Genetics

Section 1: Genes and DNA

• What is DNA?

DNA is a long macromolecule found inside cells, which carries the genetic information to instruct the cells of what proteins to make. The molecule consists of four bases: adenine, thymine, guanine and cytosine, which are arranged in long sequences along the length of the molecule. The order in which the bases are arranged determines what proteins are made by the cell. The DNA sequence of every individual is different, unless of course they are identical twins!

- **Suggested Films**
  - **What Is DNA?**
  - **FactPack: Twins**

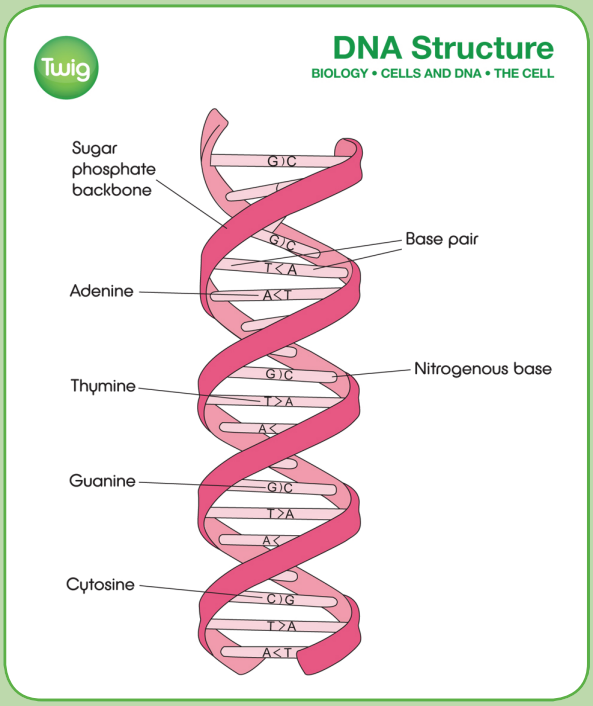
Identical twins are clones of each other as they have identical DNA

Extension Question

Q1. What does DNA stand for?

DNA stands for deoxyribonucleic acid. It is a long macromolecule constructed of repeating units called nucleotides. Each of these consists of a sugar (deoxyribose) attached to a base (adenine, thymine, cytosine or guanine) and a phosphate group.

DIAGRAM 01:



• How does DNA code for protein?

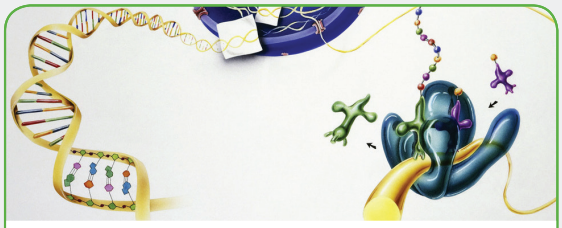
The genetic code in the DNA consists of the four bases: adenine (A), thymine (T), guanine (G) and cytosine (C), and these bases can be arranged in any order. The cell reads the code three letters at a time (for example, GGA or CGA etc), and this code can be translated into an amino acid sequence, which builds a protein. The proteins that a cell makes determine what the cell is and does. For example, red blood cells contain the protein haemoglobin for oxygen transport, and muscle cells contain the proteins actin and myosin for contraction.

- **Suggested Film**
  - **How Does DNA Make Protein?**

Extension Questions

Q2. If a protein is 500 amino acids long, how long is the gene that codes for it?

The gene is 1500 bases long because each amino acid is coded for by three bases – 3 x 500 = 1500.



The function of DNA is to carry the genetic code that makes proteins

Q3. What makes one protein different from another?

Different proteins contain different numbers and types of amino acids. For example, haemoglobin is a much longer protein than insulin, and it contains a different sequence of amino acids. Of course this also means the genes that code for these proteins are different lengths and consist of different sequences of bases.

• What is a gene?

A gene is the term used to describe a length of DNA, which codes for the production of a particular protein. For example, there is a gene for haemoglobin, and a gene for insulin, but there are also genes which determine features such as hair and eye colour, intelligence and behaviour.

A human cell contains about 25,000 – 30,000 genes packaged in the nucleus. To achieve this, the DNA has to be tightly coiled up into structures called chromosomes. Human cells contain 46 chromosomes, whereas the number of chromosomes in other species differs. For example, the genes for dogs are found on 78 chromosomes.

Extension Question

Q4. What is a chromosome?

A chromosome is a rod-like structure found inside the nucleus of a cell. It consists of a long length of DNA, wrapped tightly around proteins called histones. The number of chromosomes in the nucleus varies from species to species, but is the same within a species. Human cells have 46 chromosomes, whereas a dog has 78.

• Suggested Film

– Breeding and Behaviour

Section 2: Genetics

• How is genetic information passed to the next generation?

Genetic information is passed on to the next generation when organisms reproduce. This can be done either asexually or sexually.

In asexual reproduction only one parent is involved. The genetic information passed on to the offspring is identical to that of the parent. When two individuals are genetically identical, we call them clones. Any differences between these individuals are caused by environmental factors.

In sexual reproduction two parents are usually involved, and they both contribute some of their genetic material to the offspring. Because there is a combination of genes from both parents, the offspring retains some genetic traits from one parent and some from the other.

The only exception to this is identical twins! This happens in sexual reproduction when the fertilised egg splits into two separate embryos. All the genes are identical, and so identical twins are in fact clones.

• Suggested Film

– Inheritance: Part 1

Extension Questions

Q5. What are non-identical twins?

Non-identical twins are siblings that are born at the same time, but do not share the same genetic information. In this case, two eggs are fertilised by two sperms and so two genetically different individuals grow and develop at the same time within the mother.

Q6. When does asexual reproduction happen?

Single-celled organisms, such as bacteria and yeast, use asexual reproduction as their main method of reproduction. Some plants also use asexual reproduction, including daffodils and potato plants. A few animals even use asexual reproduction, such as starfish.

• How are genes inherited in humans?

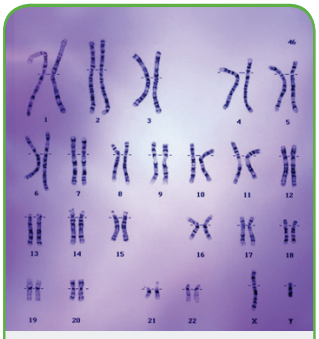
Humans reproduce sexually and so both the mother and father contribute genetic information to their offspring. Humans have 23 pairs of chromosomes in every nucleus of every cell. One of each pair was inherited from the mother and the other from the father. These chromosomes carry all the genes of the human genome.

When humans reproduce they make sex cells called gametes (sperms and eggs), which each carry 23 chromosomes, one from each of the 23 pairs. At fertilisation the sperm and egg fuse to create a zygote containing 46 chromosomes, 23 from the mother and 23 from the father.

Extension Question

Q7. What do the terms haploid and diploid refer to?

A diploid cell contains pairs of chromosomes. For example, all body cells in humans are diploid cells, containing 23 pairs of chromosomes. Haploid cells contain only one chromosome from each pair. They are made by a special cell division called meiosis. Sperm and eggs are known as haploid gametes.



Human DNA is packaged within 46 chromosomes

• Suggested Films

- **Inheritance: Part 1**
- **The Nine Months That Made Us: Egg**
- **The Nine Months That Made Us: Sperm**
- **Huntington's: The Disease**
- **Huntington's: The Dilemma**
- **Cystic Fibrosis**

• How is sex determined in humans?

What sex you are is determined by your sex chromosomes, shown with an X or a Y.

If you have two X chromosomes (XX), ovaries and other female traits develop and you are female. If you have an X and a Y chromosome (XY), testes and male traits develop and you are male.

When a male and female reproduce, all the eggs contain one X chromosome; half the sperm contain an X chromosome and the other half a Y chromosome. This means the sex of a child is determined by the type of sperm (either X or Y) which fertilises the egg.

• Suggested Film

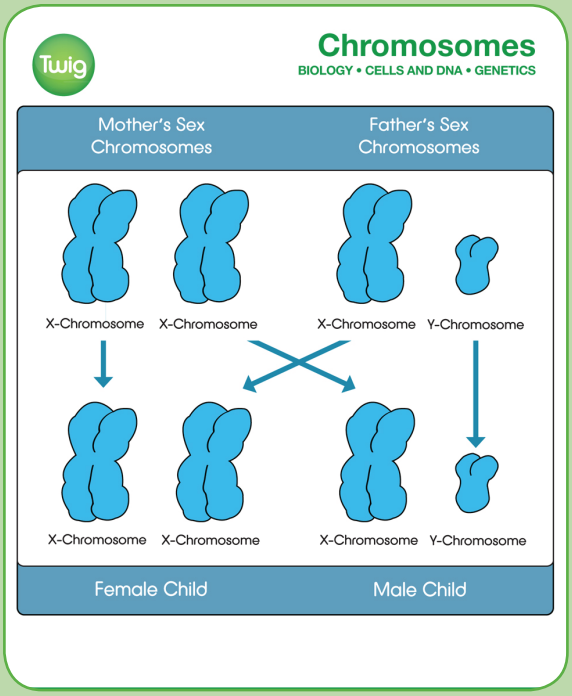
– Inheritance: Part 1

Extension Question

Q8. What are the chances of having a boy or a girl?

The chances are 50:50. Eggs contain an X chromosome, but sperm have a 50:50 chance of containing an X or Y chromosome.

DIAGRAM 02:



Section 3: Dominant and Recessive

• What are alleles?

Organisms such as humans, which inherit genetic material from both parents, have two copies of every gene. They inherit one copy from mum and one from dad. For example, every human cell contains two copies of the gene for hair colour, and two copies of the gene for blood group. However, the two copies that someone inherits are not always the same; different forms of a gene are called alleles.

The gene for blood group can exist in three different forms – A, B and O. Someone with two of the same alleles for a gene (say AA) is described as homozygous, whereas someone with two different alleles (say AO) is described as heterozygous.

In rare situations, an allele of a gene can actually change in an individual. When a gene changes in this way, this is called a gene mutation. It can happen spontaneously or might be influenced by lifestyle factors. Often the mutation might go unnoticed, but it can also cause diseases such as cancer. It could also be a factor that drives evolution by gradually causing changes to a species over time.

Extension Question

Q9. By simply looking at someone, can we tell what allele of a gene they have?

For most characteristics you can't tell what allele of a gene a person has, because it is a complex combination of alleles that creates what you see. The combination of alleles is called the genotype, and the resultant physical characteristics that you observe are called the phenotype. However, there are some characteristics that are controlled by only one gene, so you can tell what alleles someone has if they have, for instance, hitch-hiker's thumb or can roll their tongue.

• Suggested Films

– Inheritance: Part 2

– Huntington's: The Disease

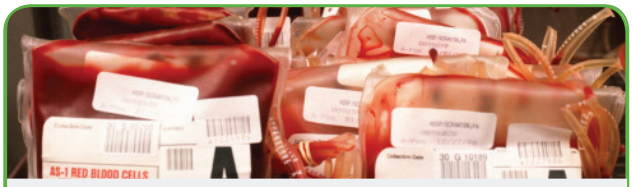
– Huntington's: The Dilemma

– Cystic Fibrosis

– Mendel and Inheritance

• What are dominant and recessive alleles?

Alleles of a gene can be dominant or recessive. For example, the allele for blood group A is dominant to the allele for blood group O, which is recessive. This means that someone who inherits an A allele from one parent, and an O allele from the other parent will be blood group A. In a similar way, the B allele is dominant to the O allele. To be blood group O someone must inherit two copies of this recessive allele (OO).



You inherit your blood group

• Suggested Films

– Inheritance: Part 2
– Huntington's: The Disease
– Huntington's: The Dilemma
– Cystic Fibrosis
– FactPack: Fruit Flies
– FactPack: Hybrid Animals

Extension Questions

Q10. How can a mother with blood group A and father with blood group B have a child who is blood group O?

Because the O allele is recessive, both the mother and father can carry this allele without it being expressed. In this case the mother would be AO and the father BO. Therefore, they can each pass a copy of the O allele to their child, who in turn will receive two copies and be blood group O.

Q11. How can someone have blood group AB?

This is an example of co-dominance in which both alleles are expressed rather than one dominating the other.

DIAGRAM 03:

Blood Type
BIOLOGY • CELLS AND DNA • GENETICS

AO x BO

	A	O
B	AB	BO
O	AO	OO

1/4 Type AB
1/4 Type B
1/4 Type A
1/4 Type O

• What is more important — nature or nurture?

The way that an organism looks, functions and behaves is the result of both its genes and the effect of its environment.

In some cases a feature is entirely due to the genes (for example blood group), and in others entirely due to the environment (for example learning to speak a language, or getting a tattoo).

However, in some cases both the genes and the environment interact to determine an organism's characteristics. For example, the height of a tree is determined by both the genes of the tree and the environment in which it grows. For features like intelligence or sporting ability, it is often hotly debated whether the influence is mainly genetic or mainly environmental.

Extension Question

Q12. What human characteristic is determined by both genes and environment?

The mass and height of a human are probably influenced by both the genes inherited and environmental factors, such as diet.

• Suggested Film

– Dogs and Wolves: Nature Or Nurture?

• Quizzes

Genetics: Part 1

Basic

• What do we call a length of DNA which codes for a characteristic, such as eye colour?

A – a base
B – a chromosome
C – a nucleus
D – a gene

• How many chromosome pairs are found in human cells?

A – 2
B – 23
C – 46
D – 64

• What sex chromosomes do sperm cells contain?

A – XX
B – XY
C – X
D – X or Y

Advanced

• How many chromosomes are found in a human cell?

A – 2
B – 23
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• What term is used to describe cells with only one copy of each chromosome pair?

A – zygote
B – diploid
C – haploid
D – sperm

• What sex chromosomes do sperm cells contain?

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• What are different forms of the same gene called?

A – alleles
B – chromosomes
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D – recessive

Genetics: Part 2

Basic

• What are different forms of the same gene called?

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B – a chromosome

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D – recessive

• What term is used to describe an allele which is always expressed if present?

A – a gene

B – a chromosome

C – dominant

D – recessive

• What are the chances that two carriers of a disease like cystic fibrosis will have a child who suffers from the disease?

A – 1 in 4

B – 1 in 2

C – 1 in 1

D – impossible

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• What are the chances that two carriers of a disease like cystic fibrosis will have a child who suffers from the disease?

A – 25%

B – 50%

C – 100%

D – impossible

• If one parent carries the Huntington gene, but the other does not, what are the chances that they will have a child who suffers from Huntington's disease?

A – 25%

B – 50%

C – 100%

D – impossible

• Answers

Genetics: Part 1

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