Cambridge Ordinary Level Notes
Biology 5090

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Contents

1 Cells

1.1 Cell structure and function

1.1.1. *Examine under the microscope, animal cells and plant cells from any suitable locally available material, using an appropriate temporary staining technique, such as methylene blue or iodine solution*

1.1.2. *Draw diagrams to represent observations of the animal and plant cells examined above*

Make sure that the diagrams have a single smooth outline.

1.1.3. *Identify on diagrams, photomicrographs or electron micrographs, the ribosomes, mitochondria, nucleus, cytoplasm and cell membrane in an animal cell*

Ribosomes are very tiny structures present in the cytoplasm of an animal cell, which are responsible for protein synthesis in an animal. Mitochondria are slightly larger, ovular structures, which are the site of aerobic respiration. Nuclei are significantly larger, circular structures which contain the genetic material of the cell. The cytoplasm is a jelly like substance, consisting mostly of water, in which the stated structures are suspended. The cell membrane holds the cell cytoplasm, which holds the rest of the structures.

1.1.4. *Identify on diagrams, photomicrographs or electron micrographs, the ribosomes, mitochondria, chloroplasts, nucleus, sap vacuole, cytoplasm, cell membrane and cellulose cell wall in a plant cell*

Ribosomes, mitochondria, nuclei, cytoplasm and cell membrane are all identically present in plant cells as they are in animal cells. Chloroplasts are medium sized green structures containing the pigment chlorophyll which is responsible for absorption of energy from sunlight. The sap vacuole is a large structure filled with cell sap. The cell wall is a protective layer of carbohydrate (cellulose) that envelopes the plant cell.

1.1.5. *Describe the structure of a bacterial cell, limited to: ribosomes, circular deoxyribonucleic acid (DNA) and plasmids, cytoplasm, cell membrane and cell wall*

Ribosomes, cytoplasm, cell membrane and cell wall are identical in bacterial cells, only the cell wall is not made of cellulose. In place of the genetic material containing nucleus, in bacterial cells, there is circular DNA suspended freely in the cellular cytoplasm. In addition to these, there are smaller circular lengths of DNA which are called plasmids.

1.1.6. *Describe the functions of the above structures in animal, plant and bacterial cells*

- *Ribosomes*: Tiny structures present in all cells. These are where proteins are made. "Instructions" on DNA molecules are read to join together

amino acids, the monomer unit of a protein (see Chapter 4), to form proteins.

- *Mitochondria*: Structures that are larger than ribosomes, which are the site of aerobic respiration in plants, animals and bacteria. Respiration is a chemical reaction that releases energy, which can then be used for many other functions.
- *Cell membrane*: Cell membranes are a very thin layer of protein and fat, which are present around all cells. This membrane controls movement of substances in and out of the cells, and it is hence said to be *partially permeable*. A partially permeable membrane allows movement of some substances whilst inhibiting movement of others.
- *Cytoplasm*: A clear jelly, consisting of mostly water. Many substances are dissolved in this jelly, and it is the site of most *metabolic reactions* which are the reactions of life.
- *Nucleus*: Nuclei are relatively large structures that are absent in bacterial cells.

2 Disease and immunity

2.1 Disease

2.1.1. *Describe a pathogen as a disease-causing organism*

Examples of such organisms include bacteria and viruses.

2.1.2. *Describe a transmissible disease as a disease in which the pathogen can be passed from one host to another*

Examples include Covid-19, influenza and the common cold.

2.1.3. *Understand that a pathogen may be transmitted:*

(a) through direct contact, including through blood or other body fluids

(b) indirectly, including from contaminated surfaces or food, from animals, or from the air

Direct contact comes down to exchange of bodily fluids. Indirect contact comes down to transmission of pathogens with an intermediary stage, with the pathogen moving through a medium, such as contaminated surfaces, animals, air etc.

2.1.4. *Describe the human body's barriers to the entry of pathogens, limited to: skin, hairs in the nose, mucus, stomach acid*

- Skin. Skin prevents pathogens' entrance. Blood clots broken skin to stop pathogens from getting into the body and causing disease.
- Hairs in the nose. Particles in the air are filtered out by the nose hairs. These particles may contain pathogens.
- Mucus. Mucus in the airway traps pathogens. They are swept up to the back of the throat and swallowed or spat out. This prevents the pathogens from entering the lungs.
- Stomach acid. The stomach contains hydrochloric acid, which kills the pathogens that are swallowed with food and the pathogens in swallowed mucus.

2.1.5. *Understand the role of the mosquito as a vector of disease*

Often, diseases can be carried by mosquitoes. An example of such a disease is *malaria*. Mosquitoes bite infected individuals, drink their blood, in which lies a pathogen. This pathogen, in some way, remains in the mosquito and is transmitted to the next person who is bitten by that mosquito. In other words, mosquitoes carry and transmit the disease. Such organisms are called *vectors*.

2.1.6. *Describe the malarial pathogen as an example of a parasite and explain how it is transmitted*

A *parasite* is an organism that is incapable of independent existence and requires a *host* to perform the functions of an organism (see Chapter 2). The malaria pathogen is an example of such an organism.

It is transmitted when an infected individual is bitten by a mosquito and that mosquito bites another individual. What happens is, the parasite enters the mosquitoes body and survives reproduces until it bites another, transferring the some of the pathogens from itself to the person.

2.1.7. *Describe the control of the mosquito that transmits malaria with reference to its life cycle*

Since the medium of spread of malaria are the mosquitoes, controlling these mosquitoes will result in the control of the disease. This may be done by many methods.

- Spraying insecticides. Spraying insecticides around human settlements will kill the mosquitoes that are already alive and which are potential carriers of the disease.
- Spreading oil over water surfaces. Mosquitoes lay their eggs in stagnant water surfaces. Oil, spread over these surfaces, will float on top of the water, preventing the mosquitoes from laying their eggs.
- Draining bodies of water. Removing stagnant bodies of water leaves mosquitoes without a place to lay their eggs.
- Predatory fish. Fish that feed on mosquito larvae can be used to populate bodies of water. These will eat the larvae and reduce mosquitoes growing to maturity.

Sleeping under mosquito nets, taking malaria preventing drugs, vaccines that provide partial immunity can all be used to *prevent* malaria. Furthermore, male mosquitoes made infertile by treatment with radiation may be released into the wild to produce infertile eggs.

2.1.8. *Explain that human immunodeficiency virus (HIV) is a viral pathogen*

2.1.9. *Describe how HIV is transmitted*

HIV spreads through direct contact. This includes unprotected sexual intercourse, blood transfusion, placental exchange and via breast milk.

2.1.10. *Understand that HIV infection may lead to Acquired Immune Deficiency Syndrome (AIDS)*

HIV targets and destroys lymphocytes (see Section 12.3). This makes the body vulnerable in that it will not be able to fight off infections. This state, where the body is susceptible to diseases, is called AIDS.

2.1.11. *Describe the methods by which HIV may be controlled*

- Screening blood. Before transfusion, blood to be transfused can be screened for the HIV pathogen.
- Reusing syringes. Reusing syringes must be avoided as traces of blood and potentially pathogens may remain on the needle.
- Condoms or femidoms. "Protection" should be used during intercouse.
- Limited partners. Multiple sexual partners should be avoided.
- Awareness. Awareness about the matter should be spread.

2.1.12. *Describe cholera as a disease caused by a bacterium, which is transmitted in contaminated water*

Cholera is a disease that is transmitted indirectly via water.

2.1.13. *Explain the importance of a clean water supply, hygienic food preparation, good personal hygiene, waste disposal and sewage treatment in controlling the spread of cholera (details of the stages of sewage treatment are not required)*

- A clean water supply. Water is used for many daily purposes including drinking and cleaning. Water from an unclean source will always contain microorganisms, some of which may be pathogens. The cholera bacterium is such a pathogen.

  A filtered and chlorinated water supply hence controls the spread of the disease.

- Hygienic food preparation. Hands must always be washed before touching food. Coughing and sneezing over food should be avoided. Hair should be carefully kept out of food. Animals should always be kept away from food. This is done to prevent bacteria from these places getting onto the food. Food should not be kept at room temperature for too long as that would cause bacteria to grow. Raw meat contains some bacteria, and hence should be kept away from cooked meat and other foods.
- Good personal hygiene. The human skin produces oil, which, when not washed, can build up and particles such as dirt and microorganisms can accumulate in it. Such things provide bacterial breeding grounds. Prevention of this can be done by regular usage of soap and shampoo.
- Waste disposal. Waste may accumulate near settlements. Chemicals may seep out of the rubbish, polluting ground and water bodies. Food waste can provide a breeding ground for cholera. Landfill sites can be dug out to dispose of waste, which, when filled up, can be covered with soil and planted with trees.

- Sewage treatment. Raw sewage contains many bacteria, including cholera. People that contact these substances may get ill. So, this liquid must be treated before it is allowed to run into rivers.

2.1.14. *Explain that the cholera bacterium produces a toxin that causes secretion of chloride ions into the small intestine, causing osmotic movement of water into the gut, resulting in diarrhoea, dehydration and loss of ions from the blood*

The toxin that the cholera bacterium secretes causes the epithelium (see Chapter 13) of the small intestine to secrete chloride ions into the lumen of the small intestine. This reduces the water potential of the inside of the small intestine, causing water from the surrounding capillaries to flow out into the intestinal lumen. This results in the patient suffering dehydration (lack of water), lack of ions. The faeces becomes watery due to this excess movement of water. This is called *diarrhoea*.

2.1.15. *Describe the effects of excessive consumption of alcohol: reduced self-control, depressant, effect on reaction times, damage to liver and social implications*

Alcohol is a *depressant*, meaning it reduces the body's awareness by reducing the amount of neurotransmitters that reach and stimulate nerves (see Chapter 14), this also increases reaction times of the drunken individual. Society also looks down upon excessive alcohol consumers.

2.1.16. *Describe the effects of tobacco smoke and its major toxic components (nicotine, tar and carbon monoxide): strong association with bronchitis, emphysema, lung cancer, heart disease, and the association between smoking during pregnancy and reduced birth weight of the baby*

- Nicotine. Nicotine narrows blood vessels, increasing blood pressure. These narrowed vessels will be more easily clogged by fat, when this occurs in coronary arteries, it will lead to coronary heart disease (see Chapter 11). As a result, blood vessels will respire anaerobically, leading to a buildup of lactic acid in the heart muscles. This causes a low pH environment in the muscles, denaturing enzymes and eventually killing the muscle, which can lead to cardiac arrest.

  Nicotine also narrows the blood vessels of the umbilical cord, reducing oxygen and nutrients reaching the baby. As a result, children of mothers who are smokers have lower birth weights.

- Tar. Tar is a *carcinogen*, which is a substance that leads to an increased chance of development of cancerous cells. Tar does so for the lung cells.

  Tar destroys the tracheal cillia (see Chapter 9), which causes mucus to acumulate in the airways. This mucus often contains trapped pathogens. This may result in frequent infections. A smoker's cough is an attempt to remove this build up of mucus, but it only scars the epithelium of the airways. This scarring make breathing difficult.

Emphysema is a result of frequent infection, meaning phagocytes are always near the lungs (see Section 12.3). These phagocytes release enzymes that break down the alveoli walls, so that they can reach their target pathogens. This results in a reduced surface area for gas exchange. Some of these enzymes also reduce the elasticity of the alveoli, reducing their capacity to stretch during breathing, causing them to burst. As the condition progresses, the individual struggles to breathe.

- Carbon monoxide. Carbon monoxide binds to haemoglobin, reducing the blood's capacity to carry oxygen. Breathing frequency and depth need to increase in order to get the same amount of oxygen into the blood. It also puts more strain on the circulatory system, increasing risk of heart diseases and strokes.

2.2 Antibiotics

2.2.1. *Describe a drug as any substance taken into the body that modifies or affects chemical reactions in the body*

2.2.2. *Describe the use of antibiotics for the treatment of bacterial infection*

2.2.3. *State that antibiotics kill bacteria but do not affect viruses*

2.2.4. *Explain how development of antibiotic-resistant bacteria, including MRSA, can be minimised by using antibiotics only when essential*

Antibiotic resistant bacteria develop as a result of mutations in bacterial populations, which cause them to be unaffected by certain antibiotics. Over the past few decades, antibiotics have been grossly overprescribed, leading to many antibiotic resistant bacterial strains developing. These resistant strains are often called superbugs, an example of which is the MRSA superbug.

To combat the growing number of antibiotic resistant bacteria, antibiotics must only be prescribed when necessary and prescribed courses must be completed by patients.

2.3 Immunity

2.3.1. *Describe active immunity as defence against a pathogen by antibody production in the body*

Lymphocytes are a type of white blood cell that are responsible for the production of antibodies. *Phagocytes* are the other type of white blood cell which can destroy and engulf pathogens by means of a process called *phagocytosis*.

2.3.2. *State that each pathogen has its own antigens, which have specific shapes*

2.3.3. *Describe antibodies as proteins that bind to antigens leading to direct destruction of pathogens, or marking of pathogens for destruction by phagocytes*

2.3.4. *State that specific antibodies have complementary shapes which fit specific antigens*

2.3.5. *Explain that active immunity is gained after an infection by a pathogen, or by vaccination*

Each lymphocyte produces only a specific antibody, which has only a specific antigen to which it can bind. The binding of antibodies to pathogens' antigens destroys the pathogen outright or these antibodies can mark these pathogens by joining many of them together to be engulfed and destroyed by phagocytes by phagocytosis.

2.3.6. *Outline the process of vaccination:*

(a) weakened pathogens or their antigens are given

(b) the antigens stimulate an immune response by lymphocytes which produce antibodies

(c) memory cells are produced that give long-term immunity

Memory cells are a type of lymphocyte that last for very long in the blood. These cells are responsible for recognising a certain pathogen. When the pathogen is detected, these cells divide, increasing in number and produce antibodies to destroy the pathogen.

2.3.7. *Explain the role of vaccination in controlling the spread of transmissible diseases*

Vaccination protects those who are vaccinated and those who are not, as the disease against which the vaccine acts will be left with very few places to replicate (unvaccinated individuals). Hence, vaccinating enough people in a population results in *herd immunity*, where unvaccinated and vaccinated people are safe of the disease as a result of what was explained above. individuals

2.3.8. *Explain that passive immunity is a short-term defence against a pathogen by antibodies acquired from another individual, limited to: across the placenta and in breast milk*

Antibodies of the mother are passed onto the fetus and baby, into the blood via placental exchange and via ingestion of breast milk, respectively. These antibodies last only a short time.

2.3.9. *Explain the importance of breast-feeding for the development of passive immunity in infants*

An infant's immune system is not well developed, and these antibodies from its mother can protect it against any diseases to which the mother is immune.

2.3.10. *State that memory cells are not produced in passive immunity*

2.3.11. *Outline how HIV affects the immune system, limited to: decreased lymphocyte numbers and reduced ability to produce antibodies, which weakens the immune system*

See Section 1.1.8 onwards, if necessary.

3 Excretion

3.1 Excretion

3.1.1. *Describe excretion as the removal of toxic materials and the waste products of metabolism from organisms*

3.1.2. *State that carbon dioxide is a waste product of respiration, which is excreted through the lungs*

3.1.3. *State that urea is a toxic waste product produced in the liver from the breakdown of excess amino acids*

3.2 Urinary system

3.2.1. *Identify, on diagrams, the kidneys, ureters, bladder and urethra and state the function of each (the function of the kidney should be described simply as removing urea and excess salts and water from the blood as urine)*

Kidneys remove urea and excess salts from the blood, forming a liquid called *urine*. This urine is *carried* to the bladder by *ureters*. The bladder is where urine is temporarily stored before being expelled from the body through the *urethra*.

3.2.2. *Explain the need for excretion, limited to toxicity of urea*

Urea is toxic, and hence must be excreted.

3.2.3. *Outline the function of a nephron and its associated blood vessels, limited to:*

(a) the role of the glomerulus in the filtration from the blood of water, glucose, urea and ions

(b) the role of the nephron in the reabsorption of all of the glucose, some of the ions and most of the water back into the blood

(c) the formation of urine containing urea, excess water and excess ions water back into the blood

Kidneys are made up of many, much smaller tubules called *nephrons*. The nephron consists of *Bowman's capsule*, *tubules*, the *loop of Henle* and a *collecting duct*.

In Bowman's capsule, there is a capillary called the *glomerulus* which is a branch of the *renal artery*. This capillary then branches out, and surrounds the rest of the nephron before joining together to form part of the *renal vein*.

As blood flows into the glomerulus, small molecules such as water, glucose, ions and urea are filtered out of the blood and into the nephron through the capsule. As the filtered liquid passes through the nephron, the useful substances that have been filtered out, such as glucose, water and some ions are reabsorbed into the blood capillaries that surround the nephron. The resulting liquid is

urine, which then collects in a collecting duct, which eventually joins into the ureter. Urine hence consists of excess water, excess ions and urea.

3.2.4. *Describe the role of the liver in the assimilation of amino acids by converting them to proteins*

Amino acids, absorbed in the small intestine, are sent to be assimilated to the liver via the hepatic portal vein (see Chapter 8). The liver assmilates amino acids by joining them together to form new proteins.

3.2.5. *Describe deamination in the liver as the removal of the nitrogen-containing part of amino acids, resulting in the formation of urea*

The removal of the nitrogen containing part of amino acids, is called *deamination*. This nitrogen containing part eventually forms urea. [1]

[1] *Excess amino acids cannot be stored. The nitrogen-containing part of amino acids is removed to form a substance similar to sugars, which is converted to glycogen and stored.*