Additional Assessment Materials
Summer 2021

Pearson Edexcel GCE in A Level Biology

Topic 6: Microbiology and Pathogens

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1 During the development of active immunity, macrophages present antigens to T helper cells.

(a) Describe how macrophages present antigens to T helper cells.

(2)

Antigens on the cell surface membrane of macrophages bind to complementary CD4 receptors on the surface of T helper cells.

(b) In an investigation into clonal selection, macrophages and T cells were isolated from two strains of guinea pig, strain 2 and strain 13.

The macrophages from each strain of guinea pig were exposed to an antigen and treated with mitomycin.

Mitomycin forms cross links between complementary strands of DNA.

These macrophages were then cultured with T cells from each of the strains of guinea pig for 72 hours.

Radioactive thymidine was included in the culture. This molecule will become incorporated into DNA during DNA replication instead of thymine.

The table shows the results of this investigation.

Source of macrophages	Level of radioactive thymidine incorporated into T cells / a.u.	
	T cells from strain 2 guinea pigs	T cells from strain 13 guinea pigs
strain 2	180	13
strain 13	17	59

(i) Explain why the macrophages were treated with mitomycin.

(3)

Mitomycin prevents macrophage DNA from unzipping and thus inhibits DNA replication. This prevents mitosis and ensures that the number of macrophages remains constant. Radioactive thymidine, which is incorporated into DNA during DNA replication, is therefore only present in cultured T cells.

(ii) Explain how radioactive thymidine becomes incorporated into the DNA.

(2)

Radioactive thymidine is complementary to adenine. It binds to adenine via two hydrogen bonds, and forms phosphodiester bonds with adjacent nucleotides, forming the sugar-phosphate backbone.

(iii) Analyse the data to explain the results of this investigation.

(4)

A greater proportion of radioactive thymidine was incorporated into T cells belonging to the same strain as the macrophages. This signifies increased DNA replication, and thus mitosis, of T cells of the same strain. This is due to greater recognition of macrophage antigens by T cell receptors and greater complementarity between T cell receptors and macrophage antigens of the same strain. Additionally, T cell recognition and clonal selection is more rapid in Strain 2 than Strain 13, signified by the higher levels of radioactive thymidine.

2 *Salmonella* are Gram negative bacteria found in the large intestine of humans.

(a) Which is the correct statement about *Salmonella*?

(1)

☐ **A** *Salmonella* has a thick peptidoglycan cell wall and produces endotoxins

☐ **B** *Salmonella* has a thick peptidoglycan cell wall and produces exotoxins

☒ **C** *Salmonella* has a thin peptidoglycan cell wall and produces endotoxins

☐ **D** *Salmonella* has a thin peptidoglycan cell wall and produces exotoxins

(b) A scientist studied the growth of *Salmonella*.

(i) *Salmonella* was isolated from a mixed culture of bacteria, using streak plating onto selective media.

Explain why this is a suitable method for isolating the *Salmonella*.

(4)

Streak plating enables dilution of a bacterial culture and isolation of a pure bacterial colony from a mixed population. This enables separation of a single *Salmonella* colony from others present in the mixed culture. This colony can then be picked up and transferred to a separate sterile agar plate. The use of a growth medium in which only *Salmonella* can survive may also enable the isolation of *Salmonella* colonies.

(ii) The scientist made a broth culture of *Salmonella* at a concentration of 5×10^3 cells per cm^3.

Ten hours later the concentration of *Salmonella* was 4×10^6 per cm^3.

Calculate the exponential growth rate constant (k) for this culture of *Salmonella* using the formula

(3)

$$k = \frac{\log_{10}N_1 - \log_{10}N_0}{0.301 \times t}$$

$$K = \frac{\log_{10}(4 \times 10^6) - \log_{10}(5 \times 10^3)}{0.301 \times 10} = 0.964 \text{ cells } cm^{-3} h^{-1}$$

Answer $0.964\ cm^{-3} h^{-1}$

(iii) In this calculation, the scientist did not allow for the time that the *Salmonella* spent in the lag phase.

Explain the effect that this will have on the calculated value for the growth rate constant.

(3)

The actual value for t is smaller than the value for t used in the calculation because the bacteria do not divide during the lag phase. Thus, the calculated value for K will be smaller than the actual value.

Malaria is caused by *Plasmodium*, a pathogenic microorganism.

Vaccination is one of many methods being used to control malaria.

In a study, the effectiveness of a vaccine for malaria was tested.

The following method was used:

- samples of *Plasmodium* were exposed to radiation and used to make a vaccine
- two groups of people, A and B, were given different doses of the vaccine
- a third group of people, C, was used as a control
- one month after vaccination, all three groups of people were exposed to mosquitoes known to contain live *Plasmodium*
- the number of people in each group with malaria was recorded.

The results are shown in the table.

Group	Treatment with the vaccine	Number of people in each group	Number of people with malaria
A	low dose	17	16
B	high dose	6	0
C	control	12	11

(a) (i) Explain why the samples of *Plasmodium* were exposed to radiation.

(2)

Radiation was used to kill *Plasmodium*. This ensures that it is not pathogenic, reducing the risk of infection by malaria. The antigens remain intact and can provoke an immune response.

(ii) State the control treatment that was given to people in group C.

(1)

Vaccinate with water.

(iii) It was claimed that this vaccine was 100% effective.

Analyse the data to criticise the validity of this claim.

(3)

The vaccine is only 100% effective for group B which received a high dose of the vaccine. None of the 6 people in group B contracted malaria. However, 16 of 17 people in group A that received a low dose contracted malaria. This is similar to the control group. Thus, not all doses of the vaccine were 100% effective. Moreover, only a small sample size was used for group B.

(iv) Describe how vaccination enabled the people in group B to have active artificial immunity against malaria.

(5)

Plasmodium engulfed by dendritic cells via phagocytosis. Pathogen's antigens displayed on the surface of dendritic cells, antigen presenting cells (APCs). APCs bind to complementary CD4 receptors on the surface of T helper cells. This activates clonal expansion of T helper cells which divide and differentiate to form a range of T cells including T memory cells. Activated T helper cells secrete cytokines which stimulate specific B cells. These differentiate to form B memory cells and plasma cells. Plasma cells synthesise and secrete complementary antibodies. Memory cells remain in the blood and provide active immunity. If *Plasmodium* antigens are encountered again, antigen presentation is rapid and destroys the pathogen before it can reproduce

(b) Anti-malarial drugs can be used to protect people from malaria.

These drugs are not always effective because *Plasmodium* develop resistance.

Explain how drug-resistant *Plasmodium* may evolve.

(3)

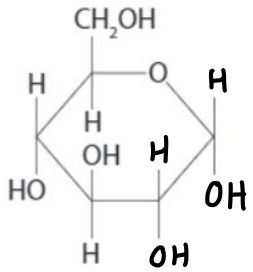
Spontaneous mutation in genes that regulate resistance to anti-malarial drugs. Genetic variation exists within *Plasmodium* species. Anti-malarial drugs serve as a selection pressure. *Plasmodium* with drug resistance have a selective advantage so survive and reproduce, passing on the drug-resistance allele to future generations.

4

Glucose and fructose are monosaccharides.

(a) Complete the diagram to show the structure of alpha glucose.

(1)



(b) The makers of sweet tasting drinks use the enzyme glucose isomerase to convert glucose into fructose.

Fructose is a monosaccharide that tastes much sweeter than glucose.

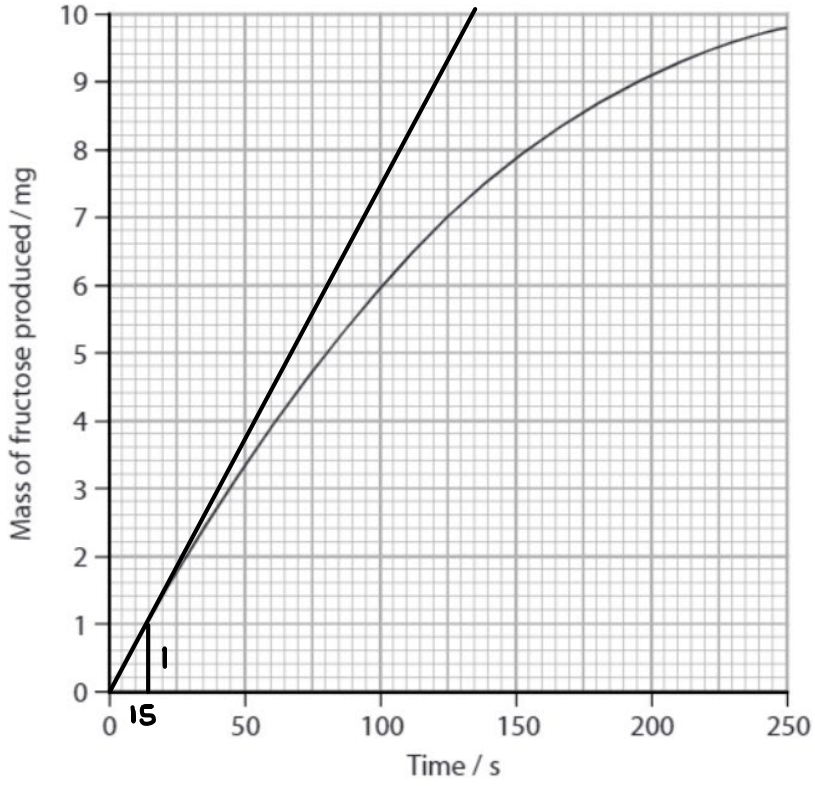
(i) Explain a possible health benefit of converting glucose into fructose for use in sweet tasting drinks.

(2)

Converting glucose into fructose means less sugar is required to produce the same sweet taste. This means the drink will contain fewer calories, reducing the risk of obesity.

(ii) A student investigated the activity of glucose isomerase.

The graph shows the results of this investigation.



Determine the initial rate of the reaction.

(1)

$\frac{1\ mg}{15\ s} = 0{\cdot}067\ mg\ s^{-1}$

Answer $0{\cdot}067\ mg\ s^{-1}$

(iii) Cofactors are non-protein molecules that help enzymes to function.

Magnesium ions act as cofactors for some enzymes.

Devise an experiment to investigate the effect of magnesium ions on the initial rate of this reaction.

(5)

Repeat the previous experiment with and without the presence of magnesium ions to determine their effect. In both experiments, ensure other variables such as temperature and pH are controlled for, for example by carrying out the experiment in a water bath and using a buffer. In each experiment, whilst using an excess of glucose and constant volume of glucose isomerase, measure the mass of fructose produced over time and determine the initial rate of reaction. Repeat both experiments at least three times to enable calculation of the mean initial rate of reactions and standard deviations.

TOTAL FOR TEST = 45 marks