Inheritance

Chromosomes, genes and DNA

- The transfer of features from one generation to the next is called inheritance
- The characteristics are controlled by genes which are like coded instructions
- The study of inheritance is known as genetics
- Genes from one generation are transmitted to the next in the gametes
- At fertilization, the gametes fuse to form a zygote which contains the genetic information from both parents
- A new individual grows from the zygote-half of its genetic information comes from its male parent and half from its female

Chromosomes

- A chromosome is a thread of DNA, made up of a string of genes
- There 46 chromosomes in the nucleus of a human cell
- This is called the diploid number
- The chromosomes are different shapes and sizes
- They can be sorted into pairs based on their shape and size
- Chromosomes are made out of a long chain molecules called DNA (deoxyribonucleic acid)
- DNA is wound around molecules of protein
- During cell division the DNA and protein are packed very tightly together and the chromosomes are coiled up
- At other times they are uncoiled so the cell can use the information in the DNA

Genes

- Genes are lengths of DNA
- Each chromosome has many genes along its length, although the actual number depends on its length
- Each gene is a unit of inheritance in that it codes for a specific protein
- It is a chemical code that the cell interprets as an instruction to make a protein molecule
- Human have between 20 000 to 25 000 different genes
- The proteins produced by cells influence how the body works and what it look like
- Some features that genes control are influenced by the environment (height i.e. diet & exercise)
- Other genes are not affected by the environment (e.g. blood group)

Protein synthesis

- The length of DNA, making up a particular gene carries the information needed to make a particular protein.
- Inside every cell, there are thousands of different chemical reactions taking place
- Enzymes control all these chemicals
- DNA determines which enzymes are produced in each cell and therefore which chemical reaction take place inside cells
- The structure of DNA contains bases
- The information is found in the sequence of bases along the length of DNA
- These determine the sequence of amino acids in the protein

- DNA also controls the production of antibodies and receptors for neurotransmitters
- DNA carries information to build proteins from amino acids
- The information moves from the DNA to the site of the protein synthesis in the ribosomes by a kind of messenger molecule
- This molecule is mRNA (messenger RNA)
- The role of mRNA is to carry a copy of the base sequence on DNA out of the nucleus to the ribosomes in the cytoplasm where protein synthesis occurs

The genetic code

- There are four different bases found in DNA (A,T, C and G)
- Each amino acid is coded for by a different base triplet on DNA
- When mRNA copies the code on DNA it does so by the rule of base pairing
- However, mRNA does not have the base T-this is replaced by another base U (uracil)
- Therefore A on DNA will code for U on mRNA

The coded information on mRNA is used to assemble amino acids in the correct sequence for each protein.

- The mRNA arrives at the ribosomes from the nucleus
- The mRNA strand contains the base triplets for each particular amino acid in the protein
- The mRNA then passes through the ribosomes and each ribosome assembles amino acids into protein molecules
- The amino acids bond together forming a long chain-the protein
- The specific order of amino acids is determined by the sequence of the bases in the mRNA and each amino acid is joined to the next one by a peptide bond

All body cells in an organism contain the same genes. However, in a particular cell many genes may not be expressed because the cell makes only the specific proteins it needs

Mitosis

- Mitosis is a type of nuclear division that occurs during growth and asexual reproduction. The daughter cells are genetically identical
- Before a cell can divide, new copies of genetic information in the DNA of the chromosomes must be made
- This copying process occurs before the nucleus divides
- While it is going on, the DNA in the chromosomes is uncoiled and arranged very loosely in the nucleus
- The new copy of DNA of each chromosome is attached to the original copy
- As mitosis begins, the DNA coils up so that each chromosome becomes thicker
- During mitosis, the two copies separate so each new cell gets a copy of each chromosome
- As a result of mitosis, each daughter cell has the same chromosome number as the original parent cell
- As the chromosomes have been copied by a reliable system, they are genetically identical to each other and to the parent cell
- If they were genetically different they would be rejected by the body's immune system
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The Significance of mitosis

Mitosis is important for the following processes:

- Growth
- Repair of wounds
- Replacement of cells that wear out and die
- Asexual reproduction

Stem Cells

- Some of the cells that form an embryo remain as unspecialized cells
- They do not develop into any type of specialized cell
- These cells keep dividing by mitosis to provide the body with a constant supply of new cells
- These cells are needed to replace cells that get worn out and die
- Each time a stem cell divides, one daughter cells starts to become specialized for some specific function
- The other daughter cells remains unspecialized and undergoes mitosis again

Meiosis

- Meiosis is a type of cell division that is essential for sexual reproduction
- It takes place in the reproductive organs and results in the formation of gametes with half the normal chromosome number
- This is known as the haploid number
- Meiosis halved the number of chromosomes so egg cells and sperms cells have 23 chromosomes each
- The zygote has 46 chromosomes, 23 from the mother's egg cell and 23 from the father's sperm
- Meiosis occurs in sex organs in humans- the ovaries and testes
- In flowering plants meiosis occurs in the anthers and in the ovules
- In meiosis the daughter cells are not identical
- They are genetically different and this contributes to genetic variation that provides the raw materials for selection and allows organisms to evolve in response to changing environments

Differences between mitosis and meiosis

Mitosis	Meiosis
One division	Two divisions
The number of chromosomes remains the same	The number of chromosomes is halved
The daughter cells are genetically identical	The daughter cells are genetically different from the parent cells
Two daughter cells are formed	Four daughter cells are formed

Inheritance and genes

- Pedigree diagrams show how features are inherited in families
- An allele is a version of a gene. Most genes have many alleles

- The genotype is the genetic makeup of an organism; the phenotype is all the features of an organism other than its genotype
- A dominant allele is always expressed in the phenotype
- A recessive allele is only expressed when no dominant allele is present
- A homozygous individual has two identical alleles of a gene and a heterozygous individual has two different alleles of a gene

Monohybrid inheritance

- Monohybrid inheritance involves the inheritance of a single characteristic such as plant height or flower color

Codominance

- Codominance occurs when both alleles are expressed in the phenotype as neither is dominant over the other

Blood Groups

Genotype	Blood Group
$\mathbf{I^A I^A}$	A
$\mathbf{I^A I^O}$	A
$\mathbf{I^B I^B}$	B
$\mathbf{I^B I^O}$	B
$\mathbf{I^A I^B}$	AB
$\mathbf{I^O I^O}$	O

Sex Linkage

Sex determination

- All egg cells contain an X chromosome
- Half the sperm cells contain an X chromosome and half contain a Y chromosome
- At fertilization, the egg may fuse with either a sperm with an X chromosome or a sperm with a Y chromosome
- Since there are equal numbers of sperm with the X chromosome and sperm with the Y chromosome, there is an equal chance of the zygote inheriting XX or XY and the child being female or male

Sex inheritance

- The Y chromosome is very small and much smaller than the X
- Therefore the Y chromosome has fewer genes than the other chromosomes and far fewer than the X
- One gene of the Y chromosomes stimulates the development of the testes in the embryo
- If it is not present/mutated then the body that develops is female

Sex Linkage

- The genes that are located on the chromosomes are described as sex-linked even though they have nothing to do with determining gender or controlling sexual characteristics
- Among the gens in the X chromosomes are genes involved with controlling vision and blood clotting
- Males only have one copy of the genes that are on the X chromosomes, if any of them are recessive then the effect will be seen
- Because women have two X chromosomes they are less affected by sex linked recessive alleles and this is why sex-linked conditions are more common in boys than in girls
- Females are carries of sex linked disorders, such as red green color blindness