B3 Crash Course!

Molecules of Life

1. Appreciate that the fundamental processes of life occur inside cells.
2. In this unit you study the role of DNA in the production of proteins, the building blocks of living things.
3. This unit provides the opportunity to explain phenomena using scientific theories, models and ideas.
4. The discovery of the structure of DNA illustrates the collaborative nature of science and the need for new discoveries to be validated.
5. Know  that respiration occurs in the mitochondria providing energy for life processes.
6. Know  that chromosomes in the nucleus:
   * a) carry coded information in the form of genes
   * b) are made of a molecule called DNA.
7. Know  that the information in genes is in the form of coded instructions called the genetic code.
8. Understand that the genetic code controls cell activity and consequently some characteristics of the organism.
9. Know  that DNA controls the production of different proteins.
10. Know  that proteins are needed for the growth and repair of cells.
11. Know  that the structure of DNA was first worked out by two scientists called Watson and Crick.
12. Be able to explain why liver and muscle cells have large numbers of mitochondria.
13. **HT only**: Know  that:
    * a) some structures in cells, such as ribosomes, are too small to be seen with the light microscope
    * b) ribosomes are in the cytoplasm and are the site of protein synthesis.
14. Be able to describe the structure of DNA as two strands coiled to form a double helix, each strand containing chemicals called bases, of which there are four different types, with cross links between the strands formed by pairs of bases.
15. Be able to describe chromosomes as long, coiled molecules of DNA, divided up into regions called genes.
16. Know  that each gene:
    * a) contains a different sequence of bases
    * b) codes for a particular protein.
17. Know  that proteins are made in the cytoplasm and understand why a copy of the gene is needed: the gene itself cannot leave the nucleus.
18. **HT only**: Know  that the four bases of DNA are A, T, C and G (full names will not be required).
19. **HT only**: Be able to describe the complementary base pairings: A – T and G – C.
20. **HT only**: Be able to explain how protein structure is determined by the DNA base code, to include:
    * a) the base sequence determines amino acid sequence
    * b) each amino acid is coded for by a sequence of 3 bases.
21. **HT only**: Be able to explain how the code needed to produce a protein is carried from the DNA to the ribosomes by a molecule called mRNA.
22. **HT only**: Be able to explain how DNA controls cell function by controlling the production of proteins, some of which are enzymes.
23. Be able to describe how Watson and Crick used data from other scientists to build a model of DNA, to include:
    * a) X-ray data showing that there were two chains include: wound in a helix,
    * b) data indicating that the bases occurred in pairs.
24. **HT only**: Be able to explain why new discoveries, such as Watson and Crick’s, are not accepted or rewarded immediately, to include
    * a) the importance of other scientists repeating or testing the work.

Proteins & Mutations

1. Appreciate that the genetic material in the form of DNA codes for the production of proteins.
2. You also study the importance of understanding the role of mutations and how they can alter the proteins that a cell produces.
3. The study of enzyme action provided the opportunity to gain the skills of working accurately and safely, individually and with others, to collect first-hand data and to test a scientific explanation using scientific theories, models and ideas.
4. Know some examples of proteins to include:
   * a) collagen
   * b) insulin
   * c) haemoglobin.
5. Be able to describe enzymes as:
   * a) proteins
   * b) molecules that speed up a chemical reaction
   * c) working best at a particular temperature.
6. Understand that enzymes have active sites that substrate molecules fit into when a reaction takes place.
7. Be able to recognise that different cells and different organisms will produce different proteins.
8. Be able to describe gene mutations as changes to genes.
9. Be able to recognise that proteins are made of long chains of amino acids.
10. Be able to describe some functions of proteins, to include:
    * a) structural (limited to collagen)
    * b) hormones (limited to insulin)
    * c) carrier molecules (limited to haemoglobin)
    * d) enzymes.
11. Be able to explain how each protein has its own number and sequence of amino acids, which results in differently shaped molecules, which have different functions.
12. Be able to describe enzymes as:
    * a) biological catalysts
    * b) catalysing chemical reactions occurring in living cells: respiration, photosynthesis and protein synthesis
    * c) having a high specificity for their substrate
13. **HT only**: Be able to explain how enzyme activity is affected by pH and temperature, to include:
    * a) lower collision rates at low temperatures
    * b) denaturing at extremes of pH and high temperatures
    * c) denaturing as an irreversible change inhibiting enzyme function
    * d) denaturing changing the shape of the active site.
14. Be able to explain the specificity of enzymes in terms of the enzyme function ‘lock and key’ mechanism.
15. Be able to describe how changing temperature and pH, away from the optimum, will change the rate of reaction of an enzyme-catalysed reaction.
16. **HT only**: Calculate and interpret the Q10 value for a reaction of over a 10°C interval, given graphical or numerical  data, using the formula:
    * Q10 = rate at higher temperature / rate at lower temperature
17. Know that gene mutations may lead to the production of different proteins.
18. **HT only**: Understand that only some of the full set of genes are used in any one cell; some genes are switched off.
19. Understand that mutations occur spontaneously but can be made to occur more often by radiation or chemicals.
20. **HT only**: Understand that the genes switched on determine the functions of a cell.
21. **HT only**: Be able to explain how changes to genes alter, or prevent the production of the protein which is normally made.
22. Understand that mutations are often harmful but may be beneficial or have no effect.

Respiration

1. Understand that respiration is a vital reaction that takes place inside cells and this process releases the energy that is needed to drive many other metabolic reactions.
2. Be able to recognise that the energy provided by respiration is needed for all life processes in plants and in animals.
3. Know and use the word equation for aerobic respiration:
   * **glucose + oxygen ==> carbon dioxide + water**
4. Be able to describe examples of life processes that require energy from respiration, to include:
   * a) muscle contraction
   * b) protein synthesis
   * c) control of body temperature in mammals.
5. Be able to explain why breathing and pulse rates increase during exercise.
6. Be able to describe an experiment to measure resting pulse rate and recovery time after exercise.
   * Be able to analyse given data from a pulse rate experiment.
7. Know and use the symbol equation for aerobic respiration:
   * **C6H12O6 + 6O2 ==> 6CO2 + 6H2O**
8. Be able to use data from experiments to compare respiration rates, to include:
   * a) increased oxygen consumption
   * b) increased carbon dioxide production.
9. Calculate the respiratory quotient (RQ) using the formula (data provided):
   * **RQ = carbon dioxide produced / oxygen used**
10. **HT only**: Know that respiration results in the production of ATP and that ATP is used as the energy source for many processes in cells.
11. **HT only**: Be able to explain how the rate of oxygen consumption can be used as an estimate of metabolic rate because aerobic respiration requires oxygen.
12. **HT only**: Be able to explain why the rate of respiration is influenced by changes in temperature and pH.
13. Be able to explain why anaerobic respiration takes place during hard exercise in addition to aerobic respiration.
14. Know that this produces lactic acid which accumulates in muscles causing pain and fatigue.
15. Know and use the word equation for anaerobic respiration which releases energy:
    * **glucose ==> lactic acid**
16. Understand that anaerobic respiration releases much less energy per glucose molecule than aerobic respiration.
17. **HT only**: Be able to explain fatigue in terms of lactic acid build up (oxygen debt) and how this is removed during recovery, to include:
    * a) hard exercise causing lack of oxygen in cells
    * b) the incomplete breakdown of glucose
    * c) continued panting replacing oxygen allowing aerobic respiration
    * d) increased heart rate ensuring that blood carries lactic acid away to the liver.

Cell Division

1. Appreciate that as living things grow, the number of cells in them increases bringing significant advantages, and requires the development of complex organ systems.
2. In this unit you studied the two ways cells divide, mitosis and meiosis, and the differences between these types of cell division.
3. Be able to describe the difference between simple organisms which are unicellular and more complex organisms which are multicellular.
4. Know that most body cells contain chromosomes in matching pairs.
5. Be able to explain why the chromosomes have to be copied to produce new cells for growth.
6. Know that this type of cell division is also needed for:
   * a) replacement of worn out cells
   * b) repair to damaged tissue
   * c) asexual reproduction.
7. Know that in sexual reproduction gametes join in fertilisation.
8. Know that gametes have half the number of chromosomes of body cells.
9. Understand that in sexual reproduction to produce a unique individual half the genes come from each parent.
10. Be able to explain why sperm cells are produced in large numbers to increase the chance of fertilisation.
11. Be able to explain the advantages of being multicellular:
    * a) allows organism to be larger
    * b) allows for cell differentiation
    * c) allows organism to be more complex.
12. **HT only**: Be able to explain why becoming multicellular requires the development of specialised organ systems, limited to:
    * a) communication between cells
    * b) supplying the cells with nutrients
    * c) controlling exchanges with the environment.
13. Know that new cells for growth are produced by mitosis.
14. Be able to explain why these new cells are genetically identical.
15. Know that in mammals, body cells are diploid (two copies of each chromosome).
16. Be able to explain why DNA replication must take place before cells divide.
17. **HT only**: Be able to describe how, prior to mitosis, DNA replication occurs, to include:
    * a) ‘unzipping’ to form single strands
    * b) new double strands forming by complementary base pairing.
18. **HT only**: Be able to describe how in mitosis the chromosomes:
    * a) line up along the centre of the cell
    * b) they then divide
    * c) the copies move to opposite poles of the cell.
19. Know that gametes are produced by meiosis.
20. Be able to describe gametes as haploid (contain one chromosome from each pair).
21. Be able to explain why fertilisation results in genetic variation, limited to:
    * a) gametes combine to form a diploid zygote
    * b) genes on the chromosomes combine to control the characteristics of the zygote.
22. Be able to explain how the structure of a sperm cell is adapted to its function, to include:
    * a) many mitochondria to provide energy
    * b) an acrosome that releases enzymes to digest the egg membrane.
23. **HT only**: Be able to explain why, in meiosis, the chromosome number is halved and each cell is genetically different, to include
    * a) one chromosome from each pair separate to opposite poles of the cell in the first division
    * b) chromosomes divide and the copies move to opposite poles of the cell in the second division.

Circulatory System

1. Appreciate that the development of larger, multicellular organisms has resulted in the development of complex organ systems and in this unit you study a description of one of these systems, the **circulatory system**.
2. It explains why blood is vital for life as it transports materials around the body to and from different cells.
3. Be able to describe the functions of components of the blood:
   * a) red blood cells
   * b) white blood cells
   * c) platelets.
4. Know that the blood moves around the body in:
   * a) arteries
   * b) veins
   * c) capillaries.
5. Be able to describe the functions of the heart in the pumping of blood, to include:
   * a) the right side of the heart pumping blood to the lungs
   * b) the left side of the heart pumping blood to the rest of the body.
6. Know that blood in arteries is under higher pressure than blood in the veins.
7. Be able to explain, in terms of pressure difference, why blood flows from one area to another.
8. Be able to explain how the structure of a red blood cell is adapted to its function: size, shape, contains haemoglobin, lack of nucleus.
9. Be able to describe the function of plasma.
10. **HT only**: Be able to explain how the structure of a red blood cell is adapted to its function in terms of the small size providing a large surface area to volume ratio.
11. **HT only**: Be able to describe how haemoglobin in red blood cells reacts with oxygen in the lungs to form oxyhaemoglobin and how the reverse of this reaction happens in the tissues.
12. Be able to describe how the parts of the circulatory system work together to bring about the transport of substances around the body, to include:
    * a) arteries transporting blood away from the heart
    * b) veins transporting blood to the heart
    * c) capillaries exchanging materials with tissues.
13. **HT only**: Be able to explain how the adaptations of arteries, veins and capillaries relate to their functions, to include:
    * a) thick muscular and elastic wall in arteries
    * b) large lumen and presence of valves in veins
    * c) permeability of capillaries.
14. Be able to identify the names and positions of the parts of the heart and describe their functions, to include:
    * a) left and right ventricles to pump blood
    * b) left and right atria to receive blood
    * c) semilunar, tricuspid and bicuspid valves to prevent backflow
    * d) four main blood vessels of the heart.
15. Be able to explain why the left ventricle has a thicker muscle wall than the right ventricle.
16. **HT only**: Be able to explain the advantage of the double circulatory system in mammals, to include:
    * a) higher pressures
    * b) therefore greater rate of flow to the tissues.

Growth & Development

1. Appreciate the growth of organisms can be measured in different ways.
2. Understand that there are similarities in the patterns of growth and development in all organisms, but there are some major variations between plants and animals and this unit explores some of these differences.
3. Be able to describe the functions of parts of a plant cell to include:
   * a) vacuole, containing cell sap and providing support
   * b) the cell wall, made of cellulose to provide support.
4. Be able to describe how to make a stained slide of an onion cell.
5. Understand that bacterial cells are smaller and simpler than plant and animal cells.
6. Know that growth can be measured as an increase in height, wet mass or dry mass.
7. Interpret data on a typical growth curve for an individual.
8. Be able to describe the process of growth as cell division followed by cells becoming specialised.
9. Know that the process of cells becoming specialised is called differentiation.
10. Understand that animals grow in the early stages of their lives whereas plants grow continually.
11. Understand that all parts of an animal are involved in growth whereas plants grow at specific parts of the plant.
12. Be able to identify simple differences between bacterial cells and plant and animal cells.
13. Know that bacterial cells lack:
    * a) a ‘true’ nucleus
    * b) mitochondria
    * c) chloroplasts.
14. **HT only**: Be able to describe the difference between the arrangement of DNA in a bacterial cell and a plant/animal cell, to include:
    * a) presence/absence of a nucleus
    * b) single circular strand/chromosomes.
15. Know that dry mass is the best measure of growth.
16. Be able to interpret data on increase in mass (including wet and dry mass).
17. Be able to describe the main phases of a typical growth curve.
18. Know that in human growth there are two phases of rapid growth, one just after birth and the other in adolescence.
19. **HT only**: Be able to explain the advantages and disadvantages of measuring growth by:
    * a) length
    * b) wet mass
    * c) dry mass.
20. **HT only**: Be able to explain why the growth of parts of an organism may differ from the growth rate of the whole organism.
21. Know that undifferentiated cells called stem cells can develop into different cells, tissues and organs.
22. Know that stem cells can be obtained from embryonic tissue and could potentially be used to treat medical conditions.
23. Discuss issues arising from stem cell research in animals.
24. **HT only**: Be able to explain the difference between adult and embryonic stem cells.
25. Be able to explain why plant growth differs from animal growth, to include:
    * a) animals tend to grow to a finite size but many plants can grow continuously
    * b) plant cell division is mainly restricted to areas called meristems
    * c) cell enlargement is the main method by which plants gain height
    * d) many plant cells retain the ability to differentiate but most animal cells lose it at an early stage.

New Genes For Old

1. Appreciate that genetic engineering and genetic modification are relatively recent terms but humans have been genetically modifying animals and plants using selective breeding for thousands of years.
2. Debating the arguments for and against GM and gene therapy gives you an opportunity to discuss how and why decisions about science are made and demonstrate the limitations of science to providing factual information and new techniques.
3. Appreciate the decisions as to whether to use these techniques need to be taken by representatives of the whole population.
4. Be able to describe the process of selective breeding as involving the:
   * a) selection of desired characteristics
   * b) cross breeding
   * c) selection of suitable offspring over many generations.
5. Be able to explain how selective breeding can contribute to improved agricultural yields.
6. Know that:
   * a) selected genes can be artificially transferred from one living organism to another
   * b) this transfer of genes is called genetic engineering or genetic modification
   * c) the transfer of genes can produce organisms with different characteristics.
7. Identify features of plants and animals that might be selected for in a genetic engineering programme.
8. Be able to recognise that in the future it may be possible to use genetic engineering to change a person’s genes and cure certain disorders.
9. Be able to recognise that a selective breeding programme may lead to inbreeding, which can cause health problems within the species.
10. **HT only**: Be able to explain how a selective breeding programme may reduce the gene pool leading to problems of inbreeding, to include:
    * a) accumulation of harmful recessive characteristics
    * b) reduction in variation.
11. Be able to explain some potential advantages and risks of genetic engineering:
    * a) advantage – organisms with desired features are produced rapidly
    * b) risks – inserted genes may have unexpected harmful effects.
12. Be able to describe, in outline only, some examples of genetic engineering:
    * a) taking the genes from carrots that control beta-carotene production and putting them into rice.
      + Humans can then convert the beta-carotene from rice into Vitamin A (solving the problem of parts of the world relying on rice but lacking vitamin A)
    * b) the production of human insulin by genetically engineered bacteria
    * c) transferring resistance to herbicides, frost damage or disease to crop plants.
13. Be able to discuss the ethical issues involved in genetic modification.
14. **HT only**: Understand the principles of genetic engineering, to include:
    * a) selection of desired characteristics
    * b) isolation of genes responsible
    * c) insertion of the genes into other organisms
    * d) replication of these organisms.
15. Know that changing a person’s genes in an attempt to cure disorders is called gene therapy.
16. **HT only**: Know that gene therapy could involve body cells or gametes.
17. **HT only**: Be able to explain why gene therapy involving gametes is controversial.

Cloning

1. Appreciate that human individuals are unique, yet modern science has the ability to create genetically identical copies of complex organisms and this unit considers the advantages and disadvantages of using this scientific knowledge.
2. Possible practical and research activities you engaged in may have included:
3. Know that:
   * a) cloning is an example of asexual reproduction
   * b) cloning produces genetically identical copies (clones).
4. Know that Dolly the sheep was the first mammal cloned from an adult.
5. Be able to recognise that identical twins are naturally occurring clones.
6. Be able to recognise that plants grown from cuttings or tissue culture are clones.
7. Be able to describe how spider plants, potatoes and strawberries reproduce asexually.
8. Be able to describe how to take a cutting.
9. Understand that Dolly the sheep was produced by the process of nuclear transfer and that nuclear transfer involves placing the nucleus of a body cell into an egg cell.
10. Be able to describe some possible uses of cloning, limited to:
    * a) mass producing animals with desirable characteristics
    * b) producing animals that have been genetically engineered to provide human products
    * c) producing human embryos to supply stem cells for therapy.
11. Understand the ethical dilemmas concerning human cloning.
12. **HT only**: Be able to describe in outline the cloning technique used to produce Dolly, to include:
    * a) nucleus removed from an egg cell
    * b) egg cell nucleus replaced with the nucleus from an udder cell
    * c) egg cell given an electric shock to make it divide
    * d) embryo implanted into a surrogate mother sheep
    * e) embryo grows into a clone of the sheep from which the udder cell came.
13. **HT only**: Be able to describe the benefits and risks of using cloning technology.
14. **HT only**: Be able to explain the possible implications of using genetically modified animals to supply replacement organs for humans.
15. Be able to describe the advantages and disadvantages associated with the commercial use of cloned plants, to include:
    * a) advantage – can be sure of the characteristics of the plant since all plants will be genetically identical
    * b) advantage – it is possible to mass produce plants that may be difficult to grow from seed
    * c) disadvantage – if plants become susceptible to disease or to change in environmental conditions then all plants will be affected
    * d) disadvantage – lack of genetic variation.
16. **HT only**: Be able to describe plant cloning by tissue culture, to include:
    * a) selection for characteristics
    * b) large number of small pieces of tissue
    * c) aseptic technique
    * d) use of suitable growth medium and conditions.
17. **HT only**: Be able to explain why cloning plants is easier than cloning animals: many plant cells retain ability to differentiate unlike animal cells which usually lose this ability at an early stage.