AS 91156 Demonstrate understanding of life processes at the cellular level.

DNA Replication

(2017:3) Mitosis

The table below shows how mitosis occurs at different rates in different types of human cells.

Cell Type	Mitosis Rate (How often cells are replaced)
Skin cell	2 weeks
Liver cell	300 – 500 days
Intestinal – internal lining	4 – 5 days
Intestinal – muscle and other tissues	16 years

Discuss why the rate of mitosis varies in different human cells, using examples from the table above.

In your answer:

- explain the purpose of mitosis AND how it occurs
- provide reasons why the rate of mitosis varies in different types of human cells
- compare and contrast ALL the different types of cells in the table AND justify the mitosis rate in terms of cell function. You may use diagrams in your answer.

(2016:1) DNA Replication

(a) The model below shows DNA replication.
Label the following on the diagram: • nucleotide • nitrogen base • hydrogen bond • parent strand • daughter strand • sugar-phosphate backbone.

These questions were collated from the expired Level 2 AS 90464 Describe cell structure and function but are still useful for the new AS 91156 Demonstrate understanding of life processes at the cellular level. Some questions were collated from the Level 3 AS 90715 which included DNA replication.

(b) Explain the purpose of DNA replication.

(c) Enzymes are needed for DNA replication.

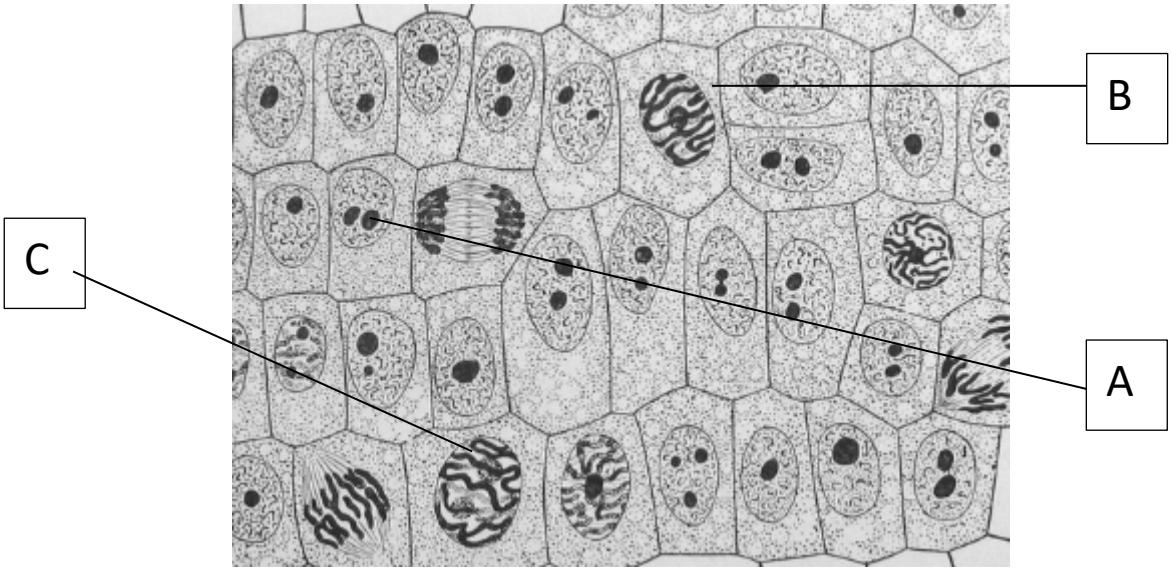
Discuss the function of enzymes in DNA replication and the factors that affect them.

In your answer include:

- a description of the structure of an enzyme
- an explanation of how enzymes function in DNA replication
- a discussion of at least three factors that affect enzymes during DNA replication.

You may use diagrams in your answer.

(2014:1) Cell division:



(a) The picture above shows onion cells in different phases of the cell cycle. The cells labelled A, B and C are not in the sequence that cell division occurs in. Put them in the correct sequence.

(b) Comprehensively discuss how and why cells divide.

In your answer;

- describe the process of mitosis
- explain the process of DNA replication and how it allows mitosis to occur
- discuss, by giving reasons, when and why different factors cause the cells to divide, AND provide examples to support your answer.

You may use diagrams to support your answer.

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(2013:3)

Mitosis occurs during the life cycles of both animals and plants.

(a) Describe what is meant by mitosis. The process of DNA replication is usually referred to as semi-conservative replication.

(b) Explain the process of how chromosomes are replicated, and why the process is known as semi-conservative replication. You may draw a labelled diagram(s) to support your answer.

(c) Almost all animals and plants develop from a fertilised cell that divides into different types of cells and tissues. The rates of mitosis vary considerably, depending on the location of the cells and the stage in the organism's life-cycle.

Discuss the statements above. In your answer include:

- a description of what affects the rate of mitosis
- reasons why the stages of an organism's life-cycle have different rates of mitosis
- at least two examples, with reasons, of the parts of plants and animals where the rate of mitosis is likely to be higher.

(2011:3)

DNA replication occurs at different rates during the lifetime of a plant or animal.

Evaluate this statement, including in your answer:

- a description of what DNA replication is
- an explanation of how the process occurs
- a discussion of why the rate of DNA replication varies during the lifetime of a plant or animal.

A labelled diagram may be used to support your answer.

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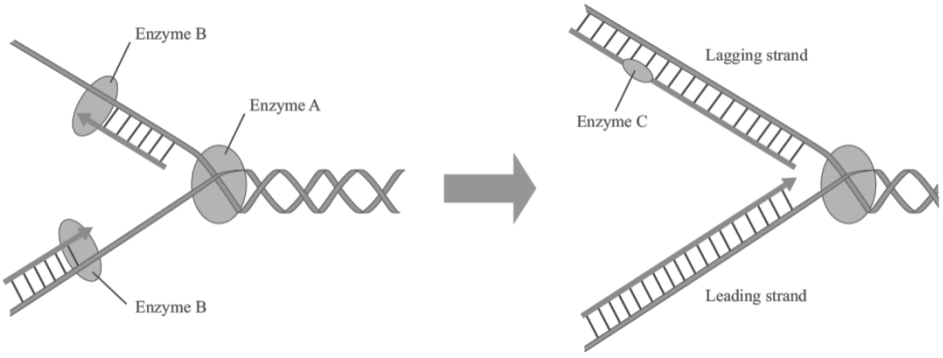
(2011:1) ***Note L3 AS90715**

The diagram below shows a simplified representation of the process of DNA replication. A, B and C are enzymes involved in the process.



(a) Explain the purpose of DNA replication.

(b) Discuss the role of enzyme action in the process of DNA replication.

In your answer you should:

- identify the enzymes shown in the diagram
- explain the role of each enzyme
- discuss the specific consequences if any of these enzymes should fail to function correctly.

(2010:1(b)) ***Note L3 AS90715**

When DNA is replicated, each of the parent strands acts as a template.

Explain why there is a difference in the way in which the parallel strands of DNA are replicated.

You may use a labelled diagram to support your answer.

(2009:1(b)) ***Note L3 AS90715**

The NF1 gene contains 8454 base pairs and codes for a protein called neurofibromin. Neurofibromin regulates the action of the Ras protein, which promotes cell division. Mutant forms of NF1 produce a protein that cannot regulate Ras properly.

When DNA is replicated, it is important that cells make exact copies of genes such as NF1. Explain why replication of a gene needs to be exact, with reference to the role of the NF1 gene.

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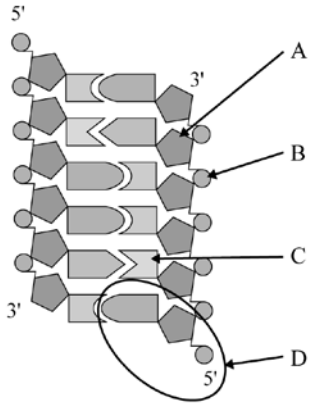
(2007:1) – *Note L3 AS90715



The following diagram shows part of a DNA molecule.

(a) Identify the structures labelled A, B, C and D in the diagram.

(b) DNA is able to make copies of itself. This process is controlled by several enzymes.

Describe the role of each of the following enzymes in DNA replication:

(i) DNA polymerase
(ii) DNA helicase
(iii) DNA ligase.

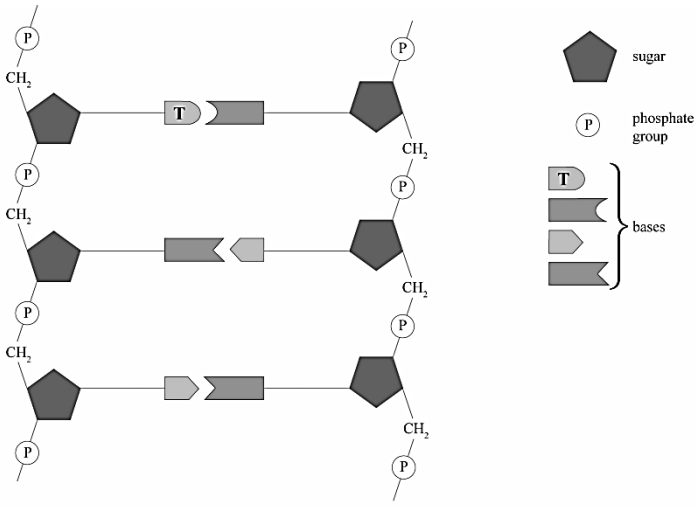
(2006:1) – *Note L3 AS90715

DNA is a polymer, made up of a large number of sub-units (nucleotides).

(a) The unlabelled diagram below shows the basic structure of a DNA molecule. Complete the diagram by giving information that clearly identifies:

- the four bases and their positions (one base has been identified in the diagram)
- the number of hydrogen bonds between bases
- the anti-parallel nature of the molecule
- which end of the DNA strand new nucleotides are added to.

Simplified structure of part of a DNA molecule



(b) Explain why DNA replication is necessary.

(c) Discuss how DNA replicates. In your discussion, you should explain:

- how replication begins
- the roles of the main enzymes involved
- leading and lagging strands
- Okazaki fragments
- the source of materials for replication.

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SOME RECENT ANSWERS

(2017:3)

Mitosis is to replicate genetically identical cells for growth / repair / asexual reproduction / same function as parent cell in body (somatic) cells.

Describes process – replicated chromosomes separate, 2 new nuclei form, cell splits in two.

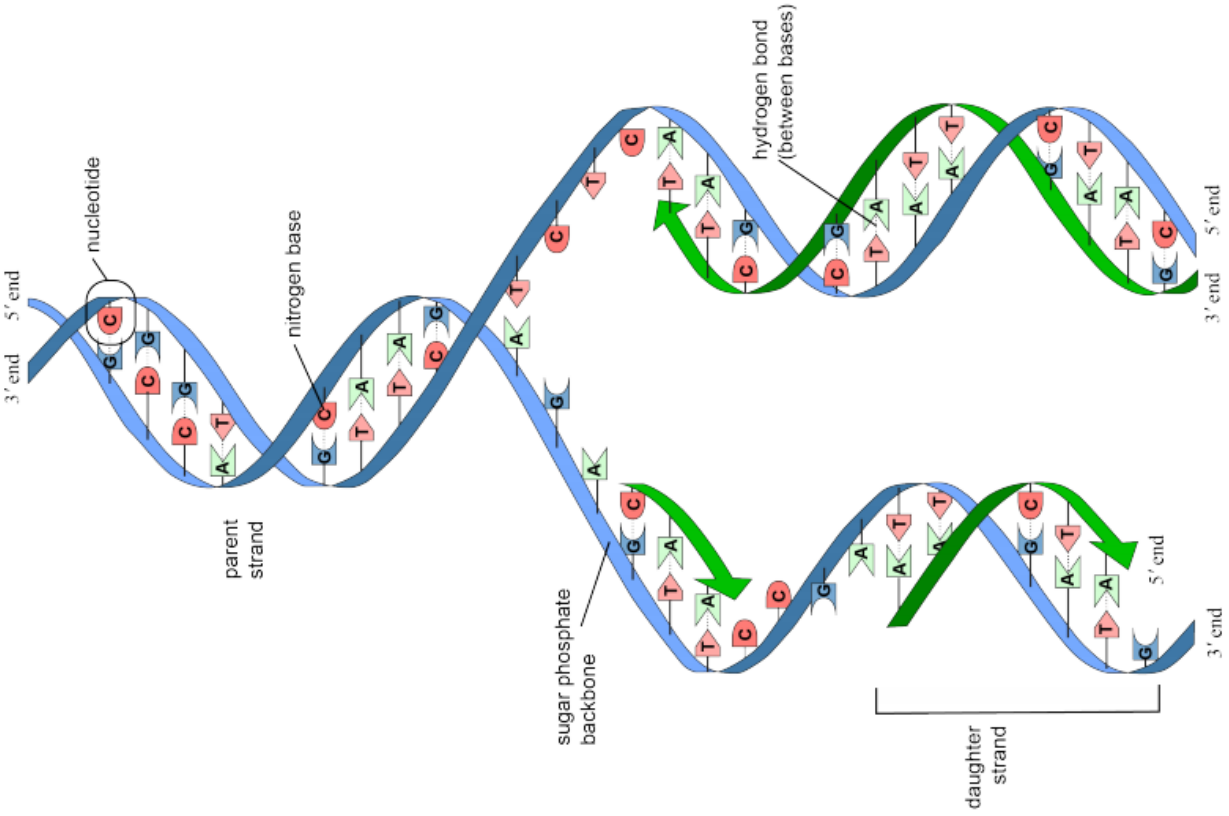
Explains process – DNA replicates / chromosomes replicate, replicated chromosomes condense and move to equator of cell while spindle fibres attach to centromere, spindle fibres pull replicated chromosomes to poles of cells and cell membrane forms around chromosomes.

Mitosis occurs during periods of growth and repair following damage to the organism when repair of tissue is necessary e.g. intestinal lining is repaired quickly because the process of digestion is abrasive and cells are 'rubbed' away when food is moved through the intestine. In the same way, skin cells are exposed to the elements and wear and tear of outside environment so will also need replacing at a fairly high rate. Liver cells are not exposed to wearing, but are exposed to a wide range of chemicals that could damage them, but at a slow rate. Therefore, they need replacing only every 300–500 days.

During periods with limited growth or replacement of cells, the rate of mitosis is not likely to be so high e.g. intestinal muscle is not replaced at a high rate because it is not exposed to the wear that the intestinal lining or skin cells are exposed to.

(2016:1)

(a)



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(b) The purpose of DNA replication is to replicate the cells' DNA in preparation for cell division. Replicated DNA is passed on to daughter cells, ensuring the new daughter cells carry out the same function as parent cells.

(c) The structure of an enzyme is composed of a protein and possible nonprotein called a co-factor. It has an active site, which joins or breaks / a 3D protein folded and joined to other proteins by hydrogen and sulphide bonds to form an active site which the substrate binds to.

Enzymes' function is to catalyse or speed up biological reactions by lowering activation energy. They are specific to a reaction and are not used up in the reaction. Enzymes are involved in each step of DNA replication. During DNA replication, a specific enzyme unwinds the DNA helix exposing nucleotides. Another enzyme synthesises the new DNA strands by adding complementary nucleotides to the template strands. During DNA replication, enzymes function using the induced fit model. The active site and substrate are not initially perfect matches for each other. The active site continues to change until the substrate is completely bound to it, at which point the final shape of the enzyme is determined. Factors that affect enzymes during DNA replication include temperature, pH, substrate concentration, co-factors, enzyme concentration, and poisons.

Temperature – all enzymes have an optimum temperature. At very low temperatures, enzyme action slows, and at high temperatures the 3D shape may change and denature. Denaturing is irreversible and means the enzyme is inactive.

Substrate – an increase in substrate concentration means more can combine with enzymes' active site and therefore increase the rate of reaction until the available enzyme molecules become 'saturated' and the rate of reaction levels off (may use an annotated diagram to show this).

pH – enzymes have an optimum pH range. Outside their optimum range can cause an enzyme's active site to denature, preventing substrates from binding. High enzyme concentration allows for increased rate of reaction.

Co-enzyme – alter the shape of the active site in such a way that it can effectively combine with substrates. A decrease in co-factor would reduce the rate of reaction or even stop the enzyme.

Inhibitors – are poisons that alter or block the active site, preventing substrates from binding.

Enzymes are involved in each step of DNA replication, and therefore the rate of DNA replication is dependent on factors affecting enzyme action. Therefore these factors would also affect growth, repair and meiosis / mitosis / cell division.

(2014:1)

(a) B C A or C A B

(b) Mitosis is to replicate genetically identical cells for growth / repair / same function as parent cell in body (somatic) cells.

Process – replicated chromosomes separate, 2 new nuclei form, cell splits in two.

DNA replication process:

An enzyme separates the DNA double helix. Free nucleotide bases A T G C match the exposed bases using the complementary base pairing rule, ie A-T and G-C. Each new helix has one parent strand and one new strand (semi-conservative).

DNA replication allows cell division to occur because all cells must replicate their DNA before division, so that each new daughter cell has the identical genetic material to the parent cell, so it can function correctly and reproduce.

Cells divide for growth, repair, regeneration, asexual reproduction.

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Cell division occurs when the distance between the cell membrane and centre of cell becomes so large that substances cannot diffuse fast enough to carry out cell processes. Therefore cells divide to have a high surface-to-volume ratio. This enables efficient chemical reactions.

Mitosis occurs during periods of growth and repair during infancy / childhood / early development in animals following the breaking of dormancy, and during seasonal growth in plants following damage to the organism when repair of tissue is necessary.

Cells will divide by mitosis when growth or replacement of cells needs to occur. This is determined by factors such as cell type / function, For example skin cells are programmed to divide more than brain cells.

Examples of cell types that divide often include, (but are not limited to) root cells, shoot tips, hair follicles, bone marrow, skin cells and mucous membranes. Cells that divide less often include Liver cells and Neurones.

(2013:3)

(a) Mitosis is the process where a single cell divides, resulting in generally two identical cells, each containing the same number of chromosomes and genetic content as that of the original cell.

(b) Semi-conservative replication is so named because each molecule of DNA that is created contains one new strand and one old strand.

Process of replication. (Names of enzymes are not necessary but may aid judgement of candidate's understanding.)

The two strands separate, exposing the bases (unwound by the enzyme helicase), which will act as the template. Two new polynucleotide chains are formed using the bases of the existing strands as a complementary template. (Carried out by DNA polymerase). Nucleotides join up following the base-pairing rule A-T and C-G. etc

(c) Identifies and describes factors affecting the rate of mitosis. Eg, temperature, pH, presence of mutagens such as alcohol or radiation, availability of raw materials in the cell, hormones, enzyme activity

Mitosis is usually higher during periods of growth and repair during infancy / childhood / early development in animals following the breaking of dormancy, and during seasonal growth in plants following damage to the organism when repair of tissue is necessary.

Mitosis occurs at a higher rate in areas where most growth or replacement of cells is occurring, such as: root / shoot tips, hair follicles, bone marrow, skin cells, mucous membranes etc.

Mitosis rates increase in areas of cellular repair, the site of damage. Mitosis rates increase in cancer cells, etc

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