Cambridge International Examinations
Cambridge Pre-U Certificate

BIOLOGY (PRINCIPAL) **9790/03**

Paper 3 Case Study and Synoptic Essay **For Examination from 2016**

SPECIMEN MARK SCHEME

1 hour 45 minutes

MAXIMUM MARK: 60

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **13** printed pages and **1** blank page.

The following abbreviations may be used in mark schemes:

/	alternative and acceptable answers for the same marking point
;	separates marking points
allow/accept/A	answers that can be accepted
AVP	any valid point – marking points not listed on the mark scheme but which are worthy of credit
AW/owtte	credit alternative wording / or words to that effect
ecf	error carried forward
ignore/I	statements which are irrelevant – applies to neutral answers
not/reject/R	answers which are not worthy of credit
ORA	or reverse argument
(words)	bracketed words which are not essential to gain credit
<u>words</u>	underlined words must be present in answer to score a mark

Section A – Case Study

1 **(a)** conversion to glycogen in liver and muscle **;**
conversion to, fat / lipid / fatty acids / triglycerides in adipose tissue **;**
GLUT4 in adipose and muscle **;**
GLUT2 in liver **;**
uptake by cells for respiration by, all cells due to GLUT1 / small intestine due to GLUT2 / neurones due to GLUT3 / nephrons/kidney, due to GLUT2 and SGLT **;** [max 3]

(b) lipid bilayer with heads and tails correctly orientated **;**
labelled, lipids / fatty acids and glycerol / phosphoglycerides **;**
transporter molecule passing through the bilayer **;**
labelled appropriately **;**
must be drawn as a channel protein [4]

(c) liver cells facilitated diffusion and PCT cells active transport **;**
active transport against concentration gradient and facilitated diffusion with the gradient **;**
active transport requires, respiratory / metabolic energy, ATP, whereas facilitated diffusion does not **;**
(in the case of SGLT / secondary active transport) the ATP / metabolic energy pumps creates the sodium gradient which causes the glucose molecules to move passively **;**
(in the case of SGLT) re-absorption of glucose from the proximal tubule is against a steep diffusion gradient / needs to take place quickly as filtrate is passing rapidly along the nephron **;** [max 3]

(d) **(i)** by exocytosis / vesicles fuse with (cell surface) membrane **;** [1]

(ii) still some permeability due to GLUT1 **;** [1]

[Total: 12]

2 **(a)** more glucose is produced by a starving person with type 2 diabetes than by a person without the condition / AW ;
perhaps because the diabetic is less able to regulate the blood sugar concentration / at a more advanced stage of starvation / reduced fat reserves ;
in type 2 diabetes, the main source/a greater proportion (of glucose), is from gluconeogenesis ;
gluconeogenesis is the production of glucose from amino acids / proteins ;
relatively small amount from glycogen as almost used up (by this stage) ;
less from glycogen with type 2 diabetes ;
as less to start with ;
correct reference to statistical significance in discussion of data ;
correct explanation of $p < 0.05$;
reference to ± as (possibly), variation / standard deviation / standard error / indication of good agreement within replicates ; [max 6]

(b) one would expect glucose to be used up in respiration in the kidney ;
many mitochondria / high rates of respiration in kidney ;
providing ATP for sodium-potassium pumps ;
ref to, selective reabsorption / active transport ;
lack of difference could be due to, gluconeogenesis / amino acids converted to glucose ;
could be a great deal of gluconeogenesis in kidney / gluconeogenesis must be, equal to kidneys' glucose consumption through respiration ; [max 4]

[Total: 10]

3 insulin secreting cells are only found in, pancreas / islets of Langerhans ;
reference to β cells as the source of insulin ;
use stem cells to replace, dysfunctional β cells / insulin-producing cells ;
so stem cells would only need to be introduced into a specific part of the body ;
whereas (in the case of type 2) cells all over the body are dysfunctional ;
and so cannot be replaced / much more difficult to replace them all ;
use of stem cells may be preferable to transplants as less invasive / fewer side-effects / no need to wait for suitable donor ;
use of patients own adult stem cells (instead of transplants or embryonic stem cells) avoids immunological rejection / need for immunosuppressant drugs ;
use of adult rather than embryonic stem cells avoids ethical issues about sourcing ;
in (advanced cases) of type 2 diabetic patients where pancreas is deteriorating β cell transplant may be of benefit but not a complete solution ;
need to understand more about what causes type 2 ; [max 8]

[Total: 8]

Section B – Synoptic Essay

Marking Strategy

Sequence of marker activities for each essay:

1. Familiarise yourself with the expected content.

2. Read through the essay.

3. Write marginal notes on script, highlight evidence of breadth, background reading, exemplification and argumentation as well as major and minor errors of fact and irrelevant material.

4. Apply the general descriptions for

- Breadth (B)
- Argumentation (A)
- Communication (C)
- Spelling, punctuation and grammar (S).

5. Match the content of the essay with the highest descriptor for Scientific Content (SC) that is fully satisfied. This represents the lowest mark that could be awarded. Then consider the next descriptor above this and, where appropriate, award intermediate marks in proportion to the degree to which this descriptor has been partially matched.

Marks should be written at the end of the essay as follows:

B = ……
A = ……
C = ……
S = ……
SC = ……
Total = ……

Breadth **Maximum 3 marks**

Mark		Descriptors
		Candidate has:
3		given a balanced account including most of the relevant topic areas and selected a wide range of facts, principles, concepts and/or examples pertinent to the title
2		given a fairly balanced account including some of the relevant topic areas and selected many of the appropriate facts, principles, concepts and/or examples pertinent to the title
1		given an account including a few of the relevant topic areas and selected some of the appropriate facts, principles, concepts and/or examples pertinent to the title
0		given an account that relies on one topic area alone and selected only a few of the appropriate facts, principles, concepts and/or examples pertinent to the title

Argumentation **Maximum 3 marks**

Mark		Descriptors
		Candidate has:
3		developed and sustained a coherent argument throughout the essay leading to an appropriate conclusion showing insight
2		introduced an argument and partially developed it, so that some coherence is shown in the essay
1		shown evidence of an argument, with little development
0		shown no evidence of argumentation

Communication **Maximum 2 marks**

Mark		Descriptors
		Candidate has**:**
2		organised and presented information clearly and used correct terminology in appropriate contexts
1		attempted to organise material and use some correct terminology, so that with re-reading the meaning becomes apparent
0		presented an unstructured answer with poor use of terminology

Spelling, punctuation and grammar **Maximum 2 marks**

Mark		Descriptors
		Candidate has**:**
2		used spelling, punctuation and grammar accurately, with no more than very few errors
1		generally used spelling, punctuation and grammar accurately, but has made a number of significant errors
0		not used spelling, punctuation and grammar accurately

Scientific Content **Maximum 20 marks**

Mark		Descriptors
		The candidate**:**
20		• recalls and consistently uses all facts and principles (relevant to the essay); • shows sound understanding of all principles and concepts; • writes accurately with no major errors and very few minor errors; • gives comprehensive detail expected from the relevant learning outcomes, with evidence of relevant reading around the subject.
16		• recalls and consistently uses most facts and principles (relevant to the essay); • shows sound understanding of most principles and concepts; • writes accurately with no major errors and few minor errors; • gives full detail expected from the relevant learning outcomes.
12		• recalls and consistently uses some facts and principles (relevant to the essay); • shows sound understanding of some principles and concepts; • writes some material accurately with not more than one major error and some minor errors; • gives most detail expected from the relevant learning outcomes.
8		• recalls some facts and principles (relevant to the essay); • shows some understanding of some principles and concepts; • writes some material accurately with more than one major error or many minor errors; • gives some detail expected from the relevant learning outcomes.
4		• recalls a few facts and principles (relevant to the essay); • shows limited understanding of a few principles and concepts; • writes material that includes many errors, some of which may be major errors; • gives little detail expected from the relevant learning outcomes.
0		• recalls no relevant facts and principles; • shows no understanding of relevant principles and concepts; • writes irrelevant material or includes many major errors; • gives no detail expected from the relevant learning outcomes.

Expected content

For each of the questions, guidance is given as to the kind of content from the syllabus that may be appropriate to answering the question. Some candidates will include all of these areas and others may write in more detail about these or may include other relevant topics, in each case reflecting the candidate's reading-around the subject and personal research and other interests. Some topics, both in the candidates' answers and in the following expected content, may not be directly on the syllabus, but it is important to credit such responses where they are given and thus they are included here.

4 'There is no evolutionary advantage in being multicellular'.

Discuss this view.

Candidates should discuss both points of view implicit in the question drawing on examples across the range of organisms studied. As much emphasis should be put on the biology of unicellular / acellular organisms as that of multicellular. An essay devoted almost entirely to animals, specifically mammals or humans is unbalanced and will not score well. Candidates should have studied several species of unicellular protoctist so should be able to draw on their own observations.

The following syllabus sections are most directly relevant: 1.1, 1.2, 2.1, 2.3, 3.1, 5.1.

specified range of multicellular organisms to include animals, plants, many fungi, some protoctists e.g. some algae

specified range of acellular / unicellular organisms to include prokaryotes / bacteria, some protoctists / fungi, e.g. yeasts

prokaryotes evolved, first / about 3500 million years ago

discussion of meaning of evolutionary advantage / more likely to survive / more successful / abundant / long-lasting / diverse

could argue that prokaryotes / unicells are more successful

(perhaps) greater biomass than eukaryotes / multicellular organisms

greater numbers / more ubiquitous / AW

still present and successful (after 3500 million years)

(perhaps) more likely to survive natural disasters / survive in wider range/extremes of physical conditions

great diversity of types of metabolism amongst prokaryotes / unicells

some prokaryotes can both photosynthesise and fix nitrogen / ref unicells forming symbioses with fungi as lichens and their even greater success in these associations

all multicellular organisms are eukaryotes

ref eukaryotic cells being symbiotic unions of previously separate cells / endosymbiosis

(perhaps) suggesting symbiotic unions superior to prokaryotes

ref structural diversity of multicellular organisms / complexity / variety of behaviour

ref to advantages of division of labour between organs / specialised cells

ref to the greater potential of division of labour / specialisation

discussion with respect to evolution

evolutionary dogma is that fitness to survive increases with natural selection

therefore most recently evolved life forms should be superior

this is a flawed argument because natural selection operates on all species all the time

therefore current life forms have equal status in terms of success / can only judge on basis of future possibilities

could consider further the particular example of humans

humans have more control over environment than any other organism

they are a product of an evolutionary trend towards greater complexity

perhaps control over environment may be greater evolutionary advantage than adaptation to change

5 All living organisms need to synthesise ATP. Explain the similarities and differences between organisms in the ways in which this is achieved.

Candidates should avoid lengthy descriptions of respiration and photosynthesis but should attempt to highlight underlying similarities and differences in whatever it is they are comparing.

Comparisons can be made between production of ATP in glycolysis and Krebs cycle by substrate-linked phosphorylation and production in chloroplasts and mitochondria by chemiosmosis.

Further points can be made by considering chemiosmosis in prokaryotes. Wider consideration can be included by discussing energy sources in different forms of nutrition.

The following syllabus sections are most directly relevant: 1.1, 1.5, 2.2, 4.2.

chemotrophs and phototrophs

source of energy to make ATP may be chemical (chemotrophs) or light (phototrophs)

all animals, fungi and most bacteria are chemotrophic

all plants, algae and some bacteria are phototrophic

most phototrophs are photosynthetic, using carbon dioxide as a source of carbon

aerobic and anaerobic respiration

all organisms / cells make ATP as a result of respiration

respiration is oxidation of a chemical to release energy which is used to make ATP

in aerobic respiration oxygen is final electron acceptor, not in anaerobic

a few bacteria are obligate anaerobes, but most organisms can do both

anaerobic is less efficient than aerobic in terms of ATP per molecule of glucose, but can be more rapid and is a useful supplement when ATP becomes limiting, e.g. when oxygen shortage

main pathways of aerobic common to all aerobic cells/organisms (glycolysis and Krebs)

if respiration is anaerobic only glycolysis occurs, not Krebs

dehydrogenation and transfer of hydrogen to coenzyme NAD

substrate-linked phosphorylation, described

oxidative phosphorylation occurs in aerobic (electron transport linked to synthesis of ATP)

hydrogen oxidised to water using oxygen in respiratory chain to release much energy

role of hydrogen carriers and respiratory chain

ref to numbers of ATP per reduced NAD and per reduced FAD

total ATP per glucose for aerobic – accept answers within range 30 to 38 per molecule of glucose

only 2 ATP per molecule of glucose for anaerobic

requires membranes / mitochondria

prokaryotes do not have mitochondria – use plasma membrane

description of chemiosmosis including role of ATP synthase

glucose not only source of energy – many other carbohydrates, as well as fats (triglycerides) and amino acids / proteins can be used

enzymes convert these to intermediates which can feed into common pathways of glycolysis and Krebs

anaerobic respiration in fungi (yeast), plants and animals (and bacteria)

reduced NAD recycled so glycolysis not prevented (by end product inhibition)

pyruvate to lactate in animals

pyruvate to ethanal to ethanol in yeast and plants

some anaerobic bacteria use an inorganic molecule as a final electron acceptor, e.g. Archaea use carbon dioxide to make methane, *Desulfovibrio* uses sulfate to make hydrogen sulfide, *Escherichia coli* uses nitrate to make nitrite.

anaerobic respiration in microbes

a form of anaerobic respiration in microorganisms in which an organic molecule is the final electron acceptor

e.g. pyruvate to lactate (e.g. *Streptococcus lactis*)

e.g. pyruvate to ethanol (ethanal is electron acceptor), e.g. yeast

bacteria very versatile – many different fermentation products

aerobic respiration in prokaryotes / chemoautotrophs (vs chemoheterotrophs)

inorganic molecules sometimes used as electron acceptors by prokaryotes e.g. chemoautotrophic bacteria (chemosynthesis)

e.g. nitrifying bacteria – energy from oxidation of inorganic substances during respiration (ammonia and nitrite)

ammonium → *Nitrosomonas* → nitrite + ATP → *Nitrobacter* → nitrate + ATP

ref to the nitrogen cycle

also *Rhizobium*, *Sulfolobus*, some sulfur bacteria, deep sea hydrothermal vents, methanogens (Archaebacteria)

photosynthesis

ATP manufacture as a result of aerobic respiration and light-dependent reactions of photosynthesis. Harnessing energy from electron flow / redox reactions on membranes in specialised organelles and requires a hydrogen (electron) donor (e.g. glucose, water, hydrogen sulfide).

ATP also made during light-dependent reactions of photosynthesis

underlying similarity with respiration is that ATP made on membranes in specialised organelle by process of chemiosmosis as a result of electron flow from electron donor to electron acceptor

organelle = chloroplast

thylakoids equivalent to cristae

energy source is light (not oxidation of chemicals) – photophosphorylation

water = electron donor to PSII (electron donor usually organic molecule in respiration)

cyclic and non-cyclic photophosphorylation

in cyclic, PSI (chlorophyll) is electron donor and acceptor

final electron acceptor for non-cyclic is NADP (compare NAD in respiration)

prokaryotes, algae, C3 and C4 plants

photosynthetic bacteria do not have chloroplasts but do have membranes, e.g. blue green bacteria

algae have simpler membrane systems than plants (no true grana)

C4 plants have larger grana than C3 plants for more efficient use of light energy

more ATP needed to drive photosynthesis than C3 plants

photoheterotrophs

photoheterotrophs a special case – organic source of carbon but use light as source of energy

e.g. ocean planktonic bacteria

6 Why do people get heart disease and what should be done about it?

Answers should be divided between discussion of risk factors for heart disease and ways in which the community (governments, health authorities, etc.) and individuals can reduce incidence / prevalence of heart disease and the methods of treatment for those with the disease.

The following syllabus section is most directly relevant: 3.1.

risk factors for heart disease

e.g. age, ethnicity, sex (males), heredity, smoking, lack of exercise, diet, obesity, diabetes, high blood pressure

heart disease and its aetiology

coronary heart disease

description of supply of oxygenated blood to heart by coronary arteries

damage to coronary arteries, e.g. by high blood pressure

role of LDLs in transporting fatty acids and cholesterol to organs

LDLs accumulate in wall of coronary artery lead to plaque

atheroma / atherosclerosis

occlusion of lumen / blood flow becomes uneven / plaque bursts

increased chance of blood clotting in artery

ref to angina / heart attack

HDLs transport cholesterol to liver

reduce chances of plaque developing

explanation of effects of risk factors

oestrogen provides protection

heredity, e.g. familial hypercholesterolaemia **;** platelet glycoprotein receptor gene involved in blood clotting **;** apolipoprotein E (APOE) involved in lipoprotein particles

treatments

inserting stents

angioplasty

coronary by-pass surgery

heart transplants

discussion of pros and cons of different treatments

preventive medicine

screen for those at risk

discussion of thresholds for determining people who need intervention to reduce risk

intervention could be determined by individual (e.g. diet, weight loss, etc.) or a medical intervention, such as drug treatment

statins to lower blood cholesterol concentrations

ref to mode of action: inhibit the enzyme HMG-CoA reductase involved in production of cholesterol in liver

warfarin used as an anticoagulant

ref to mode of action: vitamin K antagonist (inhibits enzyme that recycles oxidised vitamin K to its reduced form after it has participated in the carboxylation of e.g. prothrombin and factor VII)

β blockers to reduce blood pressure

ref to mode of action: block receptor sites for adrenaline and noradrenaline in heart

ref to control of the heart by sympathetic nervous system and endocrine system

actions that can be taken by individuals to reduce risk

improve diet, reduce weight, have regular check-ups, take exercise, stop smoking

actions that can be taken by community to reduce incidence / prevalence of heart disease

idea that prevention is cheaper than treatment, but untargeted programmes are often not cost effective

provide information to, those at risk / whole population

provide facilities for people to take exercise

advertise about dangers of choices that put people at risk, e.g. smoking

provide funding for drug treatments, e.g. statins

fund research to evaluate effectiveness of different preventative measures

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