



# Using Genetics

BIOLOGY • CELLS AND DNA • USING GENETICS

## Section 1: Cloning

### • What is a clone?

A clone is an organism which is genetically identical to another organism. Clones are produced naturally through the process of asexual reproduction. For example, bacteria can clone themselves when they divide by binary fission, and many plants are capable of propagating themselves asexually by growing structures such as runners and stolons. When a human embryo accidentally splits to form two separate cells, these can develop to form two genetically identical individuals – identical twins!



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

### • Suggested Films

- Cloning
- Factpack: Twins

### Extension Question

Q1. Are all clones identical?

No. Clones are genetically identical, but because the environment has an influence on the growth, development and behaviour of organisms, clones can look and behave quite differently.

### • What is cloning?

The term cloning usually refers to artificial methods of cloning organisms. Because individual cells contain all the genetic information needed to code for an entire organism, it is theoretically possible to take one cell only, and get it to grow and develop into a complete multi-cellular organism, such as a plant or animal. In practice it is not that simple, but techniques are now available to clone higher plants and animals.

### • Suggested Films

- Cloning
- The First Human Clone

### Extension Question

Q2. What are the advantages of cloning?

Cloning allows plant and animal breeders to produce genetically identical offspring, and thereby retain the desirable combination of features they want. For example, if a tomato breeder has an outstanding plant, he is able to replicate its genetic makeup by cloning it, whereas sexual reproduction would lead to variation in offspring.

• What techniques are used to clone plants and animals?

Farmers and gardeners have been able to clone plants for hundreds of years, by simply taking cuttings from a plant and encouraging them to root and grow in the soil away from the parent plant. Today, the technique of micro-propagation (also known as tissue culture) is more efficient, but fundamentally the same as taking a cutting. Very small pieces of plant tissue are initially grown on sterile growth media before being planted out in soil.

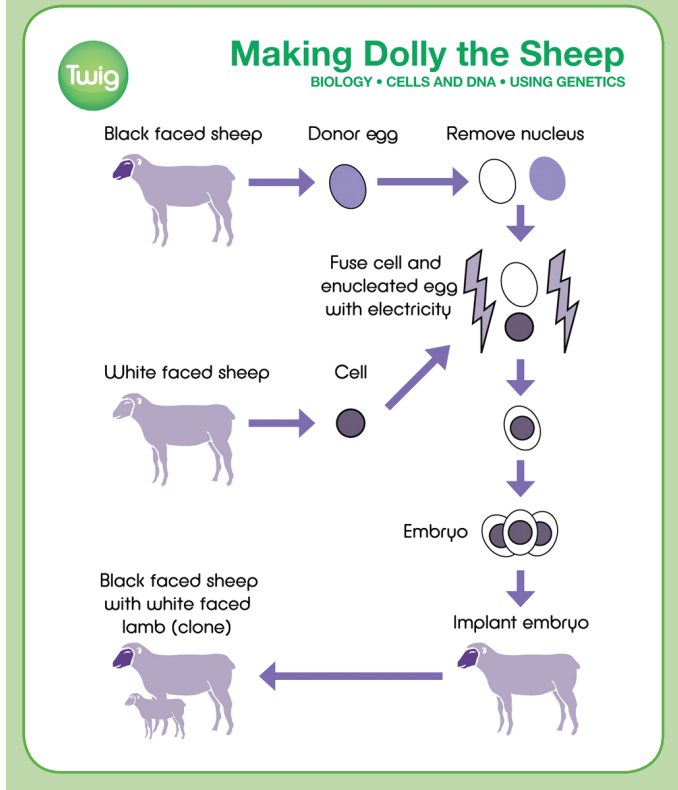
Cloning animals is more difficult, as single animal cells are not easily encouraged to divide and grow into whole organisms. One method that has been used to clone animals for several years is called embryo splitting. Embryos are washed out of the mother's uterus and the embryo is split into its constituent cells. These are then placed into separate surrogate mothers and allowed to develop into foetuses. The other method is called fusion cell cloning, or nuclear transfer cloning. An egg is removed from a female; its nucleus is removed and replaced with the nucleus from another individual of the same species. This modified egg is now placed inside the uterus of a surrogate mother and allowed to develop.

• Suggested Film  
– Dolly the Sheep



Dolly the sheep was the first cloned animal

DIAGRAM 01:



Extension Question

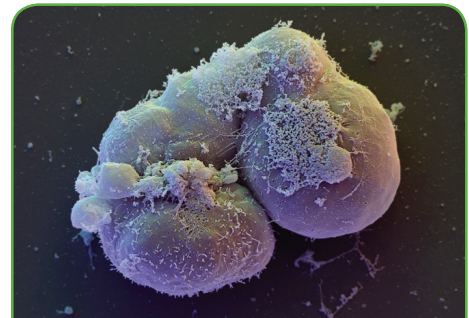
Q3. What is medical (or therapeutic) cloning?

It is theoretically possible to take the cell from a patient and use it to clone tissue which is genetically identical to that patient. This tissue could then be used to replace damaged tissue in the patient without the fear of tissue rejection.

## Section 2: Stem Cells

### • What is a stem cell?

Stem cells are cells with the potential to develop into all, or many, of the cell types of a multi-cellular organism, such as a human. For example, a fertilised egg cell (also known as a zygote) is a stem cell, as it has the potential to generate every cell type in the body. Some cells in the adult human are also called stem cells, as they are capable of developing into several different types of cell. For example, bone marrow stem cells have the potential to generate several different types of blood cell, though they don't have the ability to develop into all cell types of the human body.



Human embryonic stem cells

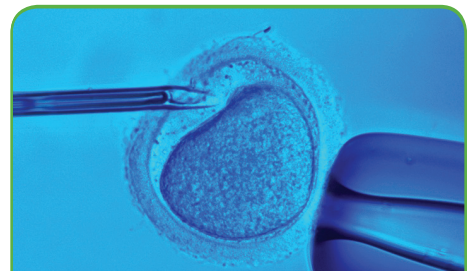
### Extension Question

#### Q4. Are all stem cells the same?

Some stem cells are called totipotent stem cells, as they have the ability to generate every cell type of an organism. Early embryonic cells are totipotent. Other stem cells, like those in the bone marrow, can only develop into a few cell types and so are called multipotent stem cells.

### • How might stem cells be useful in the treatment of disease?

Many diseases in humans are caused by the loss or damage of cell types, which cannot easily be regenerated by the body. Parkinson's disease, for example, involves the death of particular cells in the brain. Therapeutic stem cell therapy provides a possible solution for Parkinson's and other diseases. It involves taking embryonic stem cells and treating them so that they develop into the cell types required, such as brain cells or blood cells. The source of the embryonic cells is usually from an embryo that has been produced by IVF (In Vitro Fertilisation), but it could theoretically be a cloned embryo produced using a cell from the patient.



Stem cells can be manipulated using IVF

### • Suggested Films

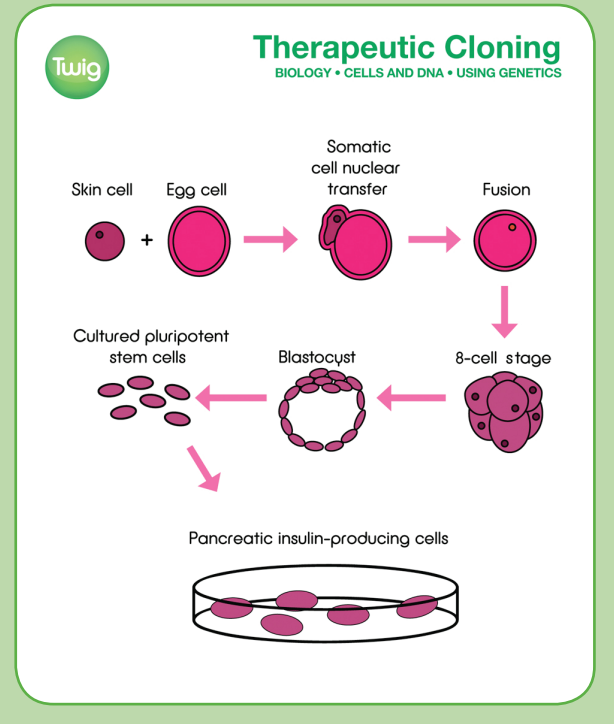
- Saviour Siblings
- Stem Cells
- Therapeutic Stem Cells

**Extension Question**

**Q5. Is therapeutic stem cell therapy unethical?**

Therapeutic stem cell therapy usually involves the production of embryos as a source of totipotent stem cells. Many people feel strongly that this is unethical, as the embryo has the potential to develop into a human being. Others believe the technique is acceptable as it can save lives, and embryos produced in this way are not capable of developing fully unless they are transferred into a female's uterus.

**DIAGRAM 02:**



**Section 3: Genetic Modification**

**• What is genetic modification?**

Genetic modification involves taking a gene from one species and combining it with the genetic material from another. For example, taking a gene from a human and introducing it into a bacterial cell where it can be expressed. Because DNA is a universal code, recognised and used in almost all living organisms, it is possible to mix genes from totally unrelated species in novel and potentially useful ways. Scientists have created sheep with bacterial genes, plants with fungal genes, and bacteria with animal genes.

**• Suggested Film**

– Genetic Modification

**Extension Question**

**Q6. What is a transgenic organism?**

A transgenic organism is an organism which contains and expresses the gene of a totally unrelated species. For example, a sheep which makes human proteins in its milk would be described as a transgenic organism.

• How is a cell genetically modified?

There are a range of different techniques, but essentially they involve using enzymes to cut out and isolate genes of interest, and then combine them with the DNA of another species. This recombinant DNA is then introduced into a host cell, which develops into a whole organism and, hopefully, expresses the gene of interest in the right tissues. Bacteria are most easily transformed, as they do not have nuclei and are easily cultured in huge numbers. They also contain small loops of DNA called plasmids, which can be easily extracted, modified and returned to bacterial cells.



Streptomycin species combined by recombinant cloning

- Suggested Film
  - Genetic Modification

Extension Question

Q7. What is a plasmid?

Plasmids are small loops of DNA found in bacteria. They are often used as vectors in genetic engineering because they can be manipulated, using enzymes, to carry genes of interest into bacteria where they can be expressed.

• Can we design humans?

Theoretically it would be possible to manipulate a human cell and then create a 'designer baby'. In practice it is hard to see how or why this would happen. The techniques involved are highly inefficient and highly unpredictable, and human characteristics like intelligence and behaviour are rarely controlled by single genes that could be manipulated. The closest we get to 'designer babies' today is when embryos are screened for genetic disorders in a process called Pre-implantation Genetic Diagnosis (PGD). In theory, in addition to genetic disorders, this approach could be used to screen for characteristics such as sex and hair colour.



As yet, it is deemed unethical and unsafe to create a human clone

Extension Question

Q8. How does pre-implantation genetic diagnosis (PGD) work?

In PGD, eggs are fertilised in vitro and allowed to develop into early embryos. Individual cells can be removed from these embryos without damaging them, and then tested for genetic disorders, sex and other possible characteristics. Once screened in this way, selected embryos can then be placed in the womb of a mother in order to develop fully.

- Suggested Films
  - The Genius Sperm Bank: Part 1
  - The Genius Sperm Bank: Part 2

• Quizzes

Cloning and Stem Cells

Basic

• What do you call organisms that are genetically identical?

- A – related
- B – the same
- C – copies
- D – clones

• What kind of reproduction produces clones?

- A – sexual
- B – asexual
- C – splitting
- D – cuttings

• What causes differences between clones?

- A – the environment
- B – the genes
- C – the parents
- D – the DNA

• What are cells called that have the ability to develop into many different cell types?

- A – gametes
- B – master cells
- C – body cells
- D – stem cells

Advanced

• For what reason are two organisms described as clones of each other?

- A – they look the same
- B – they are related
- C – they are genetically identical
- D – they have the same parents

• What causes differences between clones?

- A – the environment
- B – the genes
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• What type of cell has its nucleus removed in fusion cell cloning?

- A – a stem cell
- B – the gamete
- C – a body cell
- D – an egg cell

• What is special about stem cells?

- A – they can grow
- B – they can divide
- C – they can develop into many cell types
- D – they can move

## Genetic Modification

### Basic

• What does GM stand for?

- A – gene mixing
- B – genetic manipulation
- C – genetic modification
- D – general modification

• What is insulin used to treat?

- A – lung disease
- B – heart disease
- C – diabetes
- D – Parkinson's disease

• What types of organism have been modified to produce human insulin?

- A – viruses
- B – bacteria
- C – fungi
- D – plants

### Advanced

• What are bacterial rings of DNA called that are used in genetic modification?

- A – plasmids
- B – genes
- C – chromosomes
- D – proteins

• What are used to cut and rejoin sections of DNA?

- A – scissors
- B – pipettes
- C – hormones
- D – enzymes

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• Answers

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