BOARD OF STUDIES
NEW SOUTH WALES

2011 Biology HSC Examination
'Sample Answers'

When examination committees develop questions for the examination, they may write 'sample answers' or, in the case of some questions, 'answers could include'. The committees do this to ensure that the questions will effectively assess students' knowledge and skills.

This material is also provided to the Supervisor of Marking, to give some guidance about the nature and scope of the responses the committee expected students would produce. How sample answers are used at marking centres varies. Sample answers may be used extensively and even modified at the marking centre OR they may be considered only briefly at the beginning of marking. In a few cases, the sample answers may not be used at all at marking.

The Board publishes this information to assist in understanding how the marking guidelines were implemented.

The 'sample answers' or similar advice contained in this document are not intended to be exemplary or even complete answers or responses. As they are part of the examination committee's 'working document', they may contain typographical errors, omissions, or only some of the possible correct answers.

Section I, Part B

Question 21 (a)

Sample answer:

Boiling water, chlorination

Question 21 (b)

Sample answer:

Boiling the water for 10 minutes kills most pathogens. Chlorine added to drinking water in small quantities kills the pathogens that cause disease.

Question 22 (a)

Sample answer:

The aim of this experiment is to show the effect of pH on enzyme activity.

Question 22 (b)

Sample answer:

Each trial needs to be run for the same length of time so that the results can be fairly compared (ie time is not a variable). Include a control with no enzyme to show that the change in pH alone does not cause the breakdown of the substrate.

Question 22 (c)

Sample answer:

1	Clear
2	Clear
3	Clear
4	Clear
5	Cloudy
6	Cloudy

Question 23

Sample answer:

Watson, Crick, Franklin and Wilkins were the scientists who determined the structure of DNA. Watson and Crick had a good relationship and worked closely together. Franklin and Wilkins did not work well together and there was some level of competition between them. Some of Franklin's images and results were shown to Watson and Crick by Wilkins. Franklin kept her results secret, which may have caused her to not publish them in time for her discovery to be acknowledged. The close collaboration between Watson and Crick, with the aid of Wilkins, enabled them to determine and publish their DNA model first.

Question 24 (a)

Sample answer:

Polio

Question 24 (b) (i)

Sample answer:

The protein coat of the virus contains the surface antigens of the virus. Just as the immune system detects the antigens on the whole virus, it also detects the antigens on the protein coat and in the same way. Thus plasma cells will be developed to produce an antibody to this antigen, and memory B cells will likewise be developed. In this way, if the whole virus subsequently invades the body, antibody levels would quickly build to inactivate the virus.

Question 24 (b) (ii)

Answers could include:

Removing nucleic acid from the virus ensures that host cells will not be made to replicate viral nucleic acid and make viral protein. Thus the virus cannot multiply in the host.

OR

Suspending protein in a saline solution ensures the liquid is isotonic to blood, and blood cells will not be altered by the injection of the vaccine solution.

Question 25 (a)

Sample answer:

- B and D

Question 25 (b)

Sample answer:

- C

Question 25 (c)

Sample answer:

Aldosterone causes salt reuptake from the distal convoluted tubule and this increases the salt retained in the blood. The water is also retained to maintain osmotic balance.

Question 26 (a)

Answers could include:

Similarities

- Examines polio
- Same time frame
- Shows same trend
- Provides global data

Differences

- Estimated versus actual
- Ten-fold difference in numbers of cases of polio
- Rounded figures/exact numbers

Question 26 (b)

Sample answer:

Data required is:

- global incidence of polio in time periods before 1988 to see if trend was similar before 1988, or only started to fall after 1988
- figures on incidence of polio from different countries is needed to see correlation with vaccination programs.

Question 27

Answers could include:

- Large sample size
- Control of variables (across gender, age)
- Data that is collected and analysed:
  - diet
  - hygiene
  - location/environment
  - personal history/lifestyle
- Data analysis
  - compare for common data with and without disease
  - look for common data in people who have disease

Question 28 (a)

Sample answer:

When skin is cut or broken, genes are switched on in stem cells to trigger their development into epidermal cells or blood vessel smooth muscle cells etc, so that more of all types of skin cells are available to bridge the lesion and repair the hole in the skin. In this way, the barrier of the skin is restored intact, and the entry of pathogens into the body, and thus infectious disease, is prevented.

Question 28 (b)

Answers could include:

The oxygen-carrying capacity of the new artificial red blood cells will be equal to/greater than existing artificial blood.

New artificial blood made from skin cells will be genetically identical to other cells of the body and have the same antigens. The body will recognise these new cells as 'self' and the cells will not be rejected.

Question 29

Sample answer:

Dependent variable	The number of colonies
Independent variable	Where the sample was taken from
Control	The use of sterilised water
Safe work practices to be followed	Risk 1: Burning yourself with the Bunsen burner when sterilising the inoculating loop. Safety precaution: Take care when using the Bunsen burner, ensuring that the inoculating loop doesn't make contact with your skin. Risk 2: Growing microbes that are harmful to humans and other animals. Safety precaution: Do not open plates once they have been sealed. Dispose of plates in the correct manner.

Question 30 (a)

Sample answer:

X is a temperature probe or temperature sensor
Y is a data logger

Question 30 (b)

Sample answer:

The conclusion that, in their natural environment, the body temperature of this reptile is directly controlled by the ambient temperature cannot be drawn based on this experiment. The reptile is caged and placed in the shade, which means it is unable to use behavioural adaptations to control its body temperature.

Question 31

Answers could include:

The germ theory of disease was a major breakthrough in our understanding of biology that informs the development of treatments for infectious diseases. In this case, identifying that a disease is caused by a bacterium is important.

The understanding that the radiation of cells could induce mutations by affecting DNA, and the understanding of cell requirements, allowed scientists to produce mutations in cultured microorganisms. This production of mutations can result in new or altered cell products and cell activities, such as a mutated fungus producing a new antibiotic.

The polypeptide chemical composition of enzymes was an important development, which allows the scientist in the example to explain why the antibiotic produced by the fungus affects the bacterial enzyme but not the human enzyme. Different amino acid sequences result in different proteins, which respond differently in the presence of the antibiotic. The pathogenic bacteria are killed due to the loss of enzyme activity. The human enzyme is unaffected, so humans are unharmed by the antibiotic.

Development of systems in biology to culture microbes in the laboratory allow pure cultures to be grown and subjected to radiation.

The social implications of the development of antibiotics have been huge. They have increased the length and quality of human lives. Before the discovery and development of antibiotics, people died from what are now considered minor bacterial infections.

The development of antibiotic resistance in bacterial populations is a social problem, hastened by the misuse and overuse of antibiotics. Scientists need to develop new antibiotics to treat diseases caused by bacteria that are now resistant to earlier antibiotics.

The development of new strains of microorganisms with induced mutations in the laboratory requires careful management so that these new species of microorganisms are not released into the environment. They could disrupt natural ecosystems or cause disease in other organisms.

Section II

Question 32 (a) (i)

Sample answer:

A is an axon
B is a dendrite

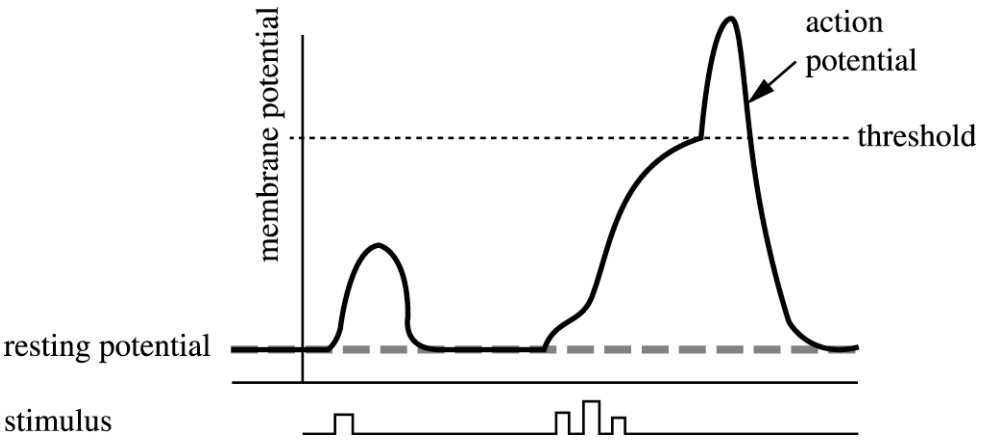
Question 32 (a) (ii)

Sample answer:

The structure *B* collects nerve signals from other neurons.

Question 32 (b)

Sample answer:



A small stimulus depolarises the membrane but not enough to reach threshold and so no action potential or signal is transferred. A larger stimulus allows the cell to reach threshold and an action potential is formed. This is then transmitted along a nerve.

Question 32 (c) (i)

Answers could include:

The role of the cornea is to:

- refract light that enters the eye
- focus light that enters the eye
- cover the iris and pupil.

Question 32 (c) (ii)

Sample answer:

Myopia occurs when the image falls short of the retina. LASIK is used to reshape the cornea so the focus of the image falls on the retina, thus reducing a person's dependence on using glasses.

Question 32 (d)

Sample answer:

The range of sound frequencies detected by:

1. humans is approximately 20 – 20 000 Hz;
2. dolphins is approximately 1000 to greater than 100 000 Hz;
3. bat is 2000 – 110 000 Hz.

The human ear is most sensitive to frequencies of about 2000 – 4000 Hz, which corresponds directly to the human speech bandwidth.

The maximum sensitivity in dolphins' hearing is between 20 000 and 80 000 Hz. The higher frequency range reflects the detection of echoes that dolphins use to sense direction and locations. The sounds that fish hear are those within the range produced by prey or predators.

Question 32 (e)

Answers could include:

Humans hear as a result of the brain coordinating a response to stimuli, which have been detected by different structures of the ear. The pinna and the ear canal assist in amplifying sound by channelling vibrating air into the eardrum, which then causes the eardrum to vibrate at the same frequency as the air. The ossicles in the middle ear vibrate, causing the fluids in the inner ear to vibrate. The membranes then produce tension on the hair cells in the organ of Corti, which activates neurons that transfer impulses to the brain. The brain interprets this as sound. Therefore, hearing is the correct interpretation of signals coming into the brain. Where one or more parts of the ear (eg the eardrum, ear canal, oval window, round window or cochlea) or brain (eg temporal lobe) are damaged, do not function correctly, or when the correct energy transformations do not occur, hearing is limited or non-existent.

Before technologies such as the integrated circuit, digital technologies and amplifiers, people with hearing loss depended on devices such as hearing trumpets, which were used to amplify sounds. Use of the hearing aid amplifies sound and benefits people who have some hearing. Amplification of sound does not assist people who have damaged or non-functioning cochleas. This is a limitation of the technology. Cochlear implants can be used to assist hearing where there is significant damage to the cochlea (eg the hairs in the organ of Corti). Hearing aids are another technology whereby sound is amplified then fed into the cochlea in the same way that a person with normal hearing hears sound. In the case of a cochlear implant, the cochlea is replaced by an implant, which replaces the non-functional part of the ear.

Question 33 (a) (i)

Sample answer:

A is a primer
B is a polymerase

Question 33 (a) (ii)

Sample answer:

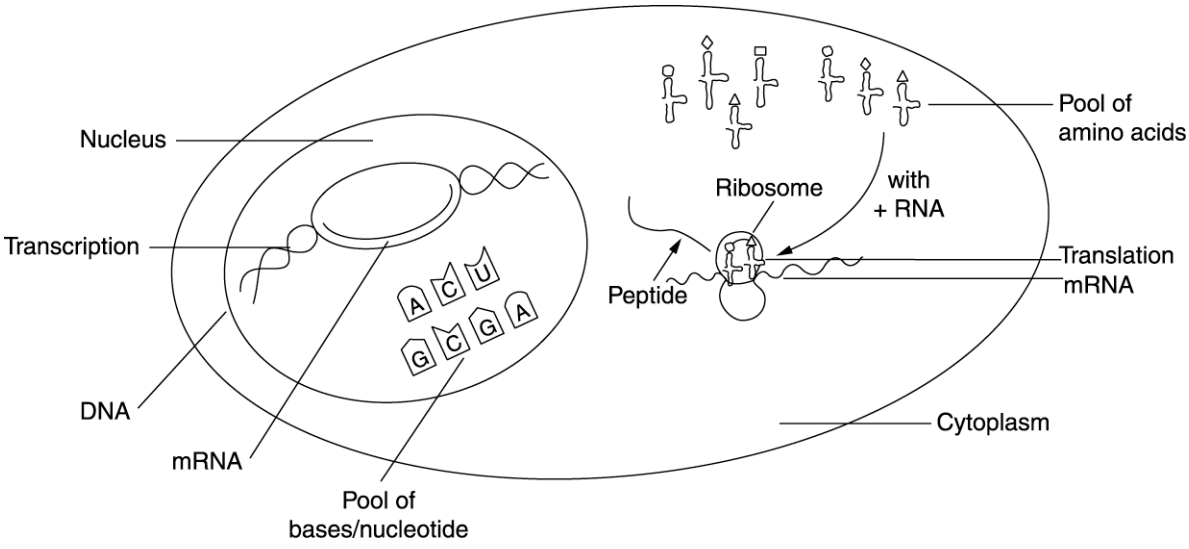
PCR or polymerase chain reaction

Question 33 (b)

Sample answer:

Transcription is the copying of DNA into mRNA. This takes place in the nucleus, where the large DNA molecule is located. So that the DNA can be copied, a pool of nucleotides – A, U, G and C – are linked together to form the complementary strand of mRNA.

Translation is the formation of a polypeptide according to groups of three bases (codons) in the template mRNA. This takes place in the cytoplasm, where the ribosomes are located. The polypeptide is formed by linking amino acids with peptide bonds. A pool of amino acids for this purpose is found in the cytoplasm.



Question 33 (c) (i)

Sample answer:

Quantitative data is generated when an observation requires measurement of a variable, for example the distance around the colony cleared by the ants was measured in metres or the change in seed size was measured and the change calculated as a percentage.

Qualitative data relates to observations that cannot be quantified, for example the ants' behaviour in clearing the ground, burying the seeds and removing other plants.

Question 33 (c) (ii)

Sample answer:

Biotechnology is the use of living organisms to make or modify a product, to improve plants or animals, or to utilise microorganisms for specific uses. The ants clearing the surface, burying grass seeds and clearing competing plants to 'farm' the grass on its own would not indicate that they have been practising biotechnology. However, the increase in seed size, of 5% over 10 years, would indicate that the ants have been selectively keeping and burying larger seeds for successive crops. This indicates that the ants have modified the grass seeds. Their farming practices show that this is done specifically to provide more food, or the same amount of food for less effort.

Question 33 (d)

Sample answer:

The addition of genes from one organism to another results in a genetically altered/transgenic organism being created.

This could have an adverse affect on some aspects of the environment; for example studies have shown that pollen from a genetically modified (GM) crop could blow onto the food plant of some butterflies and be consumed by their caterpillars. The gene added to the GM crop, normally found in a bacterium and capable of killing caterpillars, could kill the butterfly caterpillars, which do not eat the crop. This may result in the loss of the butterfly species.

Agricultural scientists can use recombinant DNA technology to generate crop plants with characteristics such as pest, herbicide or disease resistance. This would be is a more direct and less expensive way of putting genes together in one organism than that of traditional artificial selection, which has been happening for thousands of years. It could also result in a higher production of food.

Recombinant DNA technology could be used to generate harmful organisms that could be used for germ warfare. This could be done by placing harmful genes in readily spread organisms, such as some viruses.

The use of farm animals and crops, which are those that have predominantly been altered using recombinant DNA technology, may lead to a decrease in the number of genes in the gene pool. If a new challenge comes along – that is, a new disease – genes that may have conferred resistance will no longer exist.

Recombinant DNA technologies may lead to new treatments for diseases, such as using viruses to deliver genes to people with cystic fibrosis.

Question 33 (e)

Sample answer:

This is an example of biotransformation, which is using an enzyme extracted from an organism to reduce harmful chemicals to non-toxic chemicals. The technologies that could be applied to developing and producing these enzymes are as follows:

Cell culture – In being able to grow these bacteria and extract their enzymes, we need to establish the conditions for growth in the laboratory, which include the insecticides/herbicides.

Strain isolation – Initially, mixed strains of bacteria would be isolated from the soil. So that only those bacteria that produce the enzymes of interest are cultured, it would be necessary to streak culture plates so that the bacteria grow in isolated colonies. These colonies could then be cultured to test for the presence and amount of enzyme being produced.

Fermentation – To produce an enzyme in a quantity sufficient for it to be useful in a practical application, it will be necessary to progress to bulk fermentation. The conditions for optimal production would need to be tested to make this process efficient. This would include investigating factors such as temperature, food source, moisture etc.

Genetic manipulation – If the bacteria that naturally produce an enzyme only do so in small quantities, it may be necessary to manipulate the genes for the enzyme to increase production.

This could involve using RT-PCR to make copies of the gene for further manipulation. PCR uses repeated cycles of heating the DNA to separate the two strands of DNA. In the presence of primers and polymerase, the single strands of DNA are then cooled and used as a template to make more copies of the gene. This increases the quantity of DNA, making it easier to manipulate.

Copies of the gene could be placed into the original bacteria, to increase the copy number and therefore the amount of enzyme produced. Alternatively, the gene could be introduced into another organism that is easier to culture, making a transgenic organism. In both cases, this would be done using a plasmid as a vector. This requires cutting out the gene of interest and the plasmid with the same restriction enzyme to produce 'sticky ends', allowing the plasmid and gene to anneal and legating the plasmid/gene to fix the gene in the vector. The resulting recombinant DNA is then cultured with the target organism whereby the vector is incorporated into the target organism.

Question 34 (a) (i)

Sample answer:

Mutation 1 is a base substitution.
Mutation 2 is a deletion.

Question 34 (a) (ii)

Sample answer:

There is no change to the polypeptide, and the amino acid sequence remains the same.

Question 34 (b)

Sample answer:

For the following Punnett squares, use these symbols to represent genes:

ABO blood group: I^A gene for type A blood cell proteins
I^B gene for type B blood cell proteins
I^o gene for no antigenic blood proteins

Rhesus factors: Rh+ gene for Rhesus positive factor
Rh– gene for Rhesus negative factor

	I^B	I^o
I^A	$I^A I^B$	$I^A I^o$
I^o	$I^o I^B$	$I^o I^o$

	Rh+	Rh–
Rh+	Rh+ Rh+	Rh+ Rh–
Rh–	Rh– Rh+	Rh– Rh–

These Punnett squares indicate that if a parent heterozygous for the type A blood group has children with a parent heterozygous for the type B blood group, they can have all blood group possibilities in their children, which include AB Rh+ and O Rh–.

It is similar for Rhesus factor with parents being heterozygous.

Question 34 (c) (i)

Sample answer:

Selective breeding chooses animals with desirable features and mates them to get the best features in one animal. Cloning takes an animal with the required features and makes more animals using stem cells from the original animal.

Question 34 (c) (ii)

Sample answer:

The chickens were genetically modified through selective breeding because selective breeding involves genetically modifying a population, not an individual. It is the practice of choosing individuals with desirable characteristics for mating to obtain offspring that have these characteristics. The repeated selection of individuals with the desired characteristics will increase the frequency of the characteristic in the population so that eventually the population will be permanently changed.

The chickens were not cloned as claimed because cloning can refer to gene cloning or whole organism cloning. In whole organism cloning, an exact copy of an individual is made. In gene cloning, individual genes are identically copied and may be put into a different species.

So while selective breeding does not involve genetic manipulation of an individual, the genes in the population are modified.

Question 34 (d)

Sample answer:

Inheritance studies focus on conditions common to a family group and can confirm the general location of a gene on a chromosome. The Human Genome Project (HGP) uses recombinant DNA technologies to produce physical maps showing the position of genes with regard to the sequence and number of bases involved for the entire genome of an individual.

By conducting breeding experiments and mapping the recombinant genes, maps of an organism's chromosomes and the sequence of the genes can be built up. This method requires careful mating experiments and takes time. This is impractical in human studies. The technologies used for the HGP require a small tissue sample taken from any individual suspected of carrying a harmful gene, or from reference individuals, and can produce a genetic map relatively quickly. These both can be used to predict if an individual carries a harmful gene.

Traditional inheritance studies focus on phenotypic differences, whereas the HGP allows for genotypic differences to be found by comparing the genetic codes of individuals, giving the specific location and sequence of harmful genes.

Question 34 (e)

Answers could include:

DNA fingerprinting – Sexually reproducing organisms, like dingoes, have unique DNA coding. Highly variable non-coding sections of DNA can have multiple repetition of short sections of code that when treated with restriction enzymes, produce fragments that can be separated to produce banding patterns that are usually unique to the individual. By looking at banding patterns (DNA fingerprints) of dingoes and comparing them to dogs and wolves, you can see with which species they share the most bands.

Chromosome mapping – Using cross-breeding experiments, it is possible to develop a map showing the position of each gene on a chromosome. Organisms from the same species have similar chromosome maps. The more closely related the organisms are, the more similar their chromosome maps. By mapping the genome of dogs, wolves and dingoes, it could be determined how similar the dingo is to either of the other two species.

Recombinant DNA – Hybridisation between DNA from two species can be used to look for similarities between dingoes/wolves or dingoes/dogs. The DNA is heated to form single strands and then cooled so the strands can join. In hybrid DNA molecules of closely related species, the DNA strands will closely match and remain joined for longer as the mixture is reheated.

Restriction mapping – Maps can be produced by cutting DNA with restriction enzymes and separating the fragments generated by electrophoresis. By comparing the size and number of fragments, one can look for the greatest number of similarities to find the most clearly related species.

DNA sequencing – This shows the bases found at each position in the genome. By comparing the number of similarities/differences in the genome of dogs, dingoes and wolves, it would be possible to determine the relationship between them.

Question 35 (a) (i)

Sample answer:

The oldest layers are C and F
The youngest layer is A

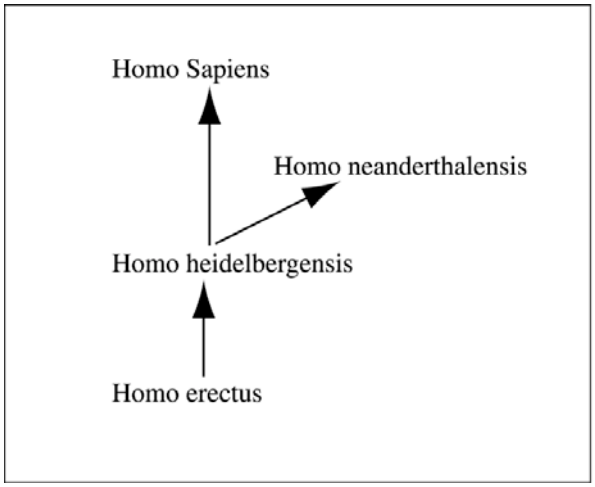
Question 35 (a) (ii)

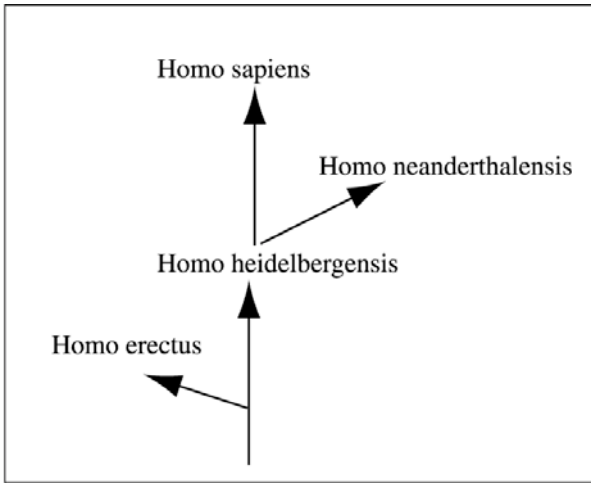
Sample answer:

Stratigraphy

Question 35 (b)

Sample answer:





In both these models, *Homo erectus* is the oldest fossil form, but it can be considered on direct line to *Homo sapiens* or a side branch from the main line. In both models, Neanderthals are seen as separate species having a recent common ancestor with *Homo sapiens*, *Homo heidelbergensis*.

Question 35 (c) (i)

Answers could include:

Homo floresiensis was small as an adult, and probably not very strong. To successfully kill a 1000 kg animal prey, *Homo floresiensis* would have had to make effective stone tools and work cooperatively in a hunt. The fossil evidence suggests the following:

- A range of stone tools indicates cultural development.
- Group hunting requires communication systems: a shared language.
- Large societies need more shared language to settle disputes and establish social rules.
- Cooking food is a cultural development, which increases the range of species that are possible foods.
- Cooking using a hearth is a higher level of cultural development, allowing for higher temperatures.
- Sharing food from a central cooking hearth illustrates a degree of social cooperation and may have involved social hierarchies of activities, rules, and codes of behaviour.

Question 35 (c) (ii)

Answers could include:

Organisms are in the same species if they can interbreed to produce fertile offspring under natural conditions. Animals in the same species share common features, though polymorphism is exhibited.

Conversely, organisms are in a different species if they cannot successfully interbreed under natural conditions. This inability to interbreed is associated with a lack of access or sufficient genetic variation in sperm and ovum so that progeny are not viable. Speciation involves the genetic and physical isolation of groups of organisms such that processes of evolution generate significant and observable physical differences between groups of organisms.

Homo floresiensis were located in space on an island, which provides physical isolation, and were located in time well away from other fossil hominids. Both these factors provided sufficient means of isolation for speciation.

Homo floresiensis had a unique combination of observable characteristics, which are different from other know fossil hominids. These differences could equate to sufficient variation from other groups to require classification into a separate species.

	Homo floresiensis	*Homo erectus*	*Homo habilis*	*Australopithecus afarensis*
Dates	18 000	1.8–3 million	2–1.6 million	3.9–2.3 million
Regional location	Indonesian island	Africa, Asia, Indonesia, Europe	Africa	Africa
Brain volume (cm^3)	380	750–12 500	600–800	400–500
Skull	Eyebrow ridges Sharply sloping forehead	Eyebrow ridges Rounded forehead	Sloping forehead	Eyebrow ridges Sharply sloping forehead
Height compared to modern human	Same as three year old	Equivalent to short modern adult humans	Equivalent to short modern adult humans	Equivalent to short modern adult humans
Upright	Yes	Yes	No	No
Bipedal	Yes	Yes	Yes	Yes
Arm : leg	Arms longer	Legs longer	Arms longer	Arms longer
Culture	Complex stone tools Complex use of fire	Complex stone tools Use of fire	Primitive stone tools No use of fire	No stone tools No use of fire

In short, while the brain was smaller than other fossil hominids and had features that were more apelike, *Homo floresiensis* was very intelligent and had developed complex cultures typical of early *Homo sapiens*. Thus it is unique.

Question 35 (d) (i)

Answers could include:

Humans in Africa encountered a range of different habitats over millennia. Populations of humans became isolated from one another, and little or no gene flow was possible between groups. Natural selection caused humans with favourable characteristics to be naturally selected. Mutation and sexual reproduction generated new variants, which could be naturally selected.

In this way, humans in isolated populations evolved and developed features that were suited to their environments. These different phenotypes observed in different isolated populations are called polymorphisms.

If environments between human populations were transitional, humans found in these environments were observed as processing a transitional combination of phenotypes. This is called lineal gradation.

Current evolution

Humans today can use technologies to assist their survival and/or their reproductive success/outcomes. This can affect their biological evolution in ways different to their predecessors. Some phenotypes unsuited to the physical environment may persist in human population when previously natural selection would have removed them. For example, white skin in high sunlight environments with use of shelters, hats, sunscreen and skin cancer surgery. This can provide for longer lives and the reproduction of white-skinned individuals into subsequent generations.

Sources of variations today are not restricted to meiosis, fertilisation and mutation. Genetic engineering, ovum, sperm or embryo selection can affect genetic the make-up of offspring. So can the increased mobility of modern human populations separated by vast oceans. This means that phenotypes observed in human populations are more varied than previously observed.

Rather than isolated and discrete populations characterised by specific gene frequencies and linked by populations of transitional gene frequencies, the human populations today contain individuals from a diversity of races and a 'melting pot' of individuals derived from intermarriage between these groups.

The incidence of defective genes in human populations has increased, as modern medicine allows for people who possess these genes to live long lives and to reproduce.

Question 35 (d) (ii)

Answers could include:

Humans evolved in Africa for millions years before they migrated across the world to other continents. Earlier forms (*Homo erectus* and *Homo neanderthalensis*) migrated two million years ago. Over that period of time, African humans evolved to be suited to a large range of African habitats and genetically diverged from each another.

The out-of-Africa hypothesis states that *Homo sapiens* migrated out of eastern Africa around 50 000 to 100 000 years ago. They displaced earlier pre-humans already in Asia and Europe.

This shorter period of divergence (100 000 years) accounts for the lesser degree of genetic diversity of humans between other countries.

Question 35 (e)

Answers could include:

The following technologies can be used to compare all three groups genetically to determine which two groups are genetically closer and therefore closer in evolutionary terms.

Karyotype analysis

White blood cells extracted from microbats, megabats and lemurs are used in karyotype analysis. Cells are chemically 'frozen' in metaphase of mitosis, and then photographed.

Photographs are cut up such that every chromosome in the genome of each species is individually imaged. Chromosome homologous pairs are identified by examining the length of chromosomes, position of centromere, and positions of bandings. Homologous pairs are arranged on a page from largest to smallest, with the sex chromosomes set apart. Homologous pairs are numbered. Each page of photographs of a complete chromosome set for a species is a karyotype.

Karyotypes can be compared between species to look for:

- similarities in numbers of chromosomes in the genome
- similar bandings on same homologous pairs in karyotype
- translocations (single mutations) that could change one karyotype into another in the process of evolution.

Species/groups or organisms whose karyotypes more closely resemble each other could be considered closer in evolutionary terms as there are fewer mutations between them.

DNA-DNA hybridisation

DNA melting points for microbats, megabats and lemurs can be measured. DNA can be extracted from microbats, megabats and lemurs, and hybridised with DNA from other groups as follows:

Lemur/microbat hybrid DNA
Lemur/megabat hybrid DNA
Microbat/megabat hybrid DNA

Melting points for hybrid DNAs can be measured.

Comparisons between a pure DNA melting point and a hybrid DNA melting point can indicate genetic similarity between groups. If the difference in melting points is small, the base sequence of DNA is very close, so the species is genetically closer and closer in evolutionary terms.

Comparison of haemoglobins

Amino acid sequencing of proteins common to all three groups can be used as a measure of genetic proximity, as amino acid sequence in proteins is determined by genes.

One such common protein is haemoglobin, which is found in red blood cells. Haemoglobin can be extracted from red blood cells from each group and the amino acid sequence determined.

The difference in amino acid sequence can be expressed in numbers of amino acids that are different between groups.

You would compare the numbers of amino acid differences between:

Lemur and microbat
Lemur and megabat
Microbat and megabat

The groups with fewer differences in amino acid sequence between them would be closer in evolutionary terms.

DNA sequencing

The whole genome of an organism can be analysed for base sequence, or complementary parts of the genome can be base sequenced.

The genomes of the microbat and lemur can be analysed in term of percentage similarity to the genomes of the megabat.

Groups of organisms with a higher percentage similarity in base sequence can be considered to have diverged from each other more recently, and therefore are closer in evolutionary terms.

Mitochondrial DNA as a molecular clock

DNA in mitochondria can be extracted, sequenced and compared between groups.

Since the mutation rate of this DNA is known precisely, the amount of difference between the m-DNA of different groups can be used as a clock to estimate the time since these groups diverged.

If the time since divergence is small, the two groups can be considered closer in evolutionary terms. If the time since divergence is large, the two groups are not closely related in evolutionary terms.

In this case, if microbats and megabats diverged from each other more recently than megabats and lemurs, then microbats and megabats are closer in evolutionary terms and it is correct that they be classified in the same order together.

However, if megabats and lemurs have diverged from each other more recently than microbats and megabats, it would be more correct to classify megabats with lemurs as primates, and not with microbats.

Question 36 (a) (i)

Sample answer:

The Calvin cycle

Question 36 (a) (ii)

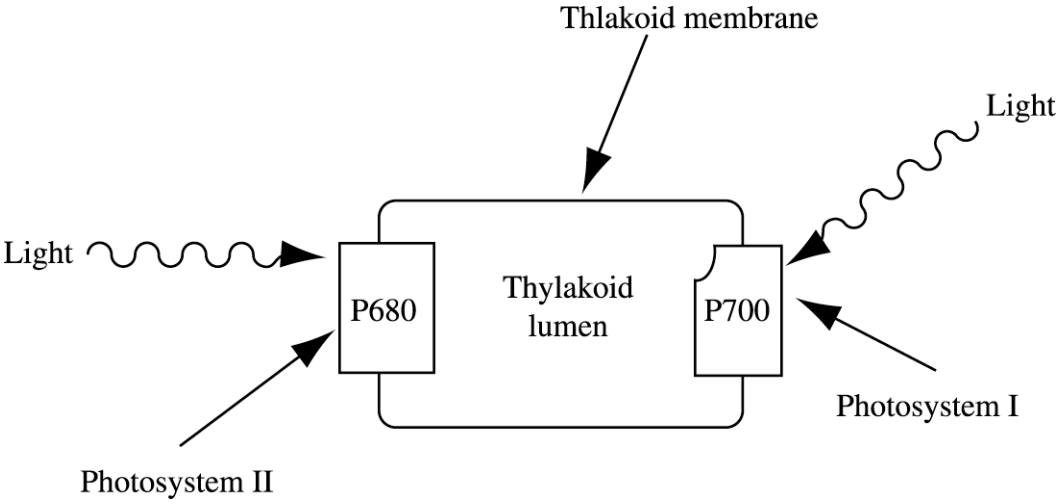
Sample answer:

A is carbon dioxide
B is glyceraldehyde phosphate

Question 36 (b)

Sample answer:

Photosynthesis occurs in the thylakoid membranes and surrounding stoma of chloroplasts. Pigment–protein complexes (chlorophyll or carotenoids) within the thylakoid membranes absorb light and pass its energy on to two distinct photosystems.



Question 36 (c)

Sample answer:

C-11 or N-13

The half-lives of these two radioactive isotopes are within measurable ranges. The reactions using the other isotopes are either too quick (N-16, O-15) or too long (C-14, H-3, S-35) to measure.

Question 36 (d)

Sample answer:

Mayer was the first to propose that photosynthesis involved the conversion of light energy into chemical energy. This was based on work from: Van Helmont, who discovered that a tree gained mass from something other than the soil it grew in; Hale, who proposed that plants obtain matter from the air; Priestly, who showed that plants could restore oxygen (make air sweet) to air that had been depleted of oxygen by a burning candle, and that the non-green parts of plants used oxygen; Senebier, who demonstrated that plants used carbon dioxide during photosynthesis; and Saussure, who discovered that sugars produced by plants obtained their carbon from carbon dioxide and hydrogen from water.

Question 36 (e)

Sample answer:

Place the cyanobacteria in a test tube and add a sufficient amount of solvent to cover the material. Grind and mix the cyanobacteria sample well. Insert a stopper in the test tube and leave the mixture in a dark environment for at least 30 minutes. This will result in the extraction of the chlorophyll from the cytosol of the cyanobacteria. Using a capillary tube, place a drop of the extract one inch from the bottom of a thin strip of chromatography paper. Let the strip of chromatography paper dry before adding another drop of the extract to the same spot as before. Keep adding drops of the extract until a distinct green 'blob' is observed on the strip of chromatography paper. Remember to let each drop dry before adding another drop of the extract. After you have added as much extract as you need, let the strip of chromatography paper dry completely.

Place a small drop of solvent into the bottom of a clear jar and attach the strip of chromatography paper so that the end of the paper containing the pigment is just touching the solvent. Ensure that the strip of paper is not touching the sides of the jar. Cover the jar and observe the migration of the pigments up the chromatography paper. Remove the strip of paper after the solvent has travelled about two to three inches and let the strip dry. The pigments will separate into distinct 'bands' with the chlorophyll appearing green. Lighter pigments (by weight) will migrate faster in the solvent compared to heavier ones, and will therefore travel to higher locations on the strip of paper.

In order to analyse the subcellular location of the new chlorophyll, the cyanobacteria will be homogenised in order to break the cell membrane. The cell lysate will then be subjected to ultracentrifugation in a sucrose density gradient in order to separate the fractions based on the size and density of the organelles. The most concentrated sucrose solution is placed at the bottom of the test tube and the least concentrated is placed near the top of the tube. The cell lysate is then carefully layered on the top and centrifuged. The chlorophyll will be identified as a distinct, thin layer of green pigment at an interface between the sucrose solutions. The absorption spectrum of the new chlorophyll can be determined using spectrophotometry.