Pearson Edexcel

Additional Assessment Materials
Summer 2021

# Pearson Edexcel GCE in A Level Biology

## Topic 7: Modern Genetics

(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- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.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

Both embryonic stem cells and induced pluripotent stem cells (iPS cells) can be used to create new heart cells.

Compare and contrast the properties and uses of embryonic stem cells with those of iPS cells.

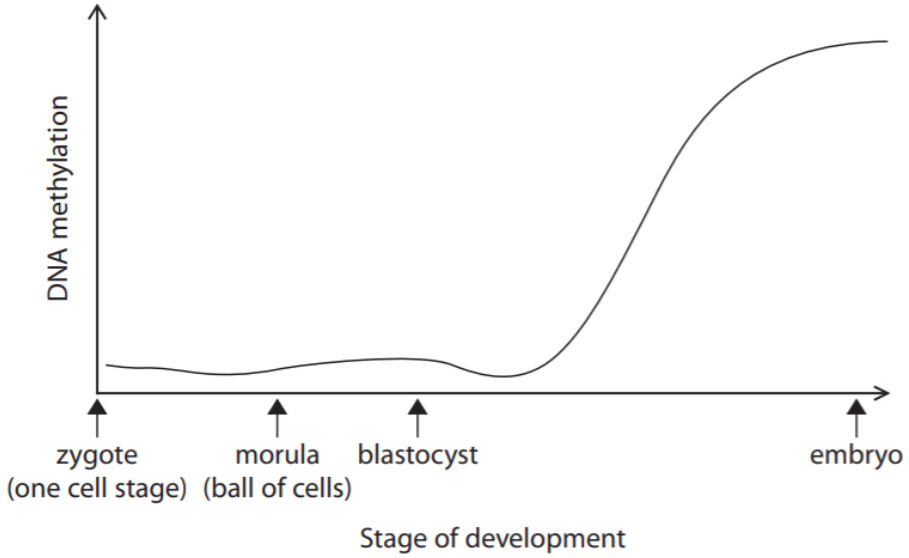
(5)

Embryonic stem cells (ESCs) are pluripotent stem cells derived from the inner cell mass of the blastocyst. In comparison, iPSCs can be derived from a range of adult somatic cell types which are reprogrammed to dedifferentiate into pluripotent stem cells. Both iPSCs and ESCs can differentiate into any cell type. However iPSCs can only differentiate into adult cells whilst ESCs differentiate into 'young' cells. The transplantation of iPSCs does not require immunosuppression as the cells are patient-specific and their use has few associated ethical issues. In comparison, ESCs are allogeneic so could potentially be rejected by the immune system. A variety of ethical issues surround the use of ESCs due to the destruction of human embryos during embryonic cell harvesting. However, other ethical issues surround stem cells (including both ESCs and iPSCs) more broadly e.g. concerns that stem cell therapies may lead to reproductive cloning of humans.

**2**

(a) Epigenetic modifications are involved in the development of an embryo.

The graph shows the changes in DNA methylation during the development of an embryo from a zygote.




(i) State the meaning of the term DNA methylation.

**(1)**

Addition of methyl groups ($-CH_3$) to cytosine bases of DNA

(ii) Describe the differences between totipotent, pluripotent and multipotent stem cells during the development of an embryo.

**(3)**

Totipotent stem cells make up the zygote and morula. They can differentiate into any cell type and can divide to form a whole organism. Pluripotent stem cells are found in the inner cell mass of the blastula. They can differentiate into any cell type and give rise to embryonic cells. Unlike totipotent stem cells they cannot give rise to the placenta. Multipotent stem cells are found in the developing embryo and can only differentiate into a limited range of cell types within a certain tissue of the body.

(iii) Analyse the graph to explain why DNA methylation is involved in the development of an embryo.

(2)

DNA methylation levels rise rapidly following the blastocyst stage of development because this is when the majority of cells differentiate and become specialised. DNA methylation decreases gene expression and switches genes 'off' by preventing transcription. Non-essential gene functions are switched off during the specialisation process.

(b) Explain why some cells are not able to become other cell types.

(2)

Once differentiation is complete, the cell is specialised. Genes switched off during the differentiation process cannot be switched back on. Thus, proteins required for the functioning of other cell types cannot be manufactured and the cell is not able to become other cell types.

**3**

Soya beans are an important crop for the production of food and oil.

(a) In the 2012 to 2013 growing season, production of soya beans was highest in the United States and second highest in Brazil.

The United States produced 93 million tonnes of soya beans from 31 million hectares.

This was 9.4% more than Brazil produced from 28 million hectares.

Calculate the difference in the yield per hectare of soya beans from these two countries.

(3)

US produced 93 million tonnes from 31 million hectares.

$\frac{93}{31} = 3$ tonnes per hectare

$\frac{93}{109.4} \times 100 = 85.00914...$

Brazil produced ~85 million tonnes from 28 million hectares.

$\frac{85.00914}{28} = 3.04$ tonnes per hectare

$3.04 - 3 = 0.04$ tonnes per hectare

Answer 0.04 tonnes

(b) Soya beans can be genetically modified to form transgenic plants.

A study of the nutritional content of soya beans from non-transgenic soya bean plants and from transgenic soya beans plants was carried out in two regions of Brazil.

The regions were Ponta Grossa and Londrina.

Tables 1 and 2 show the results of this study.

**Table 1**

| Type of plant | Region | Mean mineral content / mg per 100 g dried soya beans | | |
|---|---|---|---|---|
| | | Iron | Copper | Manganese |
| Non-transgenic | Ponta Grossa | 3.34 | 0.76 | 1.38 |
| Transgenic | Ponta Grossa | 3.44 | 0.86 | 1.40 |
| Non-transgenic | Londrina | 4.59 | 1.35 | 2.20 |
| Transgenic | Londrina | 4.15 | 1.25 | 2.02 |

**Table 2**

| Type of plant | Region | Mean organic content / mg per 100 g dried soya beans | | |
|---|---|---|---|---|
| | | Protein | Lipid | Carbohydrate |
| Non-transgenic | Ponta Grossa | 38.61 | 21.09 | 23.88 |
| Transgenic | Ponta Grossa | 38.80 | 21.19 | 23.41 |
| Non-transgenic | Londrina | 41.68 | 18.56 | 25.74 |
| Transgenic | Londrina | 40.62 | 19.87 | 25.26 |

*(i) Analyse the data to assess the nutritional content of soya beans from transgenic and from non-transgenic soya bean plants grown in these two regions.

(6)

In Ponta Grossa, transgenic soya beans have a greater mean mineral content than non-transgenic soya beans. In Londrina non-transgenic soya beans have a greater mean mineral content than transgenic soya beans. Both transgenic and non-transgenic soya beans have a higher mineral content in Londrina than Ponta Grossa. In Ponta Grossa, transgenic soya beans possess a greater protein and lipid content but lower mean carbohydrate content than non-transgenic soya beans. In Londrina, non-transgenic soya beans have a higher mean protein and carbohydrate content but a lower mean lipid content than transgenic soya beans. When comparing transgenic plants, the mean protein and carbohydrate content of those grown in Ponta Grossa is lower than that of Londrina but the lipid content is higher. When comparing non-transgenic plants, the mean protein and carbohydrate content of those grown in Ponta Grossa is again lower than that of Londrina but the lipid content is higher. Overall, these results would suggest that all soya beans grown in Londrina generally have a higher nutrional content (although lower lipid content) than soya beans grown in Ponta Grossa. In Ponta Grossa, transgenic soya beans generally have a greater nutritional value, whilst in Londrina, non-transgenic soya beans are generally more nutritious. Non-transgenic beans from Londrina are the most nutritious food source overall.

(ii) The soil in Londrina is more fertile than the soil in Ponta Grossa. Londrina has higher temperatures and rainfall during the growing season.

Explain the differences in the nutritional content of soya beans grown in these two regions.

(5)

Londrina soil is more fertile than Ponta Grossa soil. Thus, soya beans in Londrina will take up more minerals and ions (e.g. nitrates, magnesium). Nitrates are used in the production of amino acids for growth and $Mg^{2+}$ in the production of chlorophyll for photosynthesis. Thus, soya beans in Londrina will grow larger and produce more plant biomass. They therefore have a greater nutritional content. Londrina has higher temperatures during the growing season. Thus, enzymes such as RuBisCO have more kinetic energy and the rate of the Calvin cycle increases. More GP and TP are produced which can be converted into useful organic molecules such as fatty acids, amino acids, GC sugars etc. Moreover, Londrina has a greater amount of rainfall during the growing season. This increases the rate of light-dependent reactions and the transport of mineral ions throughout the plant.

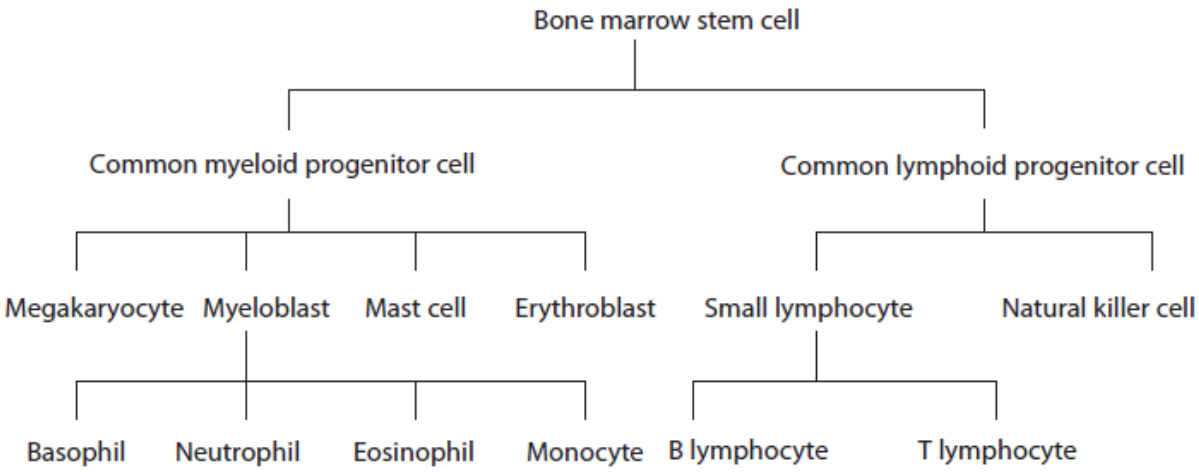
(iii) Explain why this study also analysed the types of fatty acid found in soya beans from transgenic plants and from non-transgenic plants.

(2)

To compare the proportions of different fatty acids in transgenic and non-transgenic soya beans so as to determine the health benefits of transgenic soya beans. Transgenic plants contain more oleic acid which oxidises less than linoleic acid, reducing the risk of heart disease.

4

The diagram shows some stages in the production of blood cells from bone marrow stem cells.




Explain how a bone marrow stem cell differentiates into either a common myeloid progenitor cell or a common lymphoid progenitor cell.

(4)

A mechanical or chemical stimulus (e.g. growth factor) results in the activation or 'switching on' of genes in the bone marrow stem cell. This increases gene expression and transcription. mRNA is transcribed and translated to produce specific proteins. The genes activated and subsequent proteins produced determine whether the bone marrow stem cell differentiates into a common lymphoid or myeloid progenitor cell. The expression of some genes will also be suppressed.

5

(b) Prothrombin is involved in the blood clotting process.

The *F*2 gene codes for the synthesis of prothrombin.

This gene is located from base pair 46 719 191 to base pair 46 739 504 on chromosome 11.

Determine the number of codons in this gene.

(1)

46739504 − 46719191 = 20313

20313 ÷ 3 = 6771

Answer 6771

(c) A mutation of the *F*2 gene causes thrombophilia, a condition that results in the production of excess prothrombin.

In this gene mutation, guanine is replaced with adenine.

(i) Name this type of mutation.

(1)

Substitution mutation

(ii) People without this mutation have a 1 in 1000 risk of producing a blood clot in an artery.

The mutation increases this risk by 20 times.

State the probability of producing a blood clot for people with this mutation.

(1)

0·02

(d) A genetic test can be used to find out if a person has thrombophilia.

The test involves using a restriction endonuclease to obtain genetic material from white blood cells.

This genetic material is then used in the polymerase chain reaction (PCR).

(i) State the role of a restriction endonuclease.

(1)

Enzyme that cleaves double stranded DNA into fragments at specific recognition sequences.

(ii) Describe the process of PCR.

(3)

Reaction mixture prepared by mixing DNA sample, primers, free phosphorylated nucleotides and thermostable Taq DNA polymerase. Thermocycler heated to 95°C, ke provides the energy to break hydrogen bonds between complementary bases, separating the DNA strands. Cooled to 55°C, hydrogen bonds form between primers and complementary target DNA bases. Heated to 72°C, optimum temperature for Taq DNA polymerase which joins free phosphorylated complementary nucleotides to each strand of DNA. Two copies of the initial double-stranded DNA are formed and the cycle is repeated around 30 times.

**TOTAL FOR TEST = 40 MARKS**