Biological Systems: Body systems and cells + Inheritance

Links to curriculum learning outcomes:

Body systems and cells – Third (SCN 3-13a & SCN 3-14b):

- *Using a microscope, I have developed my understanding of the structure and variety of cells and of their functions.*
- *I have extracted DNA and understand its function. I can express an informed view of the risks and benefits of DNA profiling.*

Inheritance – Fourth (SCN4 – 14c) :

- *I can use my understanding of how characteristics are inherited to solve simple genetic problems and relate this to my understanding of DNA, genes and chromosomes.*

Teachers' Notes

DNA, Chromosomes & Genes

These teachers' notes are designed to provide you with all the information you need to teach a lesson on this topic using the slide show. These notes explain the concepts in greater detail than you will need to for pupils at this level but they may help answer any complicated questions pupils have and be useful for your background knowledge. There are also notes under each slide to help you explain them.

The learning outcomes of the slide show are for pupils to understand:

- Cells are the basic building blocks of living things
- Inside our cells is a nucleus
- Our DNA is stored in the nucleus
- The nucleus contains all the instructions for the cell
- DNA is packaged into chromosomes in the nucleus
- Different bits of chromosomes represent different genes
- Our genes tell our cells and our body how to grow and develop
- Errors in our genes cause problems

- Cells are the basic building block for living things

All living things are made up of cells. Cells are the basic unit of life; they are the smallest unit of an organism that is classified as living. The analogy that bricks are the basic building blocks for houses is used to reinforce this.

Some organisms, like most bacteria, are unicellular. They are made up of one cell. Other organisms, like humans, are multi-cellular. It is estimated that humans have around a 100 trillions cells in our bodies.

- Inside our cells is a nucleus
- Our DNA is stored in the nucleus

Eukaryotic cells have a nucleus and other membrane bound organelles. DNA is stored in the nucleus and each organelle has a specific function within the cell. All the species within the Eukaryota domain, which includes protists, fungi, plants and animals, have eukaryotic cells. Individual protists are unicellular, while fungi, plants and animals are multi-cellular.

Prokaryotic cells (such as bacteria) have no nucleus or membrane bound organelles. DNA is not enclosed into a nucleus, instead it forms an irregularly shaped region known as the nucleoid. Species within the Archaea and Eubacteria domains are made up of prokaryotic cells.

The distinction between eukaryotic and prokaryotic cells is not taught to pupils at this level. To minimise confusion pupils are simply taught that DNA is stored in the nucleus.

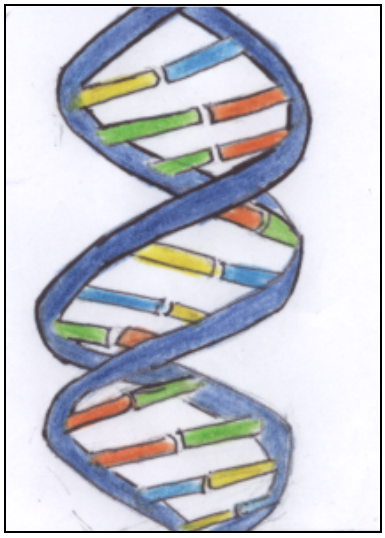
- The nucleus contains all the instructions for the cell

Each cell contains a full set of our DNA, which is stored in the nucleus. DNA stores information. It contains the instructions required to construct other components of the cell, like the proteins and RNA molecules. The analogy of a cake recipe is used in the PowerPoint to illustrate this; a recipe contains the instructions to make a cake while the DNA contains the instructions for the cell.

DNA stands for deoxyribonucleic acid. It is a nucleic acid which provides the genetic instructions used in development and functioning of all free living organisms and some viruses. It is made up of two long polymers of nucleotides with a sugar and phosphate group backbone. The sugar and phosphate group are joined together by ester bonds. The two nucleotide strands run in opposite directions to each other; they are anti-parallel.

The two long strands of DNA are twisted into a double helix structure. They look like a ladder, which has been twisted around. This double helix structure gives the DNA stability within the cells.

Below is a diagram of the structure of part of a DNA double helix, which illustrates the two strands running in opposite directions to each other:



Each individual sugar has a base attached to it. There are four different types of bases: cytosine (C), guanine (G), thymine (T) and adenine (A). (In the case of RNA, uracil (U) replaces thymine.)

The specific sequence of these 4 bases encodes the instructions telling the cell which protein to make. The base sequence is read using the genetic code. It tells the cell which amino acid to use and in which order to make up the correct protein. Each amino acid is coded for by 3 bases, which are referred to as codons. In total there are 20 standard amino acids encoded by specific codons. Genetic redundancy is a feature of the genetic code because more than one codon sequence can code for the same amino acid.

- DNA is packaged into chromosomes in the nucleus

Each DNA molecule is very long and so is packaged into structures called chromosomes. Chromosomes are found in pairs in our nucleus. Humans have 23 pairs of chromosomes. Of these, 22 are autosomes (non-sex chromosomes) and 1 is the sex chromosome pair. The sex chromosomes determine our sex. In humans, females have two X sex chromosomes (XX) while males have one X and one Y (XY).

DNA is carefully packaged into chromosomes by various proteins, including histone proteins.

- Different bits of chromosomes represent different genes
- Our genes tell our cells and our body how to grow and develop

Our genetic information specifying specific traits is carried by segments of DNA called genes. Humans have approximately 22,000 genes.

We have two copies of every gene. Different copies of a gene are referred to as alleles. For each gene, we inherit one allele from our mother and one from our father. Stronger alleles can be dominant while weaker ones are recessive.

The effect of dominant alleles is always seen regardless of whether there is one or two copies present in the cell. This is because they mask the effect of recessive alleles. The effect of recessive alleles is only seen when both recessive copies are present.

Some definitions:-

Phenotype = physical appearance of an organism
Genotype = genetic constitution of an organism, i.e. the alleles present
Homozygous = when the same two alleles are present in the genotype
Heterozygous = when two different alleles are present in the genotype

Some traits we exhibit are controlled by one gene. Some examples of these traits are free ear lobes versus attached ear lobes, tongue rolling versus non tongue rolling, dimpled chin versus not dimpled chin. However, like most things in biology, the majority of traits are more complicated. They are the result of the interaction between many genes and the environment.

- Errors in our genes cause problems

DNA damage can be caused by many different sorts of mutagens, including oxidizing and alkylating agents, UV lights and X rays. This damage can bring about a change to the DNA sequence. We have mechanisms in our cells to repair damage; sometimes our cells can repair themselves. However, sometimes damage cannot be repaired by our cells. Our bodies can no longer produce the correct proteins to function, which causes problems. Genetic diseases are caused by errors in our genes.