a year worldwide. Death from cigarette smoking comes mainly from lung cancer, but heart disease is also associated with smoking. The products of cigarette smoke (whether the smoke is directly from smoking a cigarette or from inhaling another person’s cigarette smoke) include nicotine, tar and (like car exhaust fumes) carbon monoxide.

Fig. 1 The effects of smoking on the lungs.
(Image taken from: parahospitals.com)
Nicotine
Nicotine is a highly addictive chemical compound present in the tobacco plant. Tobacco products, including cigarettes, cigars, smokeless tobacco, hookah tobacco, and most e-cigarettes, contain nicotine. Nicotine can cause the following effects:
- Reduces airflow in and out of the lungs
- Damages the cilia lining the trachea, so they cannot remove dirt and bacteria
- Raises blood pressure
- Raises heart rate
- Increases the risk of osteoporosis

Tar
Tar is a term used to describe the toxic chemical particles left behind by burning tobacco. This substance forms a brown or yellow residue. Tar sticks to the cells of the lungs and causes the following effects:
- Causes the development of cancer
- Damages lung tissue.
- It breaks down the alveoli, thus decreasing the surface area for gaseous exchange.
- Causes bronchitis or inflammation of the lining of the air passages.
- Causes’ smokers cough’.

Carbon Monoxide
Carbon monoxide (CO) is not added to tobacco but is formed when tobacco is burned incompletely. This happens when there is too little oxygen present to convert all the carbon in the tobacco into carbon dioxide. Carbon monoxide combines irreversibly with haemoglobin in the blood to cause the following effects:
- It causes less oxygen to be transported by blood.
- Reduces the smoker’s ability to take strenuous exercise and causes breathlessness.
- If a pregnant woman smokes, carbon monoxide gets into the blood of the fetus and combines with the haemoglobin. Less oxygen gets to the growing tissues, resulting in a baby with a lower birth weight; this is associated with a greater risk of health problems during and after birth.
Marijuana
This is a green or grey mix of dried shredded flowers and leaves of the hemp plant *Cannabis sativa* – also called by many other names, including pot, herb, ganja and weed. The active ingredient is THC (tetrahydrocannabinol) which causes the ‘high’ that users experience when they smoke the drug.

Marijuana smoke is unfiltered. Users inhale more deeply and hold the smoke in the lungs. Thus, the effects on the lungs are more significant than those caused by tobacco smoke because more tar and more carbon monoxide are inhaled. The short-term effects of marijuana can include:

- problems with memory and learning.
- distorted perception.
- difficulty in thinking.
- difficulty in problem-solving.
- loss of coordination.
- increased heart rate.
- anxiety.
- panic attacks.

**Homework**
Identify three ways by which the use of cigarettes can be reduced.

**References**
Instructions: Answer all questions in the spaces provided.

1. Cigarette smoking is a public health concern because cigarette smoke contains chemicals that can destroy lung tissue.
   a) State TWO ways in which the appearance of the lung of a smoker differs from that of a non-smoker.

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   b) Suggest TWO benefits of placing a ban on the smoking of cigarettes in public places.

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2. Name the addictive component in cigarettes and suggest ONE negative impact of drug addiction.

   Addictive component

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   Negative impact

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3. Suggest SIX reasons why humans who smoke heavily have less oxygen available to the cells for respiration.

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4. Emphysema is a lung disease that frequently develops from smoking. With this disease, the walls of some alveoli break down and become surrounded by harder fibrous tissues. Explain why smokers with this disease will have a higher-than-normal breathing rate after exercise.

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5. The table below gives data on a survey done on smoking.

<table>
<thead>
<tr>
<th>Smoking Category</th>
<th>Number of Persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-smoker</td>
<td>50</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>15</td>
</tr>
<tr>
<td>Pipe smoker</td>
<td>5</td>
</tr>
<tr>
<td>Cigarette smoker</td>
<td>30</td>
</tr>
</tbody>
</table>

Present the data in the above table as a pie chart. Show your calculations.
WEEK 2        LESSON 3

TOPIC: Transport in Animals

Sub-topic: The Circulatory System

CONTENT

Large multicellular organisms have a small surface-area-to-volume ratio. This means that they need transport systems to carry substances to and from cells around the body. A transport system is necessary to get important and needed substances to every cell and transport waste or toxic substances away from every cell. Blood is how substances travel to and from cells. These substances dissolve in blood, which is mainly water and diffused into the cells where they are needed. This transport system is called a circulatory system. The circulatory system is made up of three parts:

- the heart, which pumps blood around the body
- the blood, is the fluid being pumped and contains all the materials to be transported around the body.
- the blood vessels (like pipes) through which blood flows to get to and from the cells. These are the arteries, veins, and capillaries.

The Heart

The heart pumps blood to all parts of the body. The walls of the heart are made up of a special type of muscle called cardiac muscle. The mammalian heart is divided into the right and left side. Each side has two parts or chambers:

- the atrium, which receives blood
- the ventricle, which pumps blood away.
Humans have a double circulatory system in which the blood flows through the heart twice during one complete circulation in the body. The two circulations are:

- **Pulmonary circulation** – deoxygenated blood flows from the heart, through the pulmonary arteries to the lungs and back to the heart in the pulmonary veins as oxygenated blood.
- **Systemic circulation** – oxygenated blood flows from the heart, through the aorta and other arteries to all the other organs of the body and then back to the heart through the vena cava as deoxygenated blood.

The circulation is also described as a closed circulatory system. This is because the blood remains inside blood vessels during its journey throughout the body.
Valves prevent the backflow of blood in the heart. The bicuspid and tricuspid valves, known as the atrioventricular valves, ensure that blood flows in one direction through the heart only. Tendons attached to the walls of the heart hold them in place. When the ventricles contract, blood pushes back on these valves, forcing them shut. So, the blood can only move forward into the pulmonary arteries and aorta. Semi-lunar valves are found at the start of the pulmonary artery and aorta. They prevent the backflow of blood into the ventricles when they relax.
The heart ‘beats’ when the muscles of the heart contract and relax. The ‘lub’ sound is made during ventricular systole as blood is forced against the closed tricuspid and bicuspid valves. The ‘dub’ sound is made during ventricular diastole when blood impacts on the closed semi-lunar valves in the aorta and pulmonary artery.

The rate of heartbeat is controlled by the ‘pacemaker’, which is found in the muscle between the ventricles. It has its natural rhythm of stimulating contractions, usually around 70–80 beats per minute. This can be speeded up by hormones such as adrenalin and by activity.

**Homework**

Name the types of blood vessels.

**References**


https://www.pinterest.co.uk/pin/536702480595458976/
**Week:** Two  
**Lesson:** Three  
**Topic:** The Circulatory System

**Instructions:** Answer ALL questions in the spaces provided.

1. Fill in the parts of the heart in the spaces provided.

2. Blood that has been oxygenated in the lungs must first be pumped through the heart before it is sent to all the other organs of the body. Describe the pathway that blood takes as it flows into the heart from the lungs until it is pumped out of the heart to be sent to the rest of the body.
3. State TWO physiological diseases that affect the circulatory system.

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4. Some babies are born with a small opening in the wall/septum between the two upper chambers of the heart. Suggest how this condition would affect the functioning of the heart when the atria contract.

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5. Heart muscle cells obtain their requirements from blood transported in the coronary arteries.
   a) Name TWO substances that the heart muscle cells will receive in this blood supply.

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b) Identify ONE substance found in the blood supply that can cause the coronary artery walls to thicken.

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c) How does the thickening of the coronary arterial wall affect the heart?

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WEEK 3          LESSON 1

TOPIC: Transport in Humans

Sub-topic: Blood Vessels

CONTENT

Blood flows through blood vessels to get to all parts of the body from the heart and then from the body back to the heart. There are three kinds of blood vessel:

- Arteries (and arterioles) – carry blood away from the heart
- Capillaries are tiny vessels that pass close to all body cells
- Veins (and venules) – carry blood back to the heart

![Fig. 1 Structure of the types of blood vessels](image)
(Image taken from: nigerianscholars.com)
The Circulation

Blood leaves the left side of the heart at high pressure and flows through the aorta, the largest artery, to all parts of the body. When the capillaries reach the body cells, the blood gives up food and oxygen and picks up wastes, such as carbon dioxide and urea. Deoxygenated blood returns to the heart via the veins and is collected into the main vein called the vena cava. From the right side of the heart, blood flows to the lungs to be oxygenated, then back to the left side of the heart. This flow is repeated continuously. The tissues of the heart itself are supplied with oxygen by the coronary arteries. In its circulation throughout the body, the blood picks up food (such as glucose and amino acids) from the gut, hormones from endocrine glands, and other vital substances. It also drops off waste products to be excreted, like urea and carbon dioxide, at sites where the body can get rid of them, that is, the kidneys and the lungs.

<table>
<thead>
<tr>
<th>Arteries</th>
<th>Capillaries</th>
<th>Veins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Carry blood <strong>away</strong> from the heart at <strong>high</strong> pressure</td>
<td>-Supply all cells with their <strong>requirements</strong> -Take away <strong>waste</strong> products</td>
</tr>
<tr>
<td><strong>Structure of wall</strong></td>
<td>-<strong>Thick</strong>, strong -Contain <strong>muscles</strong>, <strong>elastic fibres</strong> and <strong>fibrous</strong> tissue</td>
<td><strong>Very thin</strong>, only one cell thick</td>
</tr>
<tr>
<td><strong>Lumen</strong></td>
<td>-<strong>Narrow</strong> -Varies with heartbeat (increases as a pulse of blood passes through)</td>
<td>-<strong>Very narrow</strong> -Just wide enough for a red blood cell to pass through</td>
</tr>
<tr>
<td><strong>Valves</strong></td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>How structure fits function</strong></td>
<td>-Strength and elasticity needed to withstand the pulsing of the blood, prevent bursting and maintain pressure wave -Helps to maintain <strong>high blood pressure</strong>, preventing blood flowing backwards</td>
<td>-No need for strong walls, as most of the blood pressure has been lost -Thin walls and narrow lumen bring blood into close contact with body tissue, allowing diffusion of materials between capillary and surrounding tissues. -White blood cells can squeeze between cells of the wall</td>
</tr>
</tbody>
</table>

*Fig. 2 A comparison between the types of blood vessels.*

(Image taken from: pmgbiology.com)
Fig. 3 The Circulatory System in Humans
(Image taken from: Biology for CSEC® Examinations)

**Note:** Blood is red. Oxygenated blood is bright red. Deoxygenated blood is dark red. It is a convention to use blue to represent deoxygenated blood. It does not mean that deoxygenated blood is blue; it is not.
Homework

Identify the components of blood.

References


https://pmgbiology.com/tag/artery/

Instructions: Answer all questions in the spaces provided.

1. Figure 1 shows blood vessels used to transport fluids around the body of a mammal.

   a) Which blood vessel, A or B, represents a vein?

   b) Justify the reason for your choice in (1) (a) above.

   c) Identify ONE structure visible in Figure 1, which helps a vein to carry out its function.

   d) Explain how the structure identified in (b) allows the vein to fulfil its function.
2. Explain why the aorta has the thickest walls of all the blood vessels found in the circulatory system.

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3. Describe two differences between blood leaving and arteriole and blood entering a venule, having passed across a capillary network.

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4. Explain how blood flows in one direction in the circulatory system.

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5. Differentiate between oxygenated and deoxygenated blood.

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WEEK 3 LESSON 2

TOPIC: Transport in Humans

Sub-topic: Blood

CONTENT

Blood is a constantly circulating fluid providing the body with nutrition, oxygen, and waste removal. Blood is mostly liquid, with numerous cells and proteins suspended in it, making blood thicker than pure water. Plasma makes up about half the content of blood and is about 90% of water. The blood cells are of two main types, red and white. There are also fragments of cells called platelets.

The respiratory gases, oxygen, and carbon dioxide are transported around the body in the blood. Most of the carbon dioxide is transported in solution in blood plasma as hydrogen carbonate ions. Oxygen is carried by the molecule haemoglobin, which is found inside red blood cells. Haemoglobin is a protein that is combined with iron – this gives it its red colour. Each molecule of haemoglobin combines reversibly with up to four molecules of oxygen.

![Blood and its components](image)

**Fig. 1** Blood and its components
(Image taken from: Biology for CSEC Study Guide).
Blood Clotting

Blood clotting, or coagulation, is an important process that prevents excessive bleeding when a blood vessel is injured. Platelets and proteins in your plasma work together to stop the bleeding by forming a clot over the injury. Typically, your body will naturally dissolve the blood clot after the injury has healed. Blood clotting seals wounds to restrict the loss of blood and prevents the entry of pathogens through open wounds.
Fig. 2 Formation of a blood clot
(Image taken from: ib.bioninja.com.au)

Homework
Explain how blood clots can be dangerous to humans.

References


Instructions: Answer ALL questions given in the lines provided.

1. Figure 1 shows the components of blood.

   a) Identify the components of blood that are labelled A, B and C in Figure 1.

   A ________________________________
   B ________________________________
   C ________________________________

   b) Complete the flow diagram shown in Figure 2 by filling in the missing words in D, E and F.

   Figure 2. Diagram showing steps in blood clotting
2. Name FOUR major components that make up human blood and explain how the oxygen transported by the blood becomes available to cells for the production of energy.

Components

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Explanation

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3. Distinguish between white blood cells and red blood cells.

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4. Discuss how a clot protects the body from blood loss and infection.

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5. There are cell fragments found in the blood. Explain how the structure of the cell fragments allow them to carry out their function efficiently.

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WEEK 3

TOPIC: Transport in Humans

Sub-topic: Blood Groups and Hypertension

CONTENT

Blood transfusions in humans were risky procedures until the discovery of the major human blood groups by Karl Landsteiner, an Austrian biologist and physician, in 1900. Until that point, physicians did not understand that death sometimes followed blood transfusions when the type of donor blood infused into the patient was incompatible with the patient’s blood.

There are four blood groups, known as A, B, AB, and O. These groups are based on proteins, called antigens, present on the surface of red blood cells. For example, if antigen A is present on all the red blood cells of a person, that person is said to have blood group A. There are also antibodies present in the blood plasma. These are associated with antigens. So, a person with blood group A, for example, has antigen A (A) on their red cells and antibody anti-B (b) in their plasma.

During a transfusion, it is important to note:

- the protein (or antigen) on the red blood cell of the donor.
- the type of antibody present in the plasma of the recipient.

If the antibody matches the antigen, the red blood cells stick together, and transfusion will not be successful.
Hypertension

High blood pressure (hypertension) is a common condition in which the long-term force of the blood against your artery walls is high enough that it may eventually cause health problems, such as heart disease.

Blood pressure is determined by the amount of blood your heart pumps and the amount of resistance to blood flow in your arteries. The more blood your heart pumps and the narrower your arteries, the higher your blood pressure. A blood pressure reading is given in millimetres of mercury (mm Hg). It has two numbers.

- **The top number (systolic pressure).** The first, or upper, number measures the pressure in your arteries when your heartbeats.
- **The bottom number (diastolic pressure).** The second, or lower, number measures the pressure in your arteries between beats.

Hypertension can develop without symptoms or signs and is sometimes called the ‘silent killer’. It is linked with several factors such as:

- high levels of emotional stress.
- lack of exercise.
- obesity.
- tobacco smoking.
- high alcohol intake.
- high blood cholesterol levels.

All these factors are influenced by lifestyle and can be controlled by changing lifestyle. A healthy lifestyle that includes regular exercise, no smoking, low intake of fat, salt, and alcohol, can prevent the development of hypertension.

![Blood Pressure Categories](image)

**Fig. 2** Blood Pressure Categories
(Image taken from: dentalcare.com)

**Homework**

Explain how diet and the environment can contribute to hypertension.

**References**


https://www.dentalcare.com/en-us/professional-education/ce-courses/ce567/hypertension

https://courses.lumenlearning.com/nemcc-ap/chapter/blood-typing/
**Instructions:** Answer ALL questions given in the lines provided.

1. Diets high in saturated fats may lead to the formation of plaques in blood vessels. Explain how such deposits may lead to hypertension.

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2. Hypertension (or high blood pressure) is among the leading causes of death in the Caribbean. Table 1 provides data about the number of deaths reported among males and females from this disease in some Caribbean countries from 1985 to 2000.

**TABLE 1: DEATHS FROM HYPERTENSION IN SOME CARIBBEAN COUNTRIES FROM 1985 TO 2000**

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>800</td>
<td>1050</td>
</tr>
<tr>
<td>1990</td>
<td>830</td>
<td>1040</td>
</tr>
<tr>
<td>1995</td>
<td>870</td>
<td>1120</td>
</tr>
<tr>
<td>2000</td>
<td>1150</td>
<td>1500</td>
</tr>
</tbody>
</table>

a) On the grid provided on the following page, draw a bar graph to represent the data in Table 1.
Graph showing the number of deaths from hypertension
b) Suggest THREE reasons for the difference in the number of deaths among males and females due to hypertension.

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3. Outline THREE ways by which we can lower or control high blood pressure.

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4. Identify the blood group that is the universal donor and the blood group that is the universal recipient and explain what is meant by the universal donor and universal recipient.

Universal Donor

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Explanation

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Universal Recipient

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WEEK 4

LESSON 1

TOPIC: Immunity

Sub-topic: The Role of Blood in Defending the Body

CONTENT

Blood plays an important role in defending the body against pathogens. Pathogens are microorganisms that cause disease, for example, bacteria, viruses, protists, and fungi. The body’s first line of defence is the skin which acts as a physical barrier. When there are breaks in this barrier, such as cuts or sores, the body reacts to produce blood clots and a meshwork of fibrous scar tissue. The opening is thus blocked, which prevents pathogens from entering the body. Phagocytes, white blood cells, sometimes leave the blood and migrate towards the infection site, where they engulf, kill, and remove microorganisms before they cause disease. This is our second line of defence.

Fig. 1 Phagocytes engulfing microorganism at site of infection
(Image taken from: Biology for CSEC® Examinations)
Immune Response
If more dangerous, specific pathogens invade the body, and then an immune response is triggered. Lymphocytes, another kind of white blood cells, recognise the pathogen and mobilise more lymphocytes to make antibodies that attack, disarm, destroy, and removes the pathogen. An antibody is produced by the immune system in response to anything foreign in the body, an antigen. Immune responses are very specific and produce antibodies that are specific to a particular antigen. To defend the body against disease, antibodies act in several ways:
   - they cause the antigens to clump together, resulting in their death and easy removal by the phagocytes.
   - they neutralise toxins produced by the antigens.
   - they prevent the antigen from entering body cells.
Recognition of antigens and production of the specific antibodies against them takes time. During that time, the antigens will have produced symptoms of the disease. Once the antibodies are produced, the antigens or the toxins they produce are destroyed or neutralised, and the symptoms disappear. The antibodies then gradually disappear from the blood, but they leave behind special memory lymphocytes. If the specific antigen invades a second time, the memory lymphocytes immediately recognise them and rapidly make large amounts of the specific antibody. This time, the antigens are destroyed before symptoms develop, and the person is said to be immune to that disease. This happens naturally and is called natural immunity.

Homework
Identify the types of immunity.

References

Week: Four  
Lesson: One  
Topic: The Role of Blood in Defending the Body

Instructions: Answer ALL questions given in the lines provided.

1. Explain the importance of the body, having different ways of defending itself from the disease.

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2. Distinguish between antigen and antibody.

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3. Discuss the role of phagocytes in defending the body against microorganisms.

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4. Outline the steps the body takes in an immune response.

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5. Explain the importance of blood clots in protecting the body.

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CONTENT

Immunity is the capability of multicellular organisms to resist harmful microorganisms. A person is immune to disease if, upon infection with the disease, no symptoms develop. Immunity can be naturally or artificially acquired.

Fig. 1 How Immunity is Acquired
(Image taken from: clinicalinfo.hiv.gov)
Immunisation provides immunity to communicable diseases. This is achieved by injecting, or administering orally, small amounts of dead or weakened (attenuated) antigens into the body. This is called vaccination. The body is stimulated to produce antibodies. Smallpox has been eradicated because of immunisation programmes. Vaccines against tuberculosis (TB) and hepatitis B have also been developed, but there are still no vaccines against diseases such as leprosy, malaria, and AIDS, despite much research.

The importance of immunisation or vaccination is seen when children are protected from dangerous diseases like polio, measles, mumps, tetanus, and whooping cough. This is achieved in a programme of immunisation where often a second booster injection is given. This stimulates a much quicker production of antibodies which is longer lasting and which protects the child from the disease for a considerable time.

Countries have vaccination programmes to protect their populations. The vaccine protects whole populations, including people who cannot be vaccinated. This happens because pathogens have no place to reproduce if everyone or nearly everyone is vaccinated. In the same way, COVID-19 vaccines are being developed with small amounts of dead or attenuated pathogens or nucleic acid vaccines which use genetic material – either RNA or DNA – to provide cells with the instructions to make the antigen in a race to end the ongoing pandemic.

**Homework**

State two advantages of being vaccinated.

**References**


Instructions: Answer all questions in the spaces provided.

1. Immunity may be naturally or artificially acquired. Discuss THREE differences between natural immunity and artificial immunity and describe any THREE steps of the mechanism (in the body) by which artificial immunity is acquired.

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2. Peter, who has not had a tetanus vaccine, gets his foot punctured by a nail. He is given a tetanus antiserum injection at the hospital. Suggest why he is given an antiserum injection instead of a vaccine.

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3. Chemotherapy is a treatment that destroys both the malignant (bad) cells and the good cells in the body. Explain why a person undergoing chemotherapy would have decreased natural immunity.
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4. A student is about to travel to a country where yellow fever is rampant. Discuss why a vaccine that provides passive acquired immunity is NOT suitable for this student.
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5. A recent outbreak of swine flu was caused by the H1N1 virus. One prevention measure adopted by some countries was an immunisation programme.
   a) Suggest two disadvantages of immunisation.
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   b) The H1N1 virus is spread through the air. Suggest TWO precautions, other than immunisation, that an individual can take to avoid getting the disease.
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6. Identify ONE communicable disease and the pathogen that causes the disease.

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7. The spread of communicable diseases that affect humans declined significantly when artificial immunisation through the use of vaccines.

a) Describe how a vaccine works in building immunity.

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b) Suggest why vaccines may NOT always have the desired effect in treating persons infected with the disease.

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TOPIC: Storage in Plants and Animals

Sub-topic: Food Storage in Plants

CONTENT

Plants and animals store food in their bodies for the same reasons, such as:

- to overcome the need for continuous manufacture; during the night, photosynthesis stops because there is no light
- to overcome the need for continuous food intake; animals cannot eat continuously because other activities are also important
- to provide for periods of scarcity, like droughts and famines
- to provide for special functions (muscle cells need their own store of food)
- to produce reproductive structures (fruits, seeds, and embryos must store food).

Glucose is the main product of photosynthesis. This type of molecule can be used for respiration or converted to starch for storage. Plants are capable of adapting leaves, stems, and roots to store food. Some plants produce a large root that travels deep into the soil, known as a taproot.
A bulb (onion) is an underground storage organ formed from the plant stem and leaves. At the bottom of the bulb is a thin, flat disc called the basal plate, which is a compressed stem, and the roots grow from the underside of this. The body of the bulb is made up of layers of fleshy scales, which are modified leaves. In the centre of the bulb is the bud for the next year’s flower. Examples of

A rhizome is a swollen stem bearing leaves and roots, which grows horizontally on or just below the surface. It is similar to a corm, but new rhizomes are not produced annually. Instead, the older parts die off, and the tips of the rhizome grow longer. Rhizomes usually have scaly reduced leaves.
along their surface, which have resting buds in the axils. A rhizome may be propagated by division when these resting buds will grow and produce leaves for a new plant.

**Fig. 3-5** Stems as food storage sites

(Image taken from: Biology for CSEC® Examinations).
Seeds contain a store of food for germination. The cotyledon(s) or endosperm of seeds store starch, protein, and lipids. This store is used up during germination as the embryo develops. The seed respires, using the stores to provide energy for growth and development into a seedling. The stores are needed until the seedling develops leaves and can photosynthesise.
Homework
Identify other examples of food storage in plants.

References


Week: Four
Lesson: Three
Topic: Food Storage in Plants

Instructions: Answer ALL questions given in the lines provided.

1. a) Starch is the most common carbohydrate that is found in the leaves of green plants. Describe a test that the students could do in the laboratory to investigate whether starch is present in the leaves of the seedlings.

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b) Name ONE plant organ, other than leaves, where starch may be found.

2. Both plants and humans store some of their unused nutrients.
   a) Name TWO storage organs in plants and the nutrients stored in EACH.

   b) Suggest THREE reasons why plants need to store nutrients.

3. During their life cycle, plants may store large amounts of excess food. Explain TWO advantages to the plant of storing food in its seeds.

4. Describe TWO situations in the life cycle of a plant when stored food is used.

5. Differentiate between a rhizome and a corm.
TOPIC: Storage in Plants and Animals

Sub-topic: Food Storage in Animals

CONTENT

Animal cells also store glucose but not as starch. Animals store glucose as glycogen in granules. Cells respire continuously, and animals always breathe for their supply of oxygen, but they do not feed continuously for their supply of glucose.

Fats are a more concentrated source of energy than carbohydrates and proteins. One gram of fat yields twice the amount of energy as compared to one gram of carbohydrate. Excess fat is stored under the skin of mammals. In cold conditions, a thick layer of fat called blubber is used as energy stores and as insulation for the animal.

Fig. 1 Whale’s blubber
(Image taken from: whalesforever.com)
As blood passes through the liver, the excess glucose (from a meal) is changed to glycogen and stored. The liver is the main storage organ for glycogen. Glycogen is also stored in the muscles, where it can be quickly accessed for muscle contraction. The liver also stores minerals (iron and potassium) and vitamins A, D and B12. After a meal, vitamins, minerals, and other nutrients from the food pass from the intestine into the blood. This nutrient-rich blood then passes through the liver, where the vitamins and minerals in excess are stored for times when they are lacking in the blood.

![Liver diagram](image)

**Fig. 2** Nutrient-rich blood travels directly to the liver from the intestine. (Image taken from: Biology for CSEC® Examinations).

**Homework**

List two uses of fats in humans.

**References**


https://www.whalesforever.com/whales-blubber.html
**Week:** Five  
**Lesson:** One  
**Topic:** Food Storage in Animals

**Instructions:** Answer the following questions by CIRCLING ‘T’ if the statement is true and ‘F’ if the statement is false.

1. Animals store complex carbohydrates such as starch.  
   
2. Glycogen is stored in the liver.  
   
3. Iron is a mineral stored in the liver.  
   
4. Fats are a primary source of energy for animals.  
   
5. The muscles also store glycogen.  
   
6. Blubber is fat stored in animals.  
   
7. Excess vitamins are stored in the liver.  
   
8. The blood also stores excess vitamins.  
   
9. Carbohydrates give twice as much energy as fats.  
   
10. Glycogen is converted to glucose for use by the body.  

**KEY**

1. F  
2. T  
3. T  
4. F  
5. T  
6. T  
7. T  
8. F  
9. F  
10. T
WEEK 5                                   LESSON 2

TOPIC: Sexually Transmitted Infections

Sub-topic: Gonorrhoea and HIV/AIDS

CONTENT
Sexually transmitted infections are transmitted from an infected person to an uninfected person through sexual contact (vaginal, oral, and anal sex).

Gonorrhoea
Gonorrhoea is caused by a bacterium that can only survive inside the moist lining of the male and female reproductive tract. It is known as ‘the clap’ to many, but here in Guyana, it is commonly known as ‘leak’. If it is present in the vagina of a woman or the urethra of a man, the infection can be transmitted from one to the other during sexual intercourse.

Gonorrhoea symptoms in men usually include:
- Burning when urinating
- Painful or swollen testicles
- White, yellow, or green discharge from the penis

Most women don’t have symptoms. If they do, they’re often mild. It can be easily mistaken for something else. They include:
- Burning or pain when urinating
- Bleeding between periods
- More vaginal discharge than is typical
- Pain in the lower abdomen
- Pain when having sexual intercourse
Gonorrhoea can be effectively treated using antibiotics. However, as with many diseases, prevention is better than cure. The following steps can be taken to prevent infection:

- Have only one partner; if both partners are disease-free, then there is no chance of infection.
- If the man uses a condom, the bacteria cannot pass through it, and infection is unlikely.
- If a person is diagnosed with gonorrhoea, then all sexual contacts should be traced, warned, and treated with antibiotics to prevent the spread of the disease.

Fig. 1 Signs and Symptoms of Gonorrhoea
(Image taken from: crossstreetmedical.com.sg)

HIV & AIDS
In 1982, doctors in North America and Africa began to see patients with rare conditions, especially rare cancer and pneumonia. Scientists discovered that these conditions were a result of immune systems that did not function efficiently. This condition was called acquired immunodeficiency syndrome or AIDS. The causative agent in the collapse of the immune system is a virus, human immunodeficiency virus or HIV. AIDS is a collection of different diseases, some cancers, and some infectious diseases.

Transmission
HIV does not survive long outside the human body. It can be transmitted by the following ways:
In semen and vaginal fluids during unprotected sexual intercourse.
In blood, if there is blood to blood contact between two people, for example, sharing needles to inject drugs
In the blood that is used in transfusion if it is not heat-treated to kill HIV
From mother to baby during birth and in breast milk

HIV is NOT spread by:
- Air or water
- Mosquitoes, ticks, or other insects
- Saliva, tears, or sweat that is not mixed with the blood of a person with HIV
- Shaking hands; hugging; sharing toilets; sharing dishes, silverware, or drinking glasses; or engaging in closed-mouth or “social” kissing with a person with HIV
- Drinking fountains
- Other sexual activities that don’t involve the exchange of body fluids (for example, touching).

Signs and symptoms
HIV and AIDS may cause the following symptoms:
- Rapid weight loss or “wasting.”
- Extreme fatigue.
- Dry cough.
- Recurring fevers or profuse night sweats.
- Swollen lymph glands in the armpits, groin, or neck.
- Prolonged diarrhoea.
- Sores in the mouth or bleeding from the genitals or anus.
- Pneumonia.
- Blotches on or under the skin or inside the mouth, nose, or eyelids.
- Depression, memory loss and other neurological effects.
Treatment, Prevention and Control

While AIDS remains incurable, patients live much longer — even decades after infection — because of the development of medications to suppress the virus.

The most effective treatment is known as antiretroviral therapy (ART), which has typically been a combination of at least three medications to prevent the patient from becoming resistant to any one drug.

Preventative and control measures include:

- Knowing your HIV status as well as your partner’s.
- Using latex condoms correctly during every sexual encounter.
- Limiting the number of sexual partners.
- Abstaining from injectable drug use and never sharing needles or syringes.
- Seeking treatment immediately after suspected HIV exposure, since newer medications known as post-exposure prophylaxis (PEP) may prevent infection if started early.
• Reducing the chance of becoming infected by obtaining pre-exposure prophylaxis (PrEP), which is a daily pill taken by people at high risk for HIV because of their sexual behaviour or from injecting drugs.

**Homework**

Identify factors that influence the rate of transmission of sexually transmitted infections.

**References**


https://www.verywellhealth.com/hiv-aids-symptoms-4014373


https://www.crosstreetmedical.com.sg/gonorrhoea


https://www.cdc.gov/hiv/risk/art/index.html
Instructions: Answer ALL questions in the spaces provided.

1. Table 1 shows some data for the incidence of AIDS in the Caribbean.

Table 1: Number of reported AIDS cases in certain Caribbean countries between 1982 and 2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of females</th>
<th>Number of males</th>
<th>Total number of cases reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1984</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>1986</td>
<td>0</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>1988</td>
<td>26</td>
<td>494</td>
<td>520</td>
</tr>
<tr>
<td>1990</td>
<td>75</td>
<td>675</td>
<td>750</td>
</tr>
<tr>
<td>1992</td>
<td>150</td>
<td>850</td>
<td>1000</td>
</tr>
<tr>
<td>1994</td>
<td>260</td>
<td>1040</td>
<td>1300</td>
</tr>
<tr>
<td>1996</td>
<td>425</td>
<td>1275</td>
<td>1700</td>
</tr>
<tr>
<td>1998</td>
<td>660</td>
<td>1540</td>
<td>2200</td>
</tr>
<tr>
<td>2000</td>
<td>890</td>
<td>1810</td>
<td>2700</td>
</tr>
</tbody>
</table>

a) On the grid below, plot a bar graph of the data given in Table 1.
b) From the information provided in the table and graph, draw TWO conclusions about the incidence of AIDS in Caribbean populations during the period 1982 to 2000.

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2. Table 2 gives the methods of transmission in reported AIDS cases in Caribbean countries during the 1982 to 2000 period.

**Table 2: Methods of transmission in reported AIDS cases during the period 1982 to 2000**

<table>
<thead>
<tr>
<th>Transmission Methods</th>
<th>Percentage Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>6</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>0.3</td>
</tr>
<tr>
<td>Intravenous devices</td>
<td>1.5</td>
</tr>
<tr>
<td>Unknown</td>
<td>17</td>
</tr>
<tr>
<td>Sexual intercourse (homosexual)</td>
<td>11</td>
</tr>
<tr>
<td>Sexual intercourse (heterosexual)</td>
<td>64</td>
</tr>
<tr>
<td>Other</td>
<td>0.2</td>
</tr>
</tbody>
</table>

a) In the space provided below, construct a pie chart to illustrate the data in Table 2.

b) Suggest ONE social implication of the data presented in Table 2 and the pie chart.

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3. A major disease affecting the Caribbean population is AIDS.
a) Gregory discovers that he is losing weight rapidly. How can he confirm whether or not he has AIDS?

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b) Identify ONE other sign/symptom of AIDS.

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4. Discuss two effects of gonorrhoea on a developing foetus.

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5. Write THREE pieces of advice you would give to teenagers to prevent the spread of sexually transmitted infections.

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MINISTRY OF EDUCATION
SECONDARY ENGAGEMENT PROGRAMME
GRADE 10
BIOLOGY

WEEK 5        LESSON 3

TOPIC: Mitosis

Sub-topic: Mitosis and Asexual Reproduction

CONTENT

Asexual reproduction only requires a single parent. The parent divides into two, or a part of the parent separates and develops into a new individual. The daughter cells are genetically identical to their parent, and their physical and behavioural characteristics are also identical except for variation due to the environment. When organisms divide asexually, they divide by mitosis. The following is an example of asexual reproduction:

- Binary fission – asexual reproduction by a separation of the body into two new bodies. In the process of binary fission, an organism duplicates its genetic material or deoxyribonucleic acid (DNA). It then divides into two parts (cytokinesis), with each new organism receiving one copy of DNA. Binary fission occurs in unicellular organisms like bacteria and protozoans like Amoeba.

![Binary fission in Amoeba](Image taken from: byjus.com)

Fig. 1 Binary fission in Amoeba

(Image taken from: byjus.com)
Vegetative propagation - or vegetative propagation is a common form of asexual reproduction in plants. In some plants, a bud grows and develops into a new plant and then becomes detached from the parent plant. Bulbs, corms, rhizomes, tubers, taproots, runners, stolons, and tillers can give rise to new plants by vegetative reproduction. A *Bryophyllum* leaf (‘leaf of life’) will generate new plants around its edges. After a while, these plantlets become detached from the parent leaf.

![Fig. 2 Many new plants can be propagated from a single *Bryophyllum* leaf (Image taken from: toppr.com)](image)

Asexual propagation also includes artificial propagation where horticulturists and agriculturists use cuttings, budding, layering, and grafting to grow new plants.

![Fig. 3 Stem cuttings used to obtain new sugarcane plants (Image taken from: ib.bioninja.com.au)](image)

Tissue culture is a form of vegetative propagation used to make large numbers of the identical plant. Like binary fission, it also results from mitosis. Using tissue culture propagation or cloning, whole plants can be made from very small pieces cut from the
parent plant. This depends on the fact that most plant cells have the potential to form a whole plant.

- Cloning – a clone is an exact copy of an organism. Cloning may be used to produce an animal with some special characteristic (such as speed in a racehorse) as that could be financially beneficial. Clones need a surrogate mother in which to develop. This is a female who is not the genetic mother but in whose womb the fertilised ovum is implanted so that it can develop as a fetus until birth.

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**Fig. 4 Cloning of fertilised eggs.**

(Image taken from: Biology for CSEC® Examinations).

A second way to create a clone is to take the nucleus of a body cell from the ‘superior’ individual and use it to replace the nucleus of an unfertilised ovum. The cell can be made to divide as it would have done if it was a fertilised ovum and implanted in the womb of a surrogate mother, but all the cells it makes now have the chromosomes from the ‘superior’ animal.

---

**Homework**

State the advantages and disadvantages of cloning.

**References**


https://www.toppr.com/ask/content/story/amp/modes-of-vegetative-propagation-113026/

Week: Five  
Lesson: Three  
Topic: Mitosis and Asexual Reproduction

**Instructions:** Answer ALL questions in the spaces provided.

1. Identify TWO parts of a plant where mitosis takes place.

2. Explain to a farmer TWO advantages of having a field of cloned sugarcane.

3. In the process of cloning an animal, the nucleus from the egg is replaced by a nucleus from a body or somatic cell of the same organism. What is the significance of this process?

4. Differentiate between binary fission and tissue culture.
5. One of the goals of modern medicine is to replace the malfunctioning organ of a patient with an organ cloned from the patient’s own tissues. Suggest TWO reasons why this might be better than using donor organs.

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<th>Lesson 3</th>
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<td>Incomplete Dominance</td>
<td>Codominance</td>
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<td>7.</td>
<td>Incomplete Dominance vs Codominance</td>
<td>Pedigree Charts</td>
<td>Sickle Cell Anaemia</td>
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<td>Genetic Engineering</td>
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WEEK 6

TOPIC: Genetics

Sub-topic: Genetic Inheritance

CONTENT

Genetic diagrams show how characteristics are inherited. Alleles can be recessive, dominant, or codominant genes.

![Genetic Diagram](Image taken from bbc.co.uk)

*Fig. 1* A genetic diagram showing a genetic cross between a tall and short plant.

In the F1 generation, all the offspring were heterozygous (Tt), 100% tall. The phenotypic ratio would therefore be 4 tall plants: 0 short plants. In the F2 generation, 75% were tall plants (Tt) with
25% homozygous dominant (TT) and 50% heterozygous (Tt). 25% were short plants being homozygous recessive (tt). The phenotypic ratio is, therefore 3 tall plants: 1 short plant.

**Punnett Square**

Genetic crossing can be completed using Punnett squares. A Punnett square is a chart that allows you to easily determine the expected percentage of different genotypes in the offspring of two parents.

![Punnett Square Layout](www.goodscience.com.au)

**Fig. 2** The general layout of a Punnett Square.

(Image taken from goodscience.com.au)

**Practice**

Patrick met Patti at a dance. They are both heterozygous for their pink body color, create a Punnett square to show the possibilities if they had children. (look at old questions!)

Cross: $\text{Pp} \times \text{Pp}$

Punnett Square

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<thead>
<tr>
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<th>$\text{P}$</th>
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<tr>
<td>$\text{P}$</td>
<td>PP</td>
<td>Pp</td>
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<tr>
<td>$\text{p}$</td>
<td>Pp</td>
<td>pp</td>
</tr>
</tbody>
</table>

Genotypes: PP, Pp, pp  
Phenotypes: Pink, yellow

Genotypic ratio: 1:2:1  
Phenotypic ratio: 3:1

**Fig. 3** An example using the Punnett Square.

(Image taken from slideplayer.com)
Homework
State the importance of genetic diagrams.

References


Instructions – Answer All questions in the spaces provided.

1. Complete the crossword puzzle below using the clues given.

ACROSS
1. The science of genes, heredity, and variation.
2. Gene variants for the same trait.
3. A form of cell division.

DOWN
1. The basic unit of life.
2. The passing of genetic factors from parents to offspring.
3. CHROMO _ _ _ _, a threadlike linear strand of DNA.

2. For each of the genotype below, determine the phenotype.

Pink flowers are dominant to white flowers.

PP ___________________ Pp ___________________ pp ___________________

Black hair is dominant to red hair.

BB ___________________ Bb ___________________ bb ___________________

Long fur in cats is recessive. Short fur is dominant.

FF ___________________ Ff ___________________ ff ___________________
3. For each of the following write whether it is homozygous dominant, heterozygous, or homozygous recessive.

KK _______________________________ pp_________________________________
Mm_______________________________ Ll__________________________________
tt_________________________________ TT_________________________________

4. For each phenotype, list the genotypes. (Remember to use the letter of the dominant trait).

Straight hair is dominant to curly.   Tail spikes are dominant to plain tails.
________ straight                ________ pointed
________ straight                ________ pointed
________ curly                   ________ round

5. In dogs, there is hereditary deafness caused by a recessive gene, “d.” A kennel owner has a male dog (Gilbert) that she wants to use for breeding purposes if possible. The dog can hear.

a) What are the two possible genotypes of Gilbert?
________________________________________
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b) If the dog’s genotype is Dd, the owner does not wish to use him for breeding so that the deafness gene will not be passed on. This can be tested by breeding the dog with a deaf female (dd). Use genetic diagrams to show the possible crosses between the male genotypes and the female dog.

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6. Black fur colour is controlled by a dominant allele, B, and brown fur colour by its recessive allele, E. Give the genotypes of the parents and offspring of a cross between a black male and a brown female that produces ½ black offspring and ½ brown offspring. Show all the steps in the working of this problem.
CONTENT

Incomplete dominance is when a dominant allele, or form of a gene, does not completely mask the effects of a recessive allele, and the organism's resulting physical appearance shows a blending of both alleles. Flower colour in some plants, such as Impatiens, shows incomplete dominance of the alleles. This means that there is a blending or combination of expression of both alleles in the heterozygous condition.

![Fig. 1 Incomplete dominance showing blending of alleles.](image)

(Image taken from biologyonline.com)
Fig. 2 Incomplete Dominance in Chickens.

(Image taken from: ramsar.org)

**Homework**

Identify any traits of incomplete dominance in humans.

**References**


https://www.youtube.com/watch?v=BAMCuNoM_1k

https://www.biologyonline.com/dictionary/incomplete-dominance
Instructions: Answer all questions in the spaces provided.

1. Define ‘incomplete dominance’.

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2. Discuss the effects of codominance, include one specific example.

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3. In snapdragons, flower colour is controlled by incomplete dominance. The two alleles are red (R) and white (r). The heterozygous genotype is expressed as pink.
   a) What is the phenotype of a plant with the genotype RR? _______________
   b) What is the phenotype of a plant with the genotype rr? _______________
   c) What is the phenotype of a plant with the genotype Rr? _______________
   d) A pink-flowered plant is crossed with a white-flowered plant. What is the probability of producing a pink-flowered plant? ____________%
      Parents: ___________ X _______________
4.  a) In Andalusian fowls, black individuals (B) and white individuals (b) are homozygous. A homozygous blackbird is crossed with a homozygous white bird. The offspring are all bluish-grey. Show the cross as well as the genotypes and phenotypes of the parents and offspring.

Parents: __________ X __________

b) What results if a black individual is crossed with a bluish-grey individual? (SHOW WORKING)

Parents: __________ X __________

5. Identify two advantages of incomplete dominance. Use examples.

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Codominance means that neither allele can mask the expression of the other allele. As a result, traits associated with each allele are displayed simultaneously. An example of codominance for a gene with multiple alleles is seen in the human ABO blood group system. Persons with type AB blood have one allele for A and one for B; the O allele is recessive (its expression is masked by the other alleles). The blood group is controlled by three different alleles: $I^A$, $I^B$ and $I^O$. $I^A$ and $I^B$ are equally or co-dominant to each other, and both are dominant to $I^O$. Only two alleles can be present in any cell, one on each homologous chromosome that carries the gene for the blood group. This gives four possible phenotypes for the blood group.

![Table Showing the Genetic Basis of Blood Grouping in Human Population](Image taken from: toppr.com)
Examples of codominance in animals include speckled chickens, which have alleles for both black and white feathers, and roan cattle, which express alleles for both red hair and white hair. Codominance is also seen in plants. For example, rhododendrons with simultaneous expression of red and white genes for flower colour display flowers with both red and white petals.

**Fig. 2** Codominance in chickens.

(Image taken from: nagwa.com)

**Fig. 3** Codominance in flowers; both colours are expressed.

(Image taken from: biologywise.com)
Homework
Identify two differences between incomplete dominance and codominance.

References


https://www.toppr.com/ask/question/what-is-codominance-explain-it-through-determination-of-blood-groups/

Unknown (2021) Codominance. Retrieved from nagwa.com:

Unknown (2021) Codominance Explained with Examples. Retrieved from biologywise.com:
https://biologywise.com/codominance-explained-with-examples
Week:      Six
Lesson:    Three
Topic:     Codominance

Instructions: Complete ALL questions in the spaces provided.

1. Define codominance.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

2. In some chickens, the gene for feather colour is controlled by codominance. The allele for black is B, and the allele for white is B^1. The heterozygous phenotype is known as erminette (black and white spotted).
   a) What is the genotype for black chickens? ____________
   b) What is the genotype for white chickens? ____________
   c) What is the genotype for erminette chickens? ____________
   d) If two erminette chickens were crossed, what is the probability that:
      They would have a black chick, ________%  
      They would have a white chick, ________%  
      Parents: _______ X _________
3. In shorthorn cattle, when a red bull (RR) is crossed with a white cow (R^1R^1), all the offspring are roan—a spotted, red, and white or milky red colour.

a) What genotypes are expected from mating a roan bull and a roan cow?

b) What phenotypes would you expect from a cross between a red bull and a white cow?

4. Using a genetic diagram and your knowledge of the ABO blood grouping in humans, show how a female with blood group A and a male with blood group B can produce offspring with blood group O.

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MINISTRY OF EDUCATION
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BIOLOGY

WEEK 7          LESSON 1

TOPIC: Genetics
Sub-topic: Incomplete Dominance Vs. Codominance

CONTENT

Incomplete dominance shows a blending of alleles, whereas in codominance, both alleles are expressed. The table below outlines the differences between incomplete and codominance.

<table>
<thead>
<tr>
<th>Incomplete Dominance</th>
<th>Codominance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete dominance occurs in the heterozygote, in which the dominant allele does not dominate the recessive allele entirely; rather, an intermediate trait appears in the offspring.</td>
<td>Codominance occurs when the alleles do not show any dominant and recessive allele relationship. However, each allele from homozygote is able to add phenotypic expressions in the offspring or simply the ‘mix’ of each allele.</td>
</tr>
<tr>
<td>The phenotype of the offspring is an intermediate of the parents’ homozygous traits</td>
<td>The phenotypic expression of homozygous in codominance is independent.</td>
</tr>
<tr>
<td>The expression of alleles in incomplete dominance is conspicuous, meaning none of the alleles dominates over the other.</td>
<td>The expression of alleles in codominance is uniformly conspicuous, meaning both alleles have an equal chance for expressing their effects.</td>
</tr>
<tr>
<td>The formed trait (phenotype) is different due to mixing both parents’ phenotypes and genotypes.</td>
<td>The formed trait (phenotype) is not different due to the no mixing of both parents’ phenotypes and genotypes.</td>
</tr>
</tbody>
</table>
The offspring do not show the parental phenotype.  
The offspring shows both parental phenotypes.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The dominant allele does not</td>
<td>The offspring phenotype</td>
</tr>
<tr>
<td>dominate over the recessive</td>
<td>produced possesses the</td>
</tr>
<tr>
<td>allele.</td>
<td>combination of two alleles and,</td>
</tr>
<tr>
<td></td>
<td>thus, shows two phenotypes</td>
</tr>
<tr>
<td></td>
<td>together.</td>
</tr>
</tbody>
</table>

Incomplete dominance examples include Pink flowers of four- o'clock flowers (*Mirabilis jalapa*) and physical characteristics in humans, such as hair colour, hand sizes, and height.

Codominance can be seen in humans and as well as in animals. The blood type (or groups A, B, and O) in humans and the spots on feathers or hairs of livestock are examples of codominance.

**Table. 1** A comparison between incomplete and codominance

![Incomplete and Codominance in flowers.](kahukubiology.blogspot.com)

**Fig. 1** Incomplete and Codominance in flowers.

**Homework**
Discuss the importance of incomplete dominance and codominance.

**References**
Week: Seven
Lesson: One
Topic: Incomplete Dominance and Codominance

Instructions: Answer the following questions by CIRCLING ‘T’ if the statement is true or ‘F’ if the statement is false.

1. In codominance, the recessive allele is masked.  T  F
2. Incomplete dominance expresses both alleles.  T  F
3. The dominant allele is expressed in incomplete dominance.  T  F
4. In codominance, the offspring shows both parental phenotypes.  T  F
5. An example of incomplete dominance in humans is height.  T  F
6. An intermediate trait occurs in codominance.  T  F
7. In codominance, the offspring shows two phenotypes.  T  F
8. An example of codominance in humans can be seen in ABO blood groups.  T  F
9. There is a mixing of both parents’ phenotypes in codominance.  T  F
10. There is a mixing of both parents’ phenotypes in incomplete dominance.  T  F

KEY
1.  F  6.  F
2.  F  7.  T
3.  F  8.  T
4.  T  9.  F
5.  T  10.  T
WEEK 7 LESSON 2

TOPIC: Genetics

Sub-topic: Pedigree Charts

CONTENT

Pedigrees are used to analyze the pattern of inheritance of a particular trait throughout a family. Pedigrees show the presence or absence of a trait as it relates to the relationship among parents, offspring, and siblings. Pedigrees represent family members and relationships using standardized symbols.

By analyzing a pedigree, we can determine genotypes, identify phenotypes, and predict how a trait will be passed on in the future. The information from a pedigree makes it possible to determine how certain alleles are inherited: whether they are dominant, recessive, autosomal, or sex-linked.

![Common Symbols used in a Pedigree Chart](Image taken from: khanacademy.org)
A family with albinism is shown in the pedigree chart below.

![Pedigree Chart](image)

**Fig. 2** Pedigree chart used to show albinism in a family.  
(Image taken from: Biology for CSEC Study Guide)

**Homework**

Construct a pedigree chart to show a trait passed on in your family.

**References**


https://www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-pedigrees/a/hs-pedigrees-review
Instructions: Answer all questions in the spaces provided.

1. Explain in your own words, pedigree chart.

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2. Use the space below to construct a pedigree chart to show the inheritance of a single trait of your choosing.
3. Suggest the importance of pedigree charts in genetics using a specific example.
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4. Answer the following questions using the pedigree charts. When naming individuals, put their generation first and then their number: Ex. IV-3

![Pedigree Chart]

a) Which members of the family above have Huntington’s Disease?
______________________________
______________________________
______________________________
______________________________

b) There are no carriers for Huntington’s Disease - you either have it or you don’t. With this in mind, is Huntington’s disease caused by a dominant or recessive trait?
______________________________

______________________________

______________________________

c) How many children did individuals I-1 and I-2 have?
______________________________

______________________________

d) How many girls did II-1 and II-2 have, and how many have Huntington’s disease?
______________________________

______________________________
5. Answer the following questions using the pedigree charts. When naming individuals, put their generation first and then their number: Ex. IV-3

a) The pedigree above shows the passing on of colourblindness. What sex can ONLY be carriers of colourblindness?
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b) Is it possible for individual IV-2 to be a carrier? Explain your answer.
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c) Why does individual IV-7 have colourblindness?
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d) Why do all the daughters in generation II carry the colourblind gene?
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e) Name two generations in IV with colourblind males.
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Sickle cell anaemia (sickle cell disease) is a disorder of the blood caused by inherited abnormal haemoglobin (the oxygen-carrying protein within the red blood cells). The abnormal haemoglobin causes distorted (sickled appearing under a microscope) red blood cells. The sickled red blood cells are fragile and prone to rupture. When the number of red blood cells decreases from rupture (haemolysis), anaemia is the result. This condition is referred to as sickle cell anaemia. The irregular sickled cells can also block blood vessels, causing tissue and organ damage and pain. Sickle cell anaemia is one of the most common inherited blood anaemias. The disease primarily affects Africans and African Americans.

Fig. 1 The effects of smoking on the lungs.
(Image taken from: mayoclinic.org)
Allele Hb\textsuperscript{N} produces normal red blood cells, and the allele Hb\textsuperscript{S} produces sickle-shaped red blood cells; the possible genotypes and phenotypes are shown in Figure 2 below. The inheritance of sickle cell anaemia is shown in Figure 3 below.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hb\textsuperscript{NN}</td>
<td>all red blood cells are normal, the person is normal</td>
</tr>
<tr>
<td>Hb\textsuperscript{SS}</td>
<td>all red blood cells take the sickle shape, the person has sickle cell anaemia</td>
</tr>
<tr>
<td>Hb\textsuperscript{NS}</td>
<td>30–40% of the red blood cells are sickle shaped, the person has sickle cell trait</td>
</tr>
</tbody>
</table>

**Fig. 2** Genotypes and Phenotypes in Sickle Cell Anaemia
(Image taken from: Biology for CSEC® Examinations)

**Fig. 3** A worked example to show sickle cell anaemia inheritance.
(Image taken from: Biology for CSEC® Examinations)

The possibility of having a child who suffers from sickle cell anaemia is 25%. The possibility of having a normal child is 25%. The ratio is 1 normal: 2 trait: 1 anaemia.

**Sickle Cell Anaemia and Malaria**
Individuals who are carriers of sickle cell disease (with one sickle gene and one normal haemoglobin gene, also known as sickle cell trait) have some protective advantage against malaria. As a result, the frequencies of sickle cell carriers are high in malaria-endemic areas. Sickle
cells infected with *Plasmodium falciparum* collapse and prevent the parasite from interfering with the cell's actin proteins, protecting the host against malaria. People with sickle cell trait are less likely to get malaria. The trait does not completely protect a person from infection but makes death from malaria less likely.

**Homework**

State the effects of a person having sickle cell anaemia.

**References**


Unknown (2020) *Sickle Cell Anaemia*. Retrieved from mayoclinic.org:
https://www.mayoclinic.org/diseases-conditions/sickle-cell-anemia/symptoms-causes/syc-20355876
Instructions: Answer all questions in the spaces provided.

1. Sickle-cell anaemia is caused by the presence of a recessive allele. Persons who are heterozygous and carry the sickle-cell allele are more resistant to a type of severe malaria than persons who are homozygous for the normal haemoglobin allele.

a) State what is meant by EACH of the following terms:

Homozygous

Heterozygous

b) With the aid of a genetic diagram, show how a man and a woman who do NOT have sickle-cell anaemia can have a child who has the disease.
c) Explain why the sickle-cell allele is more common in countries where the severe form of malaria is present.

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2. Sickle-cell anaemia is an inherited condition in which the blood of affected persons cannot transport oxygen efficiently.

a) Describe TWO symptoms of sickle-cell anaemia.
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b) Fazul is a normal male, and Shanna is a carrier of the sickle-cell trait. What is the chance that a child born to them would suffer from sickle-cell anaemia? Explain your answer with the aid of a genetic diagram. Use the following symbols: A – normal; S – sickle cell.
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3. Explain the cause of sickle cell anaemia.

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4. What do you think would happen to the prevalence of sickle cell disease if malaria were eradicated? Explain your answer.

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5. Would a blood transfusion cure a person of sickle cell anaemia? Explain your answer.

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CONTENT
Albinism is a genetic disorder where people cannot make the pigment melanin. Melanin can be found in the skin, hair, and iris of the eyes. Several enzymes are needed to make this pigment, and it is a mutation of the genes that code for one of these enzymes that is the cause of the condition. Albino people are homozygous recessive. People who are homozygous dominant or heterozygous have the allele that codes for the functioning enzyme, and so melanin is produced. This means that they have normal pigmentation. People with albinism are at greater risk for sunburn, skin cancer and damage to the eye than people with normal pigmentation.

Fig. 1 A child with albinism and one with normal pigmentation
(Image taken from: be-in-be-you.org)
Fig. 2 A genetic cross between an albino and a normal homozygous dominant parent.  
(Image taken from: slideplayer.com)

**Homework**

Investigate the presence of albinism in Guyana.

**References**


https://be-in-be-you.org/

https://slideplayer.com/slide/5946623/
Albinism is seen in persons who are homozygous for the recessive allele of a certain gene. This gene codes for the production of the skin pigment, melanin. Persons who inherit the dominant allele of this gene produce the normal amount of melanin for their race.

a) Distinguish between the following paired terms: allele/gene; dominant/recessive.

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b) Use a genetic diagram to show how a couple with normal pigmentation may produce an albino child. Use the following symbols to represent the alleles: A – normal; a – albino.

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c) Suggest TWO precautions that albino persons living in the Caribbean should take when going outdoors.

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2. Use the pedigree chart in Figure 1 to answer the following questions.

![Pedigree chart used to show albinism in a family.](image)

**Fig. 1** Pedigree chart used to show albinism in a family.

a) State the genotypes of the people in the family tree.

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b) What is the probability of the next child of 16 and 17 will have albinism? Draw a genetic diagram to show your answer.

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C) Use the family tree to determine how 21 is an albino.

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Humans have 23 pairs of chromosomes, and one pair is responsible for the sex of the organism. There are two sex chromosomes, X and Y. The genotype XX is female, and XY is male.

**Fig. 1** How sex is determined in humans
(Image taken from: Biology for CSEC® Examinations)

**Fig. 2** How sex is inherited in humans
(Image taken from: Biology for CSEC® Examinations)
Sex-Linked Characteristics
The sex chromosomes also carry genes other than those which determine sex. The characteristics of those genes are said to be sex-linked, and they are carried on the X chromosome. There are genes involved in controlling vision and blood clotting. Males only have one copy of the genes that are on X chromosomes; if any of them are recessive, then the effect will be seen. Since women have two X chromosomes, they are less affected by sex-linked recessive alleles, and therefore sex-linked conditions are more common in boys than girls. Women who are heterozygous and have a mutant allele of a gene on the X chromosomes are carriers. Two examples are colour blindness and haemophilia (Bleeder’s Disease).

Colour Blindness
One of the gene on the X chromosome controls the ability to see red and green colours. There is a mutant allele of this gene that does not produce a protein necessary for colour vision. The allele is recessive, so any girl or woman who is heterozygous, $Rr$, has a normal colour vision. Males only have one X chromosome, so if they inherited the allele $r$, they would be colour blind.

![Genetic crossing between a normal male and a female carrier of colour blindness.](Image taken from: Biology for CSEC Study Guide)

Haemophilia or Bleeder’s Disease
Haemophilia is a disease in which the blood clots very slowly. It is a mutation of the gene that codes for a blood-clotting protein on the X chromosome. The mutant allele is recessive. The
dominant allele, H, causes blood to clot normally. The recessive allele, h, causes haemophilia, a condition in which blood does not clot, and any small cut will bleed for a long time.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>X^HX^h</td>
<td>female, normal cloting of blood</td>
</tr>
<tr>
<td>X^HX^H</td>
<td>female, normal cloting of blood; she is a carrier since she carries the recessive allele but it is not expressed.</td>
</tr>
<tr>
<td>X^HX^h</td>
<td>female, a haemophiliac</td>
</tr>
<tr>
<td>X^HY</td>
<td>male, normal cloting of blood</td>
</tr>
</tbody>
</table>

**Fig. 4** The genotypes and phenotypes in haemophilia.  
(Image taken from: Biology for CSEC® Examinations)

![diagram](image)

**Fig. 5** An example of how haemophilia is inherited.  
(Image taken from: Biology for CSEC® Examinations)

**Homework**

State the effects of haemophilia.

**References**


Instructions: Answer ALL questions given in the lines provided.

1. Sometimes, persons may inherit a condition called haemophilia in which the blood doesn’t clot normally. The allele for blood clotting is located on the X chromosome. A female with normal blood clotting ability mates with a male with normal blood clotting ability to produce offspring.
   a) Complete the following genetics diagram to illustrate this information.
   Parents’ phenotypes: Male × Female
   Parents’ genotypes: _____ × X\textsuperscript{H}X\textsuperscript{h}
   Gametes: _____ × (X\textsuperscript{H}) (X\textsuperscript{h})
   Fertilization cross:

   ![Genetics Diagram]

   b) State the probability of the couple having a child with haemophilia.

   ______________________________________________________________
   ______________________________________________________________

   c) What is the likely sex of the haemophiliac child? Give ONE reason to support your answer.

   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
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   ______________________________________________________________
d) Suggest ONE reason why haemophiliacs may be more susceptible to infectious disease.
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2. The ratio of males to females is about 1:1, with slightly more females than males. Draw a genetic diagram to show why the ratio is 1:1 and suggest why there are slightly more females than males.
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3. Suggest how you can tell the difference between a sex-linked condition and one that is not.
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4. In the pedigree chart in Figure 1 below, squares represent males while circles represent females. Shaded circles or squares indicate an affected individual.

![Pedigree Chart](image)

Fig. 1 Pedigree Chart showing those affected by colour blindness.

a) Consider the cross between a colour blind female and a normal male. Construct a Punnett square for the cross. If colour blindness is recessive, what are the phenotypes of the female and male children of that cross?

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b) If one of the daughters from the cross above married a colour-blind man, what are the chances of having a colour blind son?

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WEEK 8

LESSON 3

TOPIC: Variation and Evolution

Sub-topic: Genetic Variation

CONTENT

Each organism is unique. This uniqueness is a result of genetic differences and influences of the environment and is expressed in the phenotype. Each organism is born with its genetic make-up inherited from its parents. The genetic make-up of every organism is different except for clones. Genetic variation is inherited, and the differences may be small or large.

Fig. 1 Variation seen between and among organisms.

(Image taken from: Biology for CSEC® Examinations)
Genetic variation is a measure of the genetic differences that exist within a population. The genetic variation of an entire species is often called genetic diversity. Genetic variation is caused by:

- mutation
- random mating between organisms
- random fertilization
- crossing over (or recombination) between chromatids of homologous chromosomes during meiosis.

**Variation due to the environment**

The environment also plays an especially important role in determining the phenotype of an organism. The variation seen because of the influence of the environment is not inherited but occurs because of differences in the surroundings of the organism. For example, genetically identical twins, as they grow and develop, acquire subtle differences. These differences occur because their environments are different, even if they live in the same house. They eat different foods at different times in varying amounts. Their daily activities and interests vary, and their interactions with people, even their parents, are different. The differences in their ‘environments’ may be subtle, but enough to produce differences in their physical appearance. Identical twins also have different fingerprints.

![Fig. 2 An example of variation due to the environment.](Image taken from: vecteezy.com)
The Importance of Genetic Variation

Genetic variation is advantageous because it enables some individuals and, therefore, a population to survive despite a changing environment. For example, there is low genetic diversity in the wild cheetah population: Populations of wild cheetahs have extremely low genetic variation. Because wild cheetahs are threatened, their species has a very low genetic diversity. This low genetic diversity means they are often susceptible to disease and often pass on lethal recessive mutations; only about 5% of cheetahs survive to adulthood.

Homework

List some environmental factors that can cause variation in organisms.

References


Unknown (2021). Retrieved from vecteezy.com

### Instructions: Answer questions 1 – 5 by CIRCLING the LETTER next to the correct answer.

1. The passing of physical characteristics from parent to offspring is called __________.
   - a) recessive  
   - b) dominant  
   - c) heredity  
   - d) brown eyes

2. The study of heredity if called __________.
   - a) genetics  
   - b) heterozygous  
   - c) purebred  
   - d) genotypes

3. Which of the following is a source of genetic variation?
   - a) cloning  
   - b) mutation  
   - c) mitosis  
   - d) binary fission

4. Which of the following trait is influenced by the environment?
   - a) weight  
   - b) eye colour  
   - c) hair colour  
   - d) skin colour

5. Which of the following trait is NOT influenced by genetics?
   - a) behaviour  
   - b) eye colour  
   - c) attached ear lobe  
   - d) tongue-rolling

CIRCLE ‘T’ in statement is true or ‘F’ if statement is false in questions 6 to 10.

6. Height is influenced both by genetics and the environment.  
   - T  
   - F

7. Genetic variation increases a species chance of survival.  
   - T  
   - F

8. Random fertilization does not influence variation.  
   - T  
   - F

9. Clones have different genetic make-up.  
   - T  
   - F

10. The environment does not influence the phenotype of an organism.  
    - T  
    - F
KEY
1. C
2. A
3. B
4. A
5. A
6. T
7. T
8. F
9. F
10. F
Variation in organisms deals with the differences within a species and between species. There are two types of variation: continuous and discontinuous variation.

Continuous variation
Human height is an example of continuous variation. It ranges from that of the shortest person in the world to that of the tallest person. Any height is possible between these values, and therefore it is continuous variation. For any species, a characteristic that changes gradually over a range of values shows continuous variation. Examples of such characteristics are:

- Height
- Weight

If you record the heights of a group of people and draw a graph of your results, it usually looks something like this:
The more people you measure and the smaller the categories you use, the closer the results will be to the curved line. This shape of the graph is typical of a feature with continuous variation. Weight would give a graph similar in shape.

**Discontinuous variation**

A characteristic of any species with only a limited number of possible values shows discontinuous variation. The human blood group is an example of discontinuous variation. In the ABO blood group system, only four blood groups are possible (A, B, AB, or O). There are no values in between, so this is discontinuous variation. Some examples of discontinuous variation are:

- blood group
- sex (male or female)
- eye colour
Fig. 2 A bar chart to represent the frequency of each blood group in the population
(Image taken from: bbc.co.uk)

Homework
Identify other examples of continuous and discontinuous variation.

References


Instructions: Answer ALL questions given in the lines provided.

a) Albinism (lack of pigmentation) is an example of discontinuous variation. Give TWO examples of traits that show continuous variation.

b) Figure 1 shows the variation in height of a sample of men in a population.

![Graph of Height of a Sample of Men in a Population](image)

Fig 1 Height of a sample of men in a population.

c) In the space below, construct a table using the data presented in Figure 1.
d) State TWO conclusion that can be made from Figure 1.

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e) Suggest two causes of variation among members of the same species.

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f) The blood types of the members of a class of 30 students are recorded in Table 1.

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<thead>
<tr>
<th>Blood Type</th>
<th>Number of Students</th>
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<tbody>
<tr>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>9</td>
</tr>
<tr>
<td>AB</td>
<td>2</td>
</tr>
<tr>
<td>O</td>
<td>10</td>
</tr>
</tbody>
</table>

Explain how the type of variation shown in Table 1 differs from the type of variation represented in Figure 1.
CONTENT

Natural selection is the process through which populations of living organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways. This variation means that some individuals have traits better suited to the environment than others. If the environment does not change, natural selection maintains populations of organisms, so they do not change much over time. Individuals at the extremes of the range of variation do not survive as they are not well adapted. For example, female sparrows with very long or very short wings do not survive to breed as they are often killed during stormy weather. However, when the environment changes, individuals with features that help them survive the changed conditions are at an advantage. They then compete successfully, survive, breed, and pass on their alleles which become more common in the population. Selective agents are those aspects of the environment, such as predators, disease, and competitors, that have these profound effects. Natural selection involves:

- Overproduction
- Differential survival
- Reproduction and inheritance
- Adaptation

Genetic variation is described as the raw material for natural selection because it is responsible for all the phenotypes in each generation. Environmental factors select the most favourable phenotype in a particular situation. Mutation, meiosis, and sexual reproduction ensure that there is genetic variation among individuals in each generation for natural selection to act on.
Human Impact on Natural Selection

In the following examples, humans are responsible for changing the environment by introducing antibiotics, pesticides and pollution, but have not consciously chosen which organisms will breed.

- **Antibiotic resistance** – antibiotics are chemicals that kill bacteria or inhibit their growth. Over time, bacteria can become resistant to certain antibiotics (such as penicillin). In a large population of bacteria, there may be some that are not affected by an antibiotic. These survive and reproduce - producing more bacteria that are not affected by the antibiotic. The number of strains of antibiotic-resistant bacteria has increased, partly due to the misuse of antibiotics. This has led to more infections that are difficult to control, particularly in hospitals.

  ![Image of antibiotic resistance](Image taken from: Biology for CSEC Study Guide)

- **Pesticide resistance** – selection has also happened to insect pests that have been sprayed with insecticides. Insects susceptible to insecticides die, while resistant forms survive and increase in number. The same happens to weeds that are resistant to herbicides and fungal pathogens resistant to the fungicides used to control them.

  ![Image of pesticide resistance](Image taken from: Biology for CSEC Study Guide)
Industrial Melanism – is the proportional increase of dark, or melanin, pigments in individuals of a population caused by changes in the environment resulting from industrial pollution. Both increases in the frequencies of distinct melanic forms and the general darkening of some or all forms within a population may be involved. The peppered moth *Biston betularia* is a light-coloured species with dark patches that help them to camouflage against the lichens on the barks of the trees. *F. carbonaria* which is a subspecies of *F. typica* had undergone some mutation and changed to a dark coloured moth having light-coloured patches. In the polluted areas, the light-coloured species could not protect themselves from predators. This was because the lichen population had reduced due to pollution, and the light-coloured species were easily visible on the tree barks. This replaced the *F. typica* species with the *F. carbonaria* species. Since Europe has started using environment-friendly modern technologies, the selection pressure from predation has reversed, and the moth is returning to its typical variety. This process is slower than the initial change because the allele is recessive for light colour, and copies from both the parents are required. This is called reverse industrial melanism. In Australia, one species
of snakes living in water with black and white stripes has become completely black due to urban pollution.

![Image of butterflies illustrating Industrial Melanism.](ib.bioninja.au.com)

**Fig. 3** Industrial Melanism
(Image taken from: ib.bioninja.au.com)

![Image of a turtle head sea snake with and without stripes.](irishnews.com)

**Fig. 4** The turtle head sea snake losing its stripe and becoming black due to urban pollution
(Image taken from: irishnews.com)
**Homework**

Identify other examples of human impact on natural selection.

**References**


https://www.canr.msu.edu/grapes/integrated_pest_management/how-pesticide-resistance-develops


Instructions: Answer all questions in the spaces provided.

1. Evaluate the statement, ‘Natural selection promotes biodiversity of species.’

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2. Discuss the effects of industrial melanism on populations.

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3. Discuss how a bacterium can develop antibiotic resistance.

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4. Outline the processes involved in natural selection.

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5. Suggest how natural selection is beneficial to man.

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The Caribbean is a biodiversity ‘hotspot’. This means that there are many different habitats occupied by many different species. A species is a group of related organisms that can breed and produce fertile offspring. The formation of new species is called speciation. There are two ways in which new species may arise: geographical separation or ecological or behavioural separation.

**Geographical Separation**

This occurs when populations of the same species become separated by geographical barriers such as bodies of water, flooding, earthquakes, etc. Population that is geographically isolated from another may experience different environmental conditions and so evolve differently due to natural selection. Over time, the isolated population would become more different from the original population to fill a new and different ecological niche.

*Anolis* lizards have colonized islands of the Caribbean from the mainland. They have adapted to the conditions on the different islands and diversified into different species.

*Fig. 1 Anolis* lizards of the Lesser Antilles

(Image taken from: Biology for CSEC® Examinations).
Ecological or Behavioural Separation

Speciation can occur without physical barriers. Individuals from a population can adapt to the conditions of a specific part of a habitat where there are no other individuals. Behavioural isolation prevents members of a species from mating. It is one of many processes that lead to speciation. Through this process, members of a population diverge over time in their behaviours. This continues until they can no longer mate. They then become separate species. Behavioural isolation also prevents species that just diverged from interbreeding. This keeps the two species from merging to become the same species again.


**Fig. 3** Two species of cricket based on soil preference
(Image taken from: courses.lumenlearning.com).

**Homework**
Identify other examples of speciation.

**References**


https://www.storyboardthat.com/storyboards/adrienneolson/geographical-isolation

https://courses.lumenlearning.com/boundless-biology/chapter/formation-of-new-species/
Week: Nine  
Lesson: Three  
Topic: Species and their Formation

Instructions: Answer ALL questions given in the lines provided.

1. Define speciation.

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2. Distinguish between the two types of speciation, include one example of each.

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3. Many species of birds have elaborate mating rituals that include bird calls, nest construction, and courtship displays. A researcher is comparing two populations of birds with similar morphology that live in similar niches. Male birds in one population build a nest before attempting to court a female, while males in the other population build the nest in cooperation with the female. Is it likely the researcher will classify these birds as the same species? Justify your reasoning.

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4. Using the image below, describe how these organisms became different species.

5. Using your knowledge of speciation, complete the storyboard below.
CONTENT

Artificial selection also called "selective breeding", is where humans select for desirable traits in agricultural products or animals, rather than leaving the species to evolve and change gradually without human interference, like in natural selection. Artificial selection is responsible for the considerable changes that have occurred to species, such as sheep, goats, cattle, wheat, rice, and maize.

In artificial selection:

- Humans choose a feature (or trait) to improve
- Animals or plants showing this trait are chosen for breeding
- The offspring that show improvement in this trait is used for breeding the next generation; the rest are culled, eaten, or not used for breeding.

Fig. 1 Breeds of cattle
(Image taken from: Biology for CSEC Study Guide)
Crossing existing varieties to combine features produces many new varieties. For example, Hope cattle in Jamaica were bred from high yielding Jersey cattle, Holsteins, and Zebu cattle. This is known as hybridization. Many of our crops are genetically uniform, which is a considerable risk to food security. Varieties, for example, differ from each other by very few genes. This makes them susceptible to infection by plant pathogens with the possibility of wide-scale famine.

**Differences between Natural and Artificial Selection**

Artificial and natural selection is similar in some forms in that there is a change in one or more aspects of the species over time.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Natural selection</th>
<th>Artificial selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selective agent</td>
<td>The total environment although one factor may be very important, e.g. predation</td>
<td>Humans, e.g. farmers, plant and animal breeders</td>
</tr>
<tr>
<td>Type of traits selected</td>
<td>Adaptations to the conditions in the environment at a particular time</td>
<td>Useful characteristics for humans, e.g. fast growth, high yield, docile temperament</td>
</tr>
<tr>
<td>Number of traits selected</td>
<td>All traits</td>
<td>One, or a few traits, e.g. disease resistance</td>
</tr>
<tr>
<td>Speed</td>
<td>Generally slower</td>
<td>Faster – improvement can occur in several generations</td>
</tr>
</tbody>
</table>

**Fig. 2** A comparison between natural and artificial selection

(Image taken from: Biology for CSEC Study Guide)

**Homework**

List examples of selective breeding in Guyana.

**References**


Week: Ten
Lesson: One
Topic: Artificial Selection

**Instructions:** Answer the question in the space provided.

Write an argument in support of or against the statement below. Include evidence to support your argument.

‘Selective breeding increases biodiversity’
Ministry of Education  
Secondary Engagement Programme  
Grade 10  
Biology  

Week 10  

Topic: Variation and Evolution  

Sub-topic: Genetic Engineering  

Content  

Biotechnology is the science that involves the harnessing and exploitation of biological processes, systems, and organisms (particularly microorganisms) in manufacturing industries. The most powerful tool available to biotechnologists is genetic engineering. Genetic engineering involves moving genes from one organism into another. An organism with genes added to it from another species by genetic engineering is known as a transgenic organism. Some examples of genetic engineering in food production include:  

- resistance to pathogenic fungi in maize and potato  
- resistance to insect pests in many crop plants  
- increased growth rates in salmon and chicken  
- production of meat with less fat in pork and beef animals  
- production of higher quality dairy products (e.g. milk with more protein)  
- increase in the proportion of protein in seeds such as soya  
- long shelf-life of fruits such as tomato and bananas  
- tastier and more nutritious foods like tomato  
- increase in size, and therefore in yield, of many crop plants and cattle and dairy animals  
- production and subtropical crops so they are able to grow in temperate climates (e.g. sugar cane and millet)  
- production of cows and sheep from temperate areas so that they can grow well in tropical regions  
- grain crops that can fix atmospheric nitrogen (e.g. wheat and maize).  

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Applications of Genetic Engineering

Genetic engineering has several useful applications, including scientific research, agriculture, and technology. In plants, genetic engineering has been applied to improve the resilience, nutritional value, and growth rate of crops such as potatoes, tomatoes, and rice. In medicine, genetic engineering has been used to mass-produce insulin, human growth hormones, follistim (for treating infertility), human albumin, monoclonal antibodies, antihaemophilic factors, vaccines, and many other drugs. In research, organisms are genetically engineered to discover the functions of certain genes.

Fig. 1 The production of insulin via genetic engineering
(Image taken from: Biology for CSEC Study Guide)
Fig. 1 Genetic engineering used to combat the European Corn Borer

(Image taken from: Biology for CSEC Study Guide)

Homework
Identify the uses of genetic engineering in Guyana.

References


Week: Ten
Lesson: Two
Topic: Genetic Engineering

Instructions: Answer ALL questions in the spaces provided.

1. Define genetic engineering.

2. Discuss the importance of genetic engineering and give examples.

3. Distinguish between artificial selection and genetic engineering.
4. The image below shows genetic engineering in insulin. Identify the activities occurring at each letter.

a- ____________________________________________________________________________
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b- ____________________________________________________________________________
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c- ____________________________________________________________________________
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d- ____________________________________________________________________________
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Genetic engineering could also create unknown side effects or outcomes. Certain changes in a plant or animal could cause unpredicted allergic reactions in some people, which in its original form did not occur. Other changes could result in the toxicity of an organism to humans or other organisms.

The following are stated as ecological implications of releasing genetically modified organisms:

- Herbicide-resistant superweeds
- Creation of new weeds (herbivore resistance)
- Loss of biodiversity
- Reduction of soil quality due to release of toxins from GMOs
- Harm to beneficial insects
- Creation of new pests
- Sustainable agriculture and organic farming threatened
- Crossover of genes to other species
- Production of novel allergens and carcinogens

"Playing God" has become a strong argument against genetic engineering. Several issues have also been raised as regards the acceptance of this technology. These concerns range from ethical issues to lack of knowledge on the effects genetic engineering may have. One major concern is that once an altered gene is placed in an organism, the process cannot be reversed. Public reaction to the use of rDNA (recombinant DNA) in genetic engineering has been mixed. The production of medicines through the use of genetically altered organisms has generally been welcomed. However, critics
of rDNA fear that disease-producing organisms used in some rDNA experiments might develop extremely infectious forms that could cause worldwide epidemics.

As more human genes are being used in non-human organisms to create new life forms that are genetically partly human, further ethical questions arise. For instance, what percentage of human genes does an organism have to contain before it is considered human and how many human genes would a green pepper, for example, have to contain before it can be eaten without qualms. Human genes are now being inserted into tomatoes and peppers to make them grow faster. This suggests that one can now be a vegetarian and a cannibal at the same time. For meat-eaters, the same question could be posed about eating pork with human genes. What about the mice that have been genetically engineered to produce human sperm? The question is, ‘what psychological effect would it pose on the offspring’?

Looking at the fact that genetic engineering employs viral vector that carries functional gene inside the human body; the repercussions are still unknown. There are no clues as to where functional genes are being placed. They may even replace essential genes instead of mutated genes. Thus, this may lead to another health condition or disease in human. Also, as defective genes are replaced with a functional gene, then it is expected that there will be a reduction in genetic diversity, and if human beings have identical genomes, the population as a whole will be susceptible to virus or any form of diseases.

**Homework**

Discuss the pros and cons of genetic engineering.

**References**


Instructions: Answer ALL questions in the spaces provided.

1. Genetic engineering has been used to modify tomato plants. Outline one concern that has been raised about the consumption of genetically modified foods.

2. Scientists engineered chickens to be featherless by removing the gene in chicken DNA that causes them to grow feathers. Discuss the advantages and disadvantages of this.

3. Discuss why people oppose genetic engineering.
4. Identify two benefits of genetic engineering using a specific example.

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5. Has genetic engineering helped with food security across the globe? Discuss.

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