CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge Pre-U Certificate

MARK SCHEME for the May/June 2015 series

9790 BIOLOGY

9790/02 Paper 2 (Long Answer), maximum raw mark 120

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Notes:

The following abbreviations may be used in mark schemes:

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

Section A

1 (a) (i) podocytes ; **[1]**

(ii) 1 carrying blood under higher pressure / ORA ;
2 to, prevent rupture / AW ; **A** to resist the (high) pressure
[2]

(b) (i) 1 the water, sodium ions, urea and glucose in the plasma move, into the filtrate freely / into the Bowman's capsule ;
2 none of the albumin leaves the plasma (into the filtrate) ;
3 only molecules below a certain size / radius are able to pass from **A** to **B** ;
4 a filtrate / plasma ratio of 1.0 means that the concentrations of the substance concerned in the plasma and in the filtrate are equal / the same ;
5 use of figures to quantify the radius ; e.g. < 0.36 nm all pass through ;
6 molecules at and below 1.48 nm can pass ;
7 1.48 nm may be close to the threshold size / AW ;
8 (because) most / not all, of the inulin passes through ;
9 basement membrane (of endothelial cells) determines maximum size of, molecule / ion, that can pass through ;
10 pore size of endothelial cells ;
[max 5]

(ii) 1 <u>all</u> of the glucose is reabsorbed ;
2 some sodium ions are reabsorbed ;
3 site of reabsorption (of sodium ions / glucose) in nephrons identified correctly ;
4 water and salt, loss / reabsorption, depends on, hormones / sweating / environmental temperature ;
5 water is reabsorbed therefore final concentration of urea looks high ;
6 urea variability (in blood) due to rate of, production of urea / deamination ;
[max 4]

(c) (i) 1 inulin is not metabolised (within the body) ;
2 (almost) all the inulin passes from the blood plasma (into the glomerular space) ;
3 inulin is not reabsorbed (in the nephrons) ;
[max 2]

(ii) to allow time for the inulin to become evenly dispersed in the blood / AW ; **[1]**

(iii) 12.6 $cm^3 min^{-1}$; ; **[2]**

if no answer or incorrect answer, allow 1 mark for correct working or correct evaluation of urine formation rate

GFR = $3.5 \times 0.9 / 0.25$

urine formation rate = $54 / 60 = 0.9$ ($cm^3 min^{-1}$)

[2]

(d) *answers may be expressed in terms of water potential*

1 description of relationship above normal range ;
2 description of relationship below normal range ;
3 increase in solute concentration detected by, osmoreceptors / hypothalamus ;
4 posterior pituitary releases ADH ;
5 as blood solute concentration increases, ADH secretion increases ;

6 sensation of thirst increases with increasing plasma solute concentration ;
7 stimulation of drinking to restore plasma solute concentration ;
A drinking, water / fluids, decreases blood solute concentration ;
8 hypothalamus stimulates, cerebrum / AW ;

9 both mechanisms act as negative feedback ;
10 (blood solute concentration), returns to set point / fluctuates within normal limits ;

effects of ADH
11 ADH causes, more water to be reabsorbed, in DCT / collecting duct (of nephron) ;
12 due to addition of aquaporins to tubule cell membranes ;

[max 6]

[Total: 23]

2 (a) stimulates maturation of B-cells into, plasma cells / memory B-cells, / activation of cytotoxic-T cells ;
activates, macrophages / phagocytes ;
activated by antigen-presenting cells (APCs) ;
(once activated) divide rapidly and secrete small proteins called cytokines ;

[max 2]

(b) the range within which there is a 95% probability that the true value of the mean lies ; ;

for incomplete explanations, allow 1 mark for:
95% confidence interval = 1.96 / 2, × SE ;
assuming normal distribution ;
calculated above and below sample mean ;

[max 2]

(c) 1 HAART correlates with an increase in helper-T cells ;
2 HAART correlates with combined AIDS and death rate ;
3 smaller percentage of patients have <50 cells μl^{-1}
or
increasing and decreasing percentage of patients have 51–200 cells μl^{-1}
or
larger percentage of people with > 200 cells μl^{-1} ;
4 the patients with the lowest helper-T cell counts respond particularly quickly ;
5 suggestion trend might be tending to plateau after 5–6 years
6 (which will) alleviate the susceptibility to secondary infections / cancers (that are often a feature of AIDS) ;
7 example of above ; e.g. pneumonia / Kaposi's sarcoma
8 cell count still increasing at end of investigation ;
9 no information about normal range of helper-T cells ;
10 lower graph does not distinguish between AIDS and deaths ;
11 data is from a large sample from 70 countries therefore adds to validity of conclusions ;
12 comparative use of figures or manipulation of data ;
e.g. median cell count more than doubles in 7 years
any reasonable attempt at percentage change ;
13 use of the error bars to comment on differences between figures for combined AIDS and death rate ;
14 no data on a group not receiving HAART ;

[max 6]

(d) 1 RNA is genetic material of HIV ;
2 RNA to (c)DNA through action of reverse transcriptase ;
3 NtARTi drugs act as competitive inhibitors of reverse transcriptase ;
4 NtARTi drugs resemble substrates of reverse transcriptase ;
5 NtARTi drugs occupy active site ;
6 so next nucleotide cannot join growing DNA molecule ;

[max 5]

[Total: 15]

3 Planning Task

P defining the problem

P1 hypothesis or prediction **;**
any hypothesis that can be supported by valid reasoning
e.g. the temperature optimum for respiration of arctic ground beetles will be lower than that of violet ground beetles

P2 theory to support hypothesis or prediction **; ;**
+
P3

P4 outline strategy **; ;**
+ e.g. determine rate of, respiration / oxygen consumption, at a (specified) range of
P5 temperatures with each type of beetle

P6 at least two types of variable identified, with examples **; ;**
+ *one mark for:*
P7 independent variable = temperature / type of beetle
dependent variable = rate of oxygen uptake
one mark for at least two controlled variables:
e.g. initial pressure / need to equilibrate initial pressure
constant, volume / mass, of soda lime pellets
same starting point on capillary tube
same beetles / same mass of beetles

P8 risk assessment **;**
hazard **and** precaution

[max 6]

3 Planning Task (continued)

M methods

preparation:
M1 describe preparation of soda lime in muslin bag ;
M2 reference to need to keep beetles out of contact with soda lime ;
M3 need to equilibrate internal / external pressure, by leaving tap open ;

controlling variables:
M4 use of water-bath and beaker of iced water to control temperature ;
M5 suggested range of at least 5 temperatures evenly spaced over a suitable range of at least 20 °C, but not in excess of 50 °C ;
M6 use of thermometer to check actual temperature of iced water / to check accuracy of thermostatic-control of water-bath ;
M7 allow time for temperature in apparatus to reach desired temperature ;

taking the first reading:
M8 close tap at time zero ;
M9 measure distance moved by indicator drop in standard time / time for drop to move standard distance ;
M10 calculate volume of oxygen uptake ;
M11 measure mass of beetles ;
M12 calculate rate of oxygen uptake per gram ;

repeat readings:
M13 need to return drop in capillary tube back to zero by opening tap and using syringe ;
M14 repeat at specified number of times (at least three) at each temperature ;
M15 repeat using a suitable control ; e.g. glass beads / dead beetles
M16 inert material must have the same volume as the beetles ;
M17 repeat whole experiment with other species of beetle ;

[max 10]

A analysis

A1 design a table to record results ; e.g. distance moved
A2 calculate rate as distance moved / time ;
A3 calculate, mean / median, rate of respiration from replicates at each temperature ;
A4 calculate, standard deviation / standard error ;
A5 ref. to reproducibility / variation in results ;
A6 draw graph with temperature on *x*-axis and rate of respiration on *y*-axis (**A** line or bar) ;
A7 error bars on graph based on σ / σ^2 / SE / 95%CI ;
A8 statistical comparison in terms of over-lapping error bars or *t*-test / Mann-Whitney U test / analysis of variance ;
A9 justification for this type of test ;
A10 statement of null hypothesis ;

[max 6]

[Total: 22]

Section B

4 (a) (i) *genotype(s):*
(all) BbYy,
phenotype(s):
(all) brown and banded ; **[1]**

(ii)

	BY	By	bY	by
by	BbYy	Bbyy	bbYy	bbyy
	banded brown	banded yellow	unbanded brown	unbanded yellow

gametes all correct ;
genotypes all correct ;
phenotypes correctly indicated ;
[3]

(iii) total number of snails divided by 4 / total progeny divided, into 4 equal parts / into 1 : 1 : 1 : 1 ratio ; **[1]**

(b) 1 reference to three degrees of freedom ;
2 chi-squared value is greater than chosen critical value, i.e. at 0.05 / 0.01 / 0.001 ;
3 difference between observed and expected is (statistically) significant ;
4 reject null hypothesis / results do not agree with expected ratio ;
5 explanation in terms of probability ;
e.g. the probability of, actual / observed, result approximating to a 1 : 1 : 1 : 1 ratio is less than, 0.05 / 0.01 / 0.001 ;
[max 4]

(c) 1 the genes for banding and colour are linked ;
2 genes on same chromosome ;
3 independent assortment not taking place ;
4 Yb / brown unbanded / yB / yellow banded, on same chromosome ;
5 crossing over in context ;
6 recombination result of chiasmata formation ;
7 By / brown banded / y / B / yellow unbanded, recombinants ;
8 the less the recombination rate the closer the genes / the B and Y genes are 28 mapping units apart ;
9 use of data in Table 4.1 in support of explanation ;
[max 4]

[Total: 13]

5 1 both types of snail absorb heat ;
2 dark-coloured snails warm up faster ;
3 dark-coloured snails reach a higher temperature ;
4 use of figures ;
e.g. after (approximately) 12 minutes exposure to sunlight the (internal) temperature of dark-coloured snails increased from (approximately) 26 °C to 38.5 °C whereas (in the same period of exposure) that of the light-coloured snails increased by (approximately) 36 °C
5 link between, warming up / body temperature, and activity ;
6 dark-coloured snails can start to feed earlier ;
7 this is a selective advantage ;
8 ref. to difference (between data sets) being significant ;
e.g. difference not explained by, chance / probability, of difference being due to chance less than 0.05 / a large enough sample to demonstrate a difference
9 dangers of feeding for longer / more chance of predation ;

[max 5]

[Total: 5]

6 (a) (i) 1 yellow snails are more common in open grassland habitats than in woodland (than brown and / or pink) / a larger proportion of snails in woodland tend to be brown or pink (rather than yellow) than in open habitats / ORA ;
2 unbanded snails are more common in woodland habitats than in open grassland / a larger proportion of snails in woodland tend to be unbanded than in open habitats / ORA ;
3 comment on overlap / appropriate use of figures ;

[max 2]

(ii) 1 yellow phenotype is an advantage ;
2 selection occurs ;
3 increase in frequency of the recessive allele ;

4 founder effect / described ;
5 non-random mating / genetic drift (in small populations) ;

[max 2]

(b) (i) 1 *comment on at least two of the colours*
brown decreases, yellow increases, pink slight decrease ;
2 banded increases / unbanded decreases ;

[max 2]

(ii) 1 trees removed ;
2 replaced by, grassland / low vegetation ;
3 increased temperature / ref. to global warming ;
4 AVP ; e.g. different species of tree planted

[max 2]

(c) 1 variety of / changes in, habitats / niches / microclimates ;
2 example of, environmental change / different habitats ;
3 different morphs show different adaptations ;
4 different predators in different habitats / changes in predators over time ;
5 different competitors / change in competition ;
6 different / change in, selection pressures ;
7 limited gene flow between populations ;
8 no reproductive isolation ;
9 no speciation ;

[max 4]

[Total: 12]

Section C

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, 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 a descriptor for Scientific Content (SC) (20, 16,12, 8, 4 or 0, as appropriate) and then decide whether:

- all sub-descriptors at that level have been met, together with some sub-descriptors at the level above, so that intermediate marks at the next level can be awarded
- all sub-descriptors at that level have been met, with no evidence of meeting sub-descriptors at the level above, so that full marks for that level can be awarded
- not all sub-descriptors at that level have been met so intermediate marks at that level can be awarded.

6 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 some 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 a few 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 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 but has not sustained it coherently throughout the essay.
1	shown evidence of an argument, but has not developed it successfully.
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	not organised material very well and not used terminology appropriately so that answer has to be re-read.
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.
1	used spelling, punctuation and grammar accurately, but has made significant errors.
0	not used spelling, punctuation and grammar accurately.

Scientific Content **Maximum 20 marks**

Mark		Descriptors
		The candidate**:**
20	a	recalls and consistently uses all facts and principles (relevant to the essay)
	b	shows sound understanding of all principles and concepts
	c	writes accurately with no major errors, very few minor errors
	d	gives detail fully in keeping with that expected of candidates at the end of a programme of study designed to prepare candidates for university.
16	a	recalls and consistently uses most facts and principles (relevant to the essay)
	b	shows sound understanding of most principles and concepts
	c	writes accurately with no major errors and few minor errors
	d	gives detail fully in keeping with that expected of candidates at the end of a programme of study designed to prepare candidates for university.
12	a	recalls and consistently uses some facts and principles (relevant to the essay)
	b	shows sound understanding of some principles and concepts
	c	writes some material accurately with not more than one major error and some minor errors
	d	gives detail fully in keeping with that expected of candidates at the end of a programme of study designed to prepare candidates for university.
8	a	recalls some facts and principles (relevant to the essay)
	b	shows some understanding of some principles and concepts
	c	writes some material accurately with more than one major error or many minor errors
	d	gives some detail appropriate for that expected of candidates at the end of a programme of study designed to prepare candidates for university.
4	a	recalls a few facts and principles (relevant to the essay)
	b	shows limited understanding of a few principles and concepts
	c	writes material including many errors, some of which may be major errors
	d	gives a little detail appropriate for that expected of candidates at the end of a programme of study designed to prepare candidates for university.
0	a	recalls no relevant facts and principles
	b	shows no understanding of relevant principles and concepts
	c	writes irrelevant material or includes many major errors
	d	gives no detail appropriate for that expected of candidates at the end of a programme of study designed to prepare candidates for university.

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 some of these or may include other relevant topics, in each case reflecting the candidate's reading around the subject, personal research and other interests. Some topics in the candidate's answers 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.

The main points that may be considered as the scientific content for each essay are listed below.

7 Contrast the phylogenetic (or cladistic) system with the phenetic system of classification of living organisms, and discuss to what extent each is useful to the study of biology and its practical application.

Learning outcomes: 1.7(d), 2.3(b), 2.4(a), (b), (c), (d), (e) and (f)

May also draw on examples from throughout the syllabus including, for example, 1.1(c), 1.2, 1.3(a), 1.5(a), 2.2(g).

A good essay / balanced essay with argumentation would explore:

- what is meant by the two terms with examples of each
- the usefulness of each to biological study generally (contrasting ecological fieldwork needs with the goal of taxonomy to produce a complete tree of life for all organisms perhaps)
- particular applications to Biology in fields such as medicine, agriculture and biotechnology.

Define phylogenetic approach in terms of evolutionary relationships as a 'natural system'.
Examples of features common to all living organisms that emphasise idea of common ancestry, e.g. DNA structure, method of DNA replication and genetic code, phospholipid bilayer in membranes, ATP in energy conversion and enzymes as biological catalysts.
Features which differentiate major groups, e.g. cell wall in plants and fungi but not in animals.

A natural group may include a lot of diversity but certain key features are shared, e.g. backbone of vertebrae, pentadactyl limb and dorsal nerve cord of vertebrates.

Vestigial organs, e.g. splint bone of horse can be explained in terms of phylogenetic approach.
Convergent evolution may explain apparent anomalies, e.g. similarities of eye of octopus and of vertebrate, or shape of whale and fish.
Cladistics determines proximity of related species in terms of the smallest possible number of changes from common ancestor.

Hierarchical nature of classification based on evolution, e.g. seven major taxonomic groups from kingdom to species.
Species correctly placed in phylogenetic groups are likely to share further physiological similarities as yet undiscovered.
Similarity of mammals, e.g. rats, mice and humans, explains usefulness of rats and mice for testing new pharmaceutical products for humans. Primates particularly useful as most closely related (some ethical issues against this may also be based on phylogenetics).

Define phenetic approach, compare and contrast it with phylogenetic approach.
Contexts where phenetic approach offers advantages over the phylogenetic approach. Cladistic approach may make practical identification, e.g. of commercially important agricultural pests, difficult and a more utilitarian approach based on phenetics may be more straightforward. E.g. *fungi imperfecti* are very serious agricultural pests that need to be identified. However, they are not known to manifest the sexual stages that form the basis of a phylogenetic approach to

identification. Similarly, grasses are normally identified phylogenetically by their flowers but a more phenetic key may be used to identify non-flowering (vegetative) specimens.

The species concept is partly phylogenetic as, despite variation within a species, all interbreed and produce fertile offspring and so share very recent common ancestors.
However there can be grey areas (especially in plants) and so dividing lines between very similar species can be a human construct that draws on phenetic approach.

Phylogenetics is often used together with molecular data, including DNA and protein sequence similarity, and analysis is facilitated by use of computers.
DNA sequencing in the context of cladistics [1.7 (j)].

8 Summarise how cells produce ATP and discuss why life would be impossible without ATP.

Learning outcomes: 1.1 (g), 1.3 (a), 1.5 (a), (b) and (f), 1.6 (c), 3.3 (j), 4.2 (a), (e) and (f)

A good essay / balanced essay with argumentation would explore:

- ATP structure
- how cells produce ATP, including:
  substrate level phosphorylation in respiration
  oxidative phosphorylation in respiration
  photophosphorylation in photosynthesis
  an example of prokaryotic chemiosmosis
- key areas of argumentation, especially why life would be impossible without ATP.

Individual points that might be included:
Description of the ATP molecule.
ATP as a temporary energy storage ATP $\Longleftrightarrow$ ADP + phosphate.

Outline of chemiosmosis / electron transport system.
In respiration, the electrons come from oxidation reactions when substrates like glucose are broken down to either pyruvate or CO_2.

Only a brief summary of glycolysis and the Krebs Cycle is needed, emphasising a series of reactions some of which are oxidative and lead to production of reduced NAD with only limited substrate level ATP synthesis.

Most of the ATP comes from the electron transport system in the inner mitochondrial membrane.
Comparison of yield of ATP from anaerobic versus aerobic respiration.

ATP and energy storage.
Energy can be stored as lipid and polysaccharide carbohydrate (glycogen in animals, starch in plants). ATP provides energy to build up lipids and polysaccharides. This is energy made available when the lipid and polysaccharides break down and feed into the Krebs Cycle releasing ATP again.

ATP in photosynthesis.
How ATP is produced in the light dependent reaction through electron transport.
Role of photosynthetic pigments.
Enough detail of Calvin Cycle to show how ATP drives the key which maintains continued CO_2 fixation

Examples of use of ATP and how life would be impossible without it.

ATP makes an important contribution to an efficient energy conversion through respiration, e.g. muscle action is about 42% energy efficient (compared with diesel engine of 20%) and enables efficient energy conversion at environmental temperature. Without this efficient energy transfer organisms could not get enough energy to maintain life without over-heating and denaturing proteins / enzymes.

Without ATP, photosynthesis would not take place and so plants would not grow and animals would have no food since all organic matter is derived ultimately through photosynthesis (through food chains).

Muscle contraction: role of ATP in sliding filament theory.

ATP: without it animals would be unable to move (other than extremely slowly – when in fact many mammals can run at high speeds) to, find / catch, food and to escape from, predators / harm, or to migrate to cope with seasonal environmental change.

Anabolic chemical reactions which maintain life of cells, e.g. DNA replication and protein biosynthesis. Without ATP, organisms would not be able to grow, reproduce or maintain themselves. Reference to substances which need to be continually replaced, e.g. skin cells, enzymes and hormones.
As well as providing energy for synthesis, deoxyATP is itself one of the building blocks of DNA during DNA replication along with deoxyTTP, deoxyGTP and deoxyCTP. ATP has a similar role in RNA synthesis during transcription, along with TTP, GTP and UTP. This is another reason why DNA replication, cell division and growth would be impossible without ATP.

Without ATP, humans / mammals, would be unable to resist disease – they would not be able to maintain a turnover of the different types of white blood cells and produce antibodies rapidly and in quantity, and phagocytes would be unable to ingest bacteria.

Importance of ion pumping by active transport through cell membranes, e.g. in the nervous system, ion pumps create an action potential and the secretion of neurotransmitters across synapses, and in the excretory system, kidney function relies on ATP for reabsorption of glucose and salts. Therefore, without ATP animals could not coordinate their bodies, could not respond to stimuli and could not carry out osmoregulation. Similarly, plants could not absorb mineral ions from the environment and cells in general could not regulate passage of substances across the membrane.

Examples from wider reading illustrating diversity, e.g.

- bioluminescence in glow worms, fireflies, planktonic protoctists
- electrical discharge in some fish
- beating of cilia and flagella in protoctists
- movement of vesicles round cell on microtubule tracks
- movement of cytoskeleton, endo and exocytosis.

The characteristics of life include growth, reproduction, excretion, movement (in animals), taking in substances from the environment (food in animals and CO_2 and mineral salts in plants). All these require ATP.

9 Describe the modes of action of insulin and glucagon in the regulation of blood glucose concentration. Explain how disruption of this homeostatic mechanism leads to type 2 diabetes.

Learning outcomes: 1.1 (g), 3.4 (b), (c), (d), (h) and (i)

A good essay / balanced essay with argumentation would explore homeostatic regulation of blood glucose in humans and should include details of the roles of:

- cell signalling
- mechanisms by which particular molecules pass through cell membranes
- how this regulatory system is disrupted in type 2 diabetes
- how these disruptions result in the symptoms of type 2 diabetes.

To gain a high breadth mark, candidates must avoid writing a significant amount of irrelevant material about type 1 diabetes.
To obtain a high mark for argumentation candidates must relate the symptoms of type 2 diabetes to the physiology.

Individual points that might be included:
Blood glucose is regulated by two hormones, insulin and glucagon, which are produced in islets of Langerhans of the pancreas.

There are two types of cell in the islets, β cells which produce insulin and α cells which produce glucagon. They both monitor blood glucose level in the blood circulating around them.

Normal function (no diabetes): after a meal, blood glucose level rises and glucose enters β cells of pancreas by passively diffusing through GLUT2 receptors in the cell membrane.
Insulin is already present in vesicles budded off the Golgi bodies in the β cells. An increase of glucose concentration in the cell leads to the release of insulin into the blood by exocytosis.

Consequently glucose enters muscle cells (myocytes) and adipose tissue (adipocytes) all over the body through GLUT4 receptors (in the cell membrane), and enters liver cells (hepatocytes) through GLUT2 receptors, via a form of facilitated diffusion.

The insulin binds to an insulin receptor on the cell membrane. There is a ligand-receptor interaction, followed by a signal transduction, and an enzyme cascade.

These leads to the movement of vesicles containing GLUT4 transporter (myocytes and adipocytes) and GLUT2 (hepatocytes), a G-protein receptor, to the plasma membrane and influx of glucose begins.

This stimulates the condensation of glucose to stored carbohydrate (glycogen) in hepatocytes and myocytes and to lipid in lipocytes, thus reducing blood glucose level by storing energy rich substance. Insulin also suppresses gluconeogenesis.

When the blood glucose concentration falls (as cells start to use it up) to the normal level (80 to 90 mg per 100 cm^3), release of insulin stops. Remaining insulin breaks down (half-life of 4 to 6 minutes in the blood).
When the blood glucose falls below normal, the α cells of the islets of Langerhans produce glucagon.

Glucagon binds to the glucagon receptor, a G-protein coupled receptor, particularly to hepatocytes, but also to a lesser extent, myocytes. This activates an enzyme cascade which leads to the breakdown of glycogen releasing glucose into the blood (especially from the liver) until the blood glucose concentration rises to normal.

There may be a further contribution to the increase in blood glucose through gluconeogenesis (mainly in hepatocytes).

In many cases of type 2 diabetes, insulin is produced normally but does not bind to the insulin receptor of the cells around the body (insulin resistance). Hence, glycogen is not stored and glucose production by breaking down amino acids continues unabated.

Sufferers from type 2 diabetes are not able to control the amount of glucose in the blood. After eating, it can be too high (hyperglycaemia), which causes glucose in the urine and, in severe cases, loss of consciousness. At other times, blood sugar falls too low because not enough glucose has been converted to glycogen and stored in cells and the person has hypoglycaemia and may lose consciousness. This is because nerve cells store little, if any, carbohydrate or lipid and rely on there always being enough glucose in the blood.

The symptoms are extreme thirst, frequent urination and tiredness due to lack of glucose in the blood, increased hunger and weight loss.

Attempt to explain why diabetes type 2 causes these symptoms.

A patient with type 2 diabetes typically does not respond to insulin injections.
When the insulin combines with the receptor, the vesicles containing GLUT4 transporter (myocytes and adipocytes) do not move to the cell membrane and so the glucose is not taken up normally.

In some (but not all) cases of type 2 diabetes, the person's β cells in the islets of Langerhans of the pancreas may not produce enough insulin (in addition to insulin resistance).

Type 2 diabetes can be mild (it is less all-or-nothing than type 1). In some more severe cases people suffering from it may experience nonketotic hyperosmolar coma (a condition of very high blood glucose associated with a decreased level of consciousness and low blood pressure).

In type 2 diabetes there can sometimes also be an overproduction of glucagon which exacerbates the effects of lack of insulin. This may sometimes overstimulate the release of glucose from the liver by gluconeogenesis. This may be because there may be a connection between insulin and glucagon and that absence of insulin may disrupt the control of glucagon too.

Type 2 diabetes is usually controlled by weight loss, careful diet and good exercise regime. However, sometimes medication is necessary. For example, Metaformin can be taken when blood glucose is too high and it can reduce the level by suppressing glucose release by hepatocytes. It also increases the sensitivity to what little insulin the person may be able to produce.