BOARD OF STUDIES
NEW SOUTH WALES

2012 HSC Biology
'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

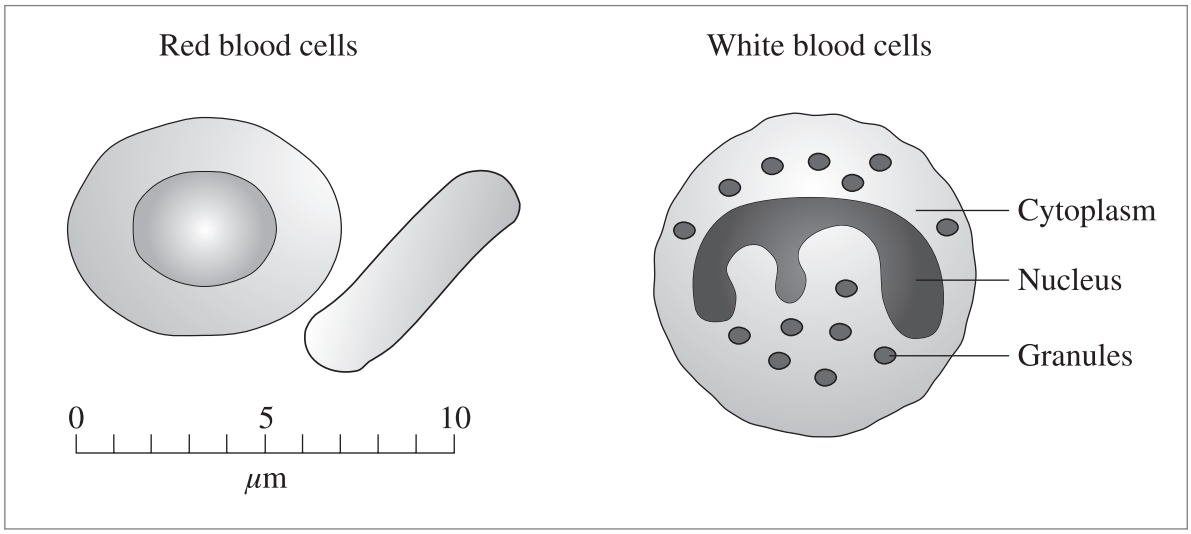
Question 21 (a)

Sample answer:

I used a mini-grid to measure the diameter of field of view of the microscope. I drew a cell in a circle representing the field. I then sketched diagrams of the same cell across the diameter, counting how many cells fitted across. I divided the diameter of the field by the number of cells.

Question 21 (b)

Sample answer:



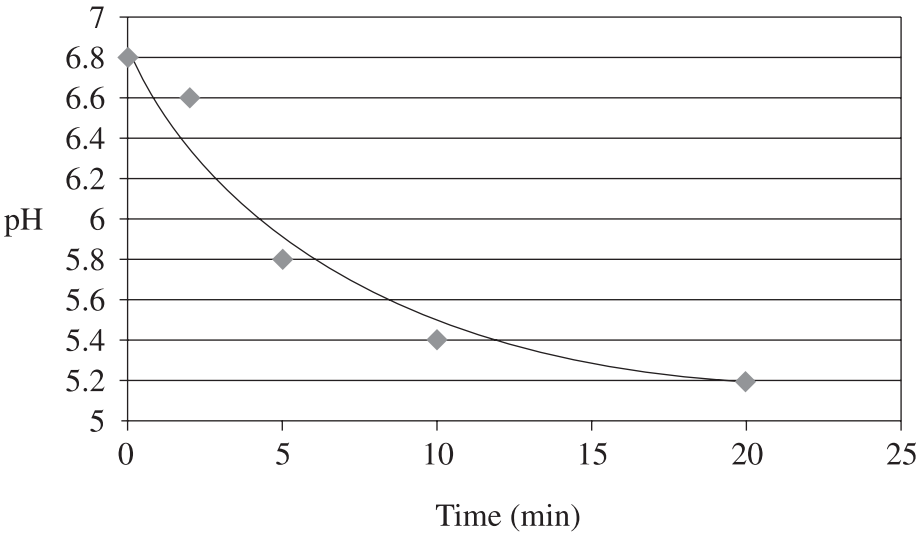
Question 22 (a)

Answers could include:

Time (min)	pH
0	6.8
2	6.6
5	5.8
10	5.4
20	5.2

Question 22 (b)

Answers could include:



Question 22 (c)

Sample answer:

The pH is continuous data measured over time and therefore should not be presented as a bar graph, making a curve of best fit better because it is not linear, but continuous.

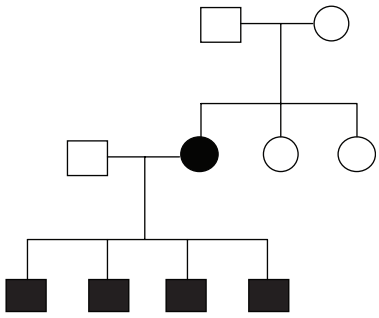
Question 23 (a)

Sample answer:

Diet and calorie intake of all family members.

Question 23 (b) (i)

Sample answer:



Question 23 (b) (ii)

Sample answer:

The grandparents do not have the disease while the mother has the disease (recessive) and the disease is not found in the grandfather while the mother has the disease (not sex linked).

Question 24 (a)

Sample answer:

Independent variable = temperature; dependent variable = enzyme activity

Question 24 (b)

Sample answer:

The activity of catalase is measured by the height of oxygen in a test tube when a fresh piece of raw potato is added to hydrogen peroxide.

Question 24 (c)

Sample answer:

Ectotherms' body temperature changes to be similar to the environment whereas endotherms have a constant temperature. Enzymes have an optimal activity over a range of temperatures in ectotherms and only a narrow optimal temperature in endotherms.

Question 25 (a)

Sample answer:

The experiment shows that a gene has been mutated by X-rays because after irradiation the mould now needs arginine to grow. This means that a gene for making the protein responsible for making arginine has been changed so arginine cannot be made. This supports the 'one gene–one protein' hypothesis because when arginine is in the medium, the mutated mould grows.

Question 25 (b)

Sample answer:

Scientific journals reference the original work by Beadle and Tatum because these are peer reviewed and subject to the scrutiny of the scientific community. Textbooks such as these are checked carefully by publishers and science educators.

Question 26

Sample answer:

The design of this study cannot validly lead to a link between disease and its likely causes. A valid questionnaire is good but the number of subjects is low and only confined to the workplace. The sample should be larger and broader. Ideally, the study should have a variety of equal categories, eg age, ethnicity, not just male: females equal. Participants should not be eliminated on the basis of their answers as this reduces the scientific validity. Any checks should be consistent, with a definite purpose related to the study, eg lungs checked. The final data should be peer reviewed for publication.

Question 27

Answer could include:

1. Quarantine horses: this prevents transmission of pathogen to other horses
2. Vets to wash body, clothes and equipment to stop the spread of pathogens
3. Vaccinate all unaffected horses, to prevent potential spread of the disease
4. Wait for incubation period to have elapsed before releasing horses from quarantine

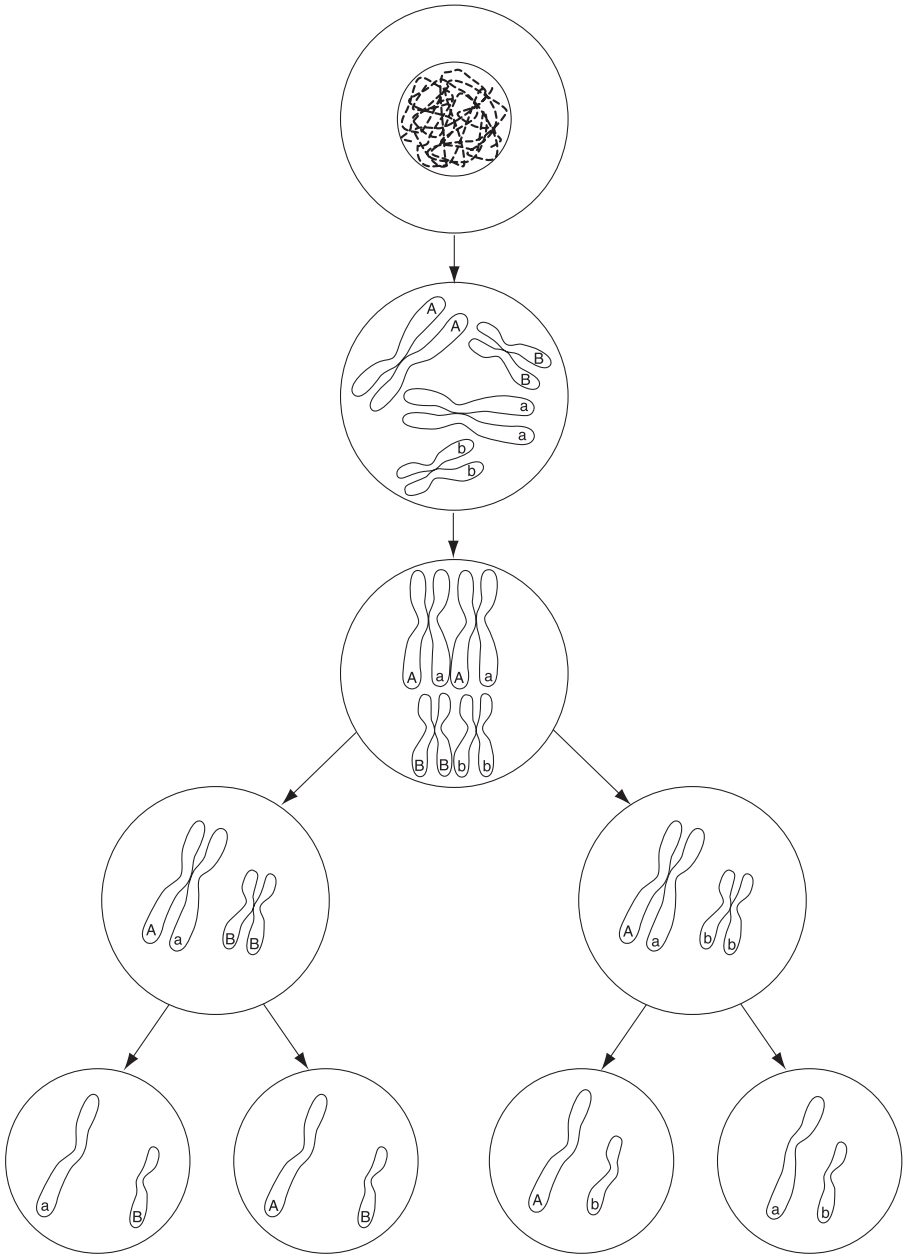
Question 28

Sample answer:

Mutations can occur when nuclei divide (DNA replicates). In asexual reproduction this can mean that daughter cells are different from the parent. In sexual reproduction, if this occurs in the gametes, the offspring can be different in a particular characteristic than both parents. If this change gives a survival advantage then they are likely to reproduce and their offspring (daughter cells) will have the new characteristic. The frequency of this characteristic will increase in the population over time – this is evolution.

Question 29 (a)

Sample answer:



Question 29 (b)

Sample answer:

In meiosis, there is a reduction division. Chromosome pairs line up together and one of each pair goes into the daughter cells. For each pair, this process is independent – hence a large number of combinations are possible.

Question 30

Sample answer:

Through microscopic observations just prior to the 1800s, it was known that bacteria were the cause of food spoilage and decay of human tissue. Louis Pasteur was able to show that these bacteria were not the result of spontaneous generation. In his famous swan-necked flask experiment he proved that dust carried bacteria onto food and caused food spoilage. This understanding has led to treatment and storage of food to kill existing microbes and sealing of the food to prevent entry of new microbes. This has also reduced the incidence of food poisoning.

Pasteur's work also indicated that pathogenic microbes could be carried in the air by dust particles from human to human. This has led to development of aseptic techniques during surgery that have extended life expectancies and the success rate of surgery.

Robert Koch developed methodologies to isolate and determine the specific microbial cause of a disease. Termed 'Koch's postulates', they are steps to follow once a disease is observed in an organism. He developed the techniques of culturing microbes and identifying microbes by colony form and microscopic form. The steps also involved the description of the disease and the innoculation of a healthy organism with a culture of the suspected pathogen.

Once a list of disease and causative pathogens had been compiled and the means to culture the pathogen has been developed, the development of vaccines was facilitated.

In general terms, the techniques of weakening or killing microbes led to the development of vaccines for identified diseases. This was first demonstrated by Pasteur who conferred immunity to anthrax by using a weakened anthrax.

Specific studies and development of techniques to understand viruses also led MacFarlane Burnet to begin our understanding of the immune system. Burnet concluded that a human immune system contained unactivated B cells that could be activated and produce an immune response following their exposure to a microbe.

This led to the development of the understanding of mechanisms underlying previous vaccination technologies and led to the exploration of further vaccination technologies such as sub unit vaccines.

Answers could include the development *of the technologies of quarantine and antibiotics*.

Question 31 (a) (i)

Answers could include:

A tympanic membrane
B ear ossicles/ossicles
C oval window

Question 31 (a) (ii)

Sample answer:

The ear ossicles amplify and transfer energy across the middle ear to the inner ear.

Question 31 (b) (i)

Answers could include:

Experiment/Model	*Eye*
Round bottom flask holding solution	Vitreous humour within round eyeball
Lens stuck onto flask	Lens of the eye
Fine paper stuck onto flask	Retina

Question 31 (b) (ii)

Sample answer:

Distance of candle from lens when image is sharp.

Question 31 (b) (iii)

Sample answer:

The model is like the eye because different lens thicknesses are required to obtain a clear image on the retina for objects at different distances. It differs from the eye because it uses different lenses rather than changing the shape of the lens during accommodation.

Question 31 (c) (i)

Sample answer:

Nocturnal animals such as cats have more rods than cones in their retinas since rods work well in low light settings and cones work well in bright light. Cats hunt for prey at night.

Insects have a compound eye composed of thousands of lens components. Each lens registers light from a different part of the environment thus enabling 360° detection of predators.

Question 31 (c) (ii)

Sample answer:

All over the body of some insects (caterpillars, grasshoppers and cockroaches) are fine hairs attached to mechanoreceptors that detect low frequency sounds. In others (mosquito) the mechanoreceptors are attached to antennae, which vibrate passively in the presence of a sound wave in air.

Crickets, grasshoppers, cicadas and butterflies have a tympanal organ: a very thin part of the exoskeleton which is stretched across a tracheae or air cavity. This organ can be located in the chest, abdomen, knee or wing area. This tympanal organ is caused to vibrate by incident sound waves in air and in some insects can detect ultrasonic waves (50-70kHz).

Bony fish have a line of mechanoreceptors along the side of the body. These comprise hair cell receptors. These have stereocilia that detect vibration and as a result release a neurotransmitter to a nerve that then carries the electrical signal to the central nervous system. They detect vibrations in the water and water flow.

In both fish and insects, the vibrations must be transduced to electrochemical energy in neurons.

Stimulus → receptor → induced vibrations → electrochemical signal → afferent pathway to CNS → processing → signal to efferent pathway → response.

The intensity and delay from different receptors helps to locate the sound and determine its nature.

Question 31 (d)

Sample answer:

Eyesight and hearing are essential for normal communication between humans and impairment diminishes the quality of life of individuals. In terms of sight, cloudiness of the lens caused by aging or pathways associated with glucose metabolism, prevents light getting to the retina. This can be treated simply by removing the lens and using spectacles to correct the focal distance, or replacing of the cloudy lens with a synthetic plastic one. Changes to the shape of the cornea or the length of the eyeball lead to hyperopia, myopia or astigmatism. These can be corrected with external lenses (spectacles or contact lenses) or by reshaping the cornea, eg LASIK. At this stage retina or optic nerve damage cannot be repaired but there is research being done with bionic eyes where charge coupled devices (CCDs) are being connected to nerves and emulate vision at low resolution. With hearing, hearing aids are used to amplify sound when the ability in the ossicles in the middle ear to respond to vibration decreases with age or abuse (loud sounds). These simply amplify the sound, but can be tuned to certain frequencies, which aids in isolating background noise. Bionic ears are used for people who are profoundly deaf due to damage to the hair cells in the cochlea but still have auditory nerve function. Essentially sound is sent by a receiver to the auditory nerves via wires implanted in the cochlea. The quality of sound is limited. With auditory nerve damage, an auditory brainstem implant can help. This is similar to the cochlear damage implant but connects directly to the auditory centre.

Question 32 (a)

Sample answer:

Biotechnological practice	*Name of chemical produced by yeast*	*Purpose of chemical produced*
Bread making	Carbon dioxide	Making bread dough rise
Wine production	Alcohol	To make alcoholic beverages

Question 32 (b) (i)

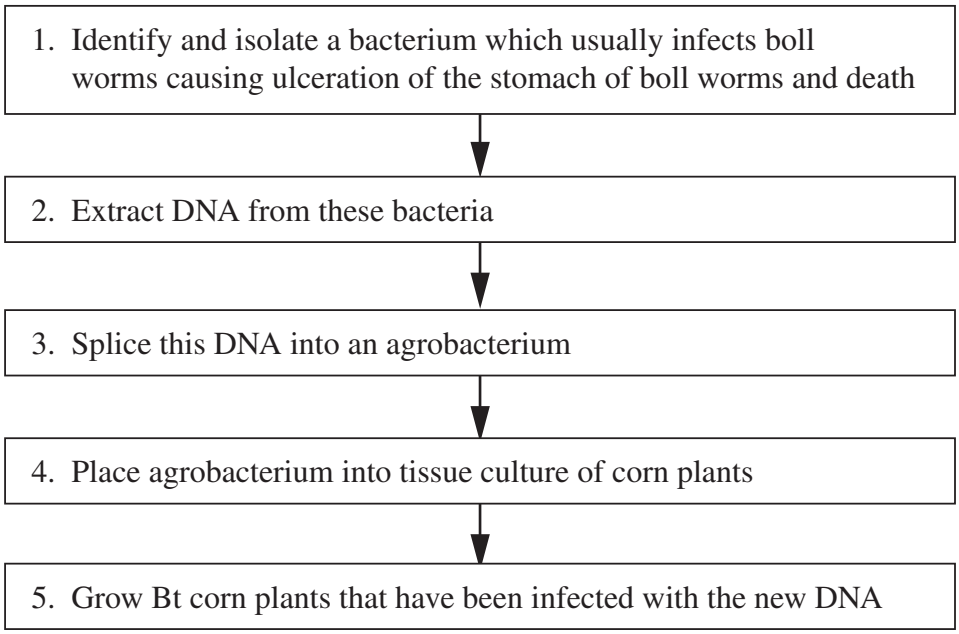
Sample answer:

Bt corn is a transgenic corn variety that contains the Bt gene that produces a toxin that harms caterpillars. This improves yield and reduces the need to spray insecticide.

Question 32 (b) (ii)

Sample answer:

The following sequence could be done:



Question 32 (c) (i)

Sample answer:

Aquaculture could be considered a biotechnology because it involves the growth of marine species in confined/contrived environments to produce useful products for human populations. It can involve development of transgenic species.

Question 32 (c) (ii)

Sample answer:

An obvious difference is that traditional agriculture is associated with producing plants for grains and fruit, whereas aquaculture involves growing water animals such as fish, echinoderms, crustaceans and molluscs. Aquaculture plants are also grown in the form of algae.

Traditional agriculture arose more than 10 000 years ago, involved clearing of land, planting desirable species and selecting the plants with the most desirable features to be used for the next plantings (selective breeding). In aquaculture, a form of clearing is also used. The water is 'cleared' by using nets around the desired species or special tanks or ponds are built, ie land is used for a completely different purpose. Although fish or algae are chosen for their desirable features, this is often enhanced these days using transgenics. Transgenic fish with antifreeze genes can be grown at low temperatures and transgenic algae can manufacture a wide range of amino acids previously confined to bacteria. Nutrients and special diets are used to enhance the growth in aquaculture, which is similar to using composting techniques in traditional agriculture. Aquaculture has the potential to supply more food because water occupies 70% of the earth's surface where arable land is <5%.

Question 32 (d)

Answers could include:

Early biotechnology, such as yeast or bacterial fermentation, was not informed by knowledge of internal cell processes. Rather it was developed from simple observations of processes which worked:

- some airborne bacteria changing milk in favourable ways
- the use of yeast on the surface of fruit to ferment crushed fruit.

We can now genetically engineer yeast, for example, to tolerate higher alcohol levels to give bigger yields.

The knowledge to do this has come from our understanding of cell biochemistry.

1. *Gene expression*

Knowledge of the means of gene expression:
m–RNA heading DNA
m–RNA at ribosome
t–RNA bringing amino acids to m–RNA

all contributed to the ability of biotechnologists to change this mechanism and change a cell product.

2. *Mechanisms of cutting and joining DNA with enzymes in cells*

Knowledge of DNA restriction enzymes – to cut up invading DNA
– DNA ligases – to mend broken DNA
contributed to the development of recombinant DNA and transgenic organisms producing useful cell products, eg cortisone and sex hormones for humans.

3. *Fermentation reaction sequences*

Once anaerobic and aerobic respiration was fully understood, these biochemical pathways could be altered using enzymes, thus changing cell products eg glycerol, lactic acid, citric acid, etc.

4. *Mass production of DNA for use in transformation of bacteria and other species*

– this was possible with the development of understanding of the polymerase enzyme system and also reverse transcriptase enzyme and high temperatures to melt DNA into single strands.

Discovering reverse transcriptase in viruses enabled application to construct DNA from RNA.

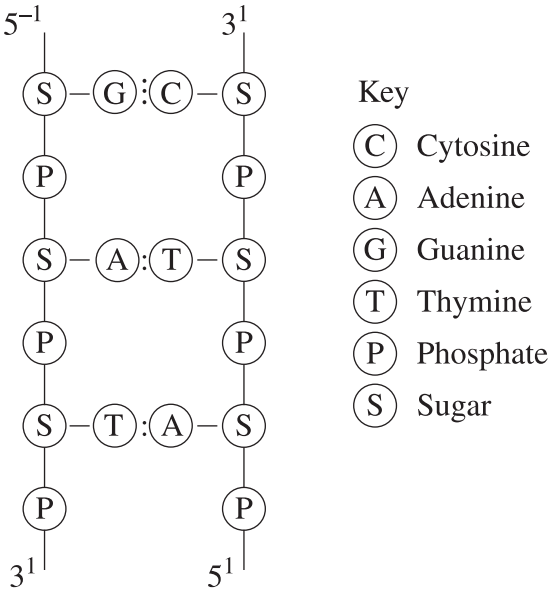
Question 33 (a)

Answers could include:

Type of cloning	*Process used*	*Example*
Gene Cloning	Production of single, identical genes for a purpose	Human insulin producing bacteria
Whole Organism Cloning	Transfer of all the DNA in a cell to the cloned organism	Dolly the Sheep

Question 33 (b) (i)

Sample answer:



Question 33 (b) (ii)

Sample answer:

Using the catalyst RNA polymerase, the DNA ‘unzips’ to provide a template on which mRNA nucleotides line up to form the complementary single strand of mRNA. The mRNA moves through the nuclear membrane to attach to a ribosome in the cytoplasm. The t-RNA with a complementary anti-codon is attracted to the mRNA, to align the amino acids into a polypetide.

Question 33 (c) (i)

Sample answer:

The HGP was an international effort to determine the position (locus) of every gene on each of the 23 chromosomes in humans and the nucleotide (base) sequence of every gene.

Question 33 (c) (ii)

Sample answer:

If the sequence of the gene is unknown, the protein that is produced from the gene can be used to determine the amino acid sequence. Using the amino acid sequence and working backwards, scientists can determine a possible DNA sequence that would code for the gene of interest. A radioactive probe of this gene will then be synthesised and allowed to base pair (nucleic acid hybridisation) with a partially denatured DNA strand on intact chromosomes. The binding of the radioactive DNA probe to a complementary section of a human chromosome can then be revealed using autoradiography.

Question 33 (d)

Sample answer:

Germ-line mutations occur in gametes and hence are transmitted to offspring and successive generations. Mutations in somatic cells are not transmitted to successive generations. If the mutation is in the coding portion of the genome, it could affect the phenotype, eg a base substitution that changed a codon and hence the amino acid being expressed could change the final protein and hence the phenotype. To function, organisms require narrow parameters. If one protein is wrongly made, one biochemical pathway would malfunction and the organism would not function normally.

Transposable genetic elements (TE) are foreign DNA sequences that can change their relative position on the genome and/or replicate themselves within the genome. TEs can disrupt the genome they invade by disrupting the base sequence of a functional gene and are likely to disable that gene – the protein the gene codes for is no longer made.

After the TE jumps, the gap in the DNA is unlikely to be repaired, again stopping the effective expression of that gene. Duplication of TEs and new locations of copies can disrupt even more genes. It can lead to chromosome elongation which disrupts pairing in mitosis and meiosis and consequently cell division.

TEs are not found in all cells of the organism like germ-line mutations. There is a chance that the coding DNA they might disrupt is not expressed in the cells in which they are located. In this way they may not affect the organism. While, the duplication of TEs and their movement through the genome can be problematic for a particular somatic cell, the abnormal functioning of one somatic cell will not necessarily disrupt the organism.

Question 34 (a) (i)

Sample answer:

In humans, compared with other primates, the pelvis is shallow and bowl-shaped to support abdominal organs when upright.
The knee is underneath pelvis (knock kneed).

Question 34 (a) (ii)

Sample answer:

The large brain relative to body size gives an advantage for learning/teaching by the adult primate in social groups, eg apes.

Question 34 (b) (i)

Sample answer:

Near identical mitochondrial DNA within one fossil site, but quite different between fossil sites, suggests that sites are isolated and individuals of a site have a common matriarch. Mitochondrial DNA is passed from mother to children. Lack of isolation would bring in different mitochondrial DNA.

Question 34 (b) (ii)

Sample answer:

Interbreeding occurred with Neanderthals and humans. Interbreeding occurred after migration from Africa. Neanderthals left Africa before modern humans evolved. Only small numbers of Neanderthals bred with humans.

Question 34 (c)

Sample answer:

Polymorphisms are the rich diversity of phenotypic forms in a species. They form as populations of the same species become isolated from each other (either physically or culturally) and diverge as a result of mutation and natural selection in different environments (or limited interbreeding due to cultural rules). The human species developed into races of genetically and physically isolated populations with unique combinations of phenotypes: skin colour, body shape, eye shape, hair type and distribution, eg major races on earth with their characteristic phenotype such as Asian versus Caucasian. Clinal gradations develop between populations in a species where the environmental selection pressures gradually change in the environments connecting two populations. In these transition environments, individuals with intermediate phenotypes can be naturally selected. These clinal gradations can be caused by human migration and settlement patterns. American Indians are a clinal gradation away from the Asian race: epicanthic eye fold (can be absent in males), light brown skin, thick hair.

Question 34 (d) (i)

Sample answer:

Fossil evidence suggests that *H. erectus* used stone tools, which enabled them to capture prey and butcher meat, and *H. neanderthalensis* used fire, which enabled cooking of food and a wider choice of food.

Question 34 (d) (ii)

Sample answer:

Biological evolution occurs when the genetic makeup of human populations changes over time. This can occur when humans are able to migrate and intermarry, or when humans who would not normally live to reproductive age do so and pass their genes onto the next generation, or when human embryos are genetically modified with new genes being introduced or some genes becoming more prevalent.

Fast transport technologies such as planes and ships allow people to migrate from their homelands to new places. Instead of staying on their tribal lands and marrying humans of their own kind, humans are venturing to new places and intermarrying with new groups of humans. This provides for new unique gene combinations resulting from inter-racial marriage.

I predict that with continued migration across the planet, differences in phenotypes between geographically differentiated racial groups will reduce over time.

Modern medicine
Modern medicine increases the life expectancy of many people who might otherwise die before reproductive age because of a disease. The genes for these diseases had a low frequency in human populations, but now have a higher frequency.

Medical treatments for asthma, heart conditions or inherited diabetes have resulted in longer lives for sufferers and thus an increased incidence of these diseases in subsequent generations.

Genetic engineering
Diseases like haemophilia have been uncommon in human history as sufferers died before reproductive age. This resulted in the genes for the disease having a low frequency in the population. Genetic engineering has allowed for the production of the clotting factor (missing in haemophiliacs) in bacteria and the development of a treatment for haemophiliacs. In this way the number of haemophiliacs in the population is likely to increase. This appears to weaken the population and decrease its ability to survive.

Question 35 (a) (i)

Sample answer:

Product is oxygen and the source is water.

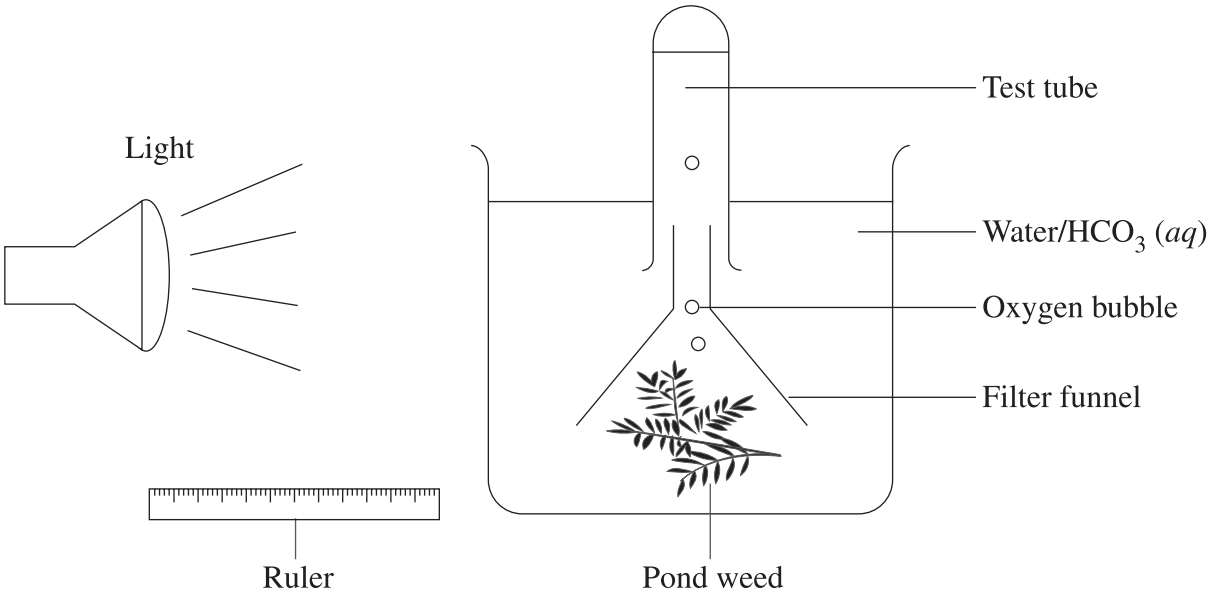
Question 35 (a) (ii)

Sample answer:

Sugars made during photosynthesis can be converted to ethanol and this is used in petrol. Oils made from plants because of photosynthesis can be used for biodiesel fuel.

Question 35 (b) (i)

Sample answer:



Question 35 (b) (ii)

Sample answer:

Measures the volume of gas in mL in relation to the distance of light from the plants.

Question 35 (b) (iii)

Sample answer:

Place the apparatus in a chamber containing different levels of carbon dioxide and measure the amount of gas being produced with the light held at a constant distance.

Question 35 (c) (i)

Sample answer:

ATP is a high energy molecule. In ATP, the phosphodiester bonds between the three phosphate groups can be broken to produce a large amount of energy which is used for driving biological reactions.

Question 35 (c) (ii)

Sample answer:

Light stimulates chlorophylls to higher energy states and this energy is transferred to a pair of chlorophyll molecules in the reaction centres of photosystem I or photosystem II, located in the granal or stromal thylakoid membranes respectively. When the chlorophyll of the reaction centre becomes excited it can readily lose electrons. In photosystem II, the electrons are lost to pheophytin and eventually transferred to the chlorophylls of photosystem I. The lost electrons are replaced via a cluster of manganese ions by the splitting of 2 water molecules into 4 hydrogen ions and oxygen. In photosystem 2, the electrons are transferred through a series of molecules to NADP+ to form NADPH. In the process hydrogens accumulate or are transferred into the lumen of the chloroplast and, when they return to the stroma via ATP synthase, they cause the synthesis of ATP from ADP.

Question 35 (d)

Sample answer:

Before radioactive tracers were used, scientists were limited to identification of reactants and products in a biochemical reaction, but this often represented the start and end of a pathway, rather than the actual reaction series. Denebier for example was able to demonstrate that CO_2 was used in photosynthesis but unable to determine where the oxygen in the CO_2 was located in the products, ie in the glucose or in the water.

When radioactive isotopes were first used, it was important to know the half-life of the isotope so as to test for the presence within a small number of half-lives lest the concentration fell too low to be measured, eg C-11 – 20.38 minutes and O-15 – 122.24 seconds. Ruben used CO_2 with single-cell algae to find out the series of organic molecules in which CO_2 was incorporated in the early stages of carbon fixation.

Calvin used 14 CO_2 (long half-life) for pulse-chase experiments with single-celled algae. He used alcohol to kill the cells at regular time intervals, determining the sequence of organic molecules produced at each time interval by using paper chromatography. Using this method he determined the reaction pathway for carbon fixation.