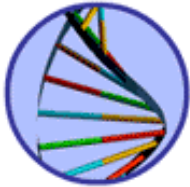


## Applications for human use

[Home](#)

Biotechnology has been used to develop many new medicines and new ways of detecting disease. It has the potential for treating diseases in new ways, called gene therapy, and can also be put to new uses, such as DNA profiling.

This section looks at the way biotechnology is being applied to human uses, including development of medicines, genetic testing, the human genome project, DNA profiling and cloning.



### **Human hormones, other proteins and vaccines**

### **The human genome project**

### **Genetic testing**

### **Gene therapy**

### **Cloning of human cells**

### **DNA profiling**

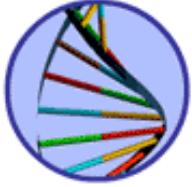
### **Regulation of research in Australia**

 **What will I choose?**

## Human hormones, other proteins and vaccines

[Home](#) > [Human uses](#)

Splicing of the human insulin gene into bacterial cells has been used to produce pure human insulin for the treatment of diabetes. It is possible for this technique to be used to make other human hormones such as human growth hormone, the blood-clotting factor needed to treat haemophilia, and erythropoietin used to treat anaemia. Biotechnology can also be used to produce large amounts of other proteins that are of benefit to humans and to produce new and much safer vaccines than in the past.



### **Production of proteins by pharming Vaccines**

 **Gene splicing interactive**



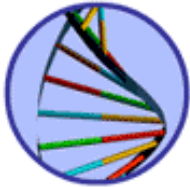
## Production of proteins by pharming

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Many animals can now be genetically engineered to be living pharmaceutical factories which can produce large amounts of human proteins in their milk. This technique is sometimes called pharming. The animals commonly used are cows, sheep, pigs, goats, rabbits and mice.

Human DNA, containing the genes for the specific protein required, is injected into the host animal embryo. The embryo is placed in a surrogate mother to be born and raised. As an adult the animal produces the human protein in its milk. The animal is milked and the protein purified from the milk for use as a medicine for humans.

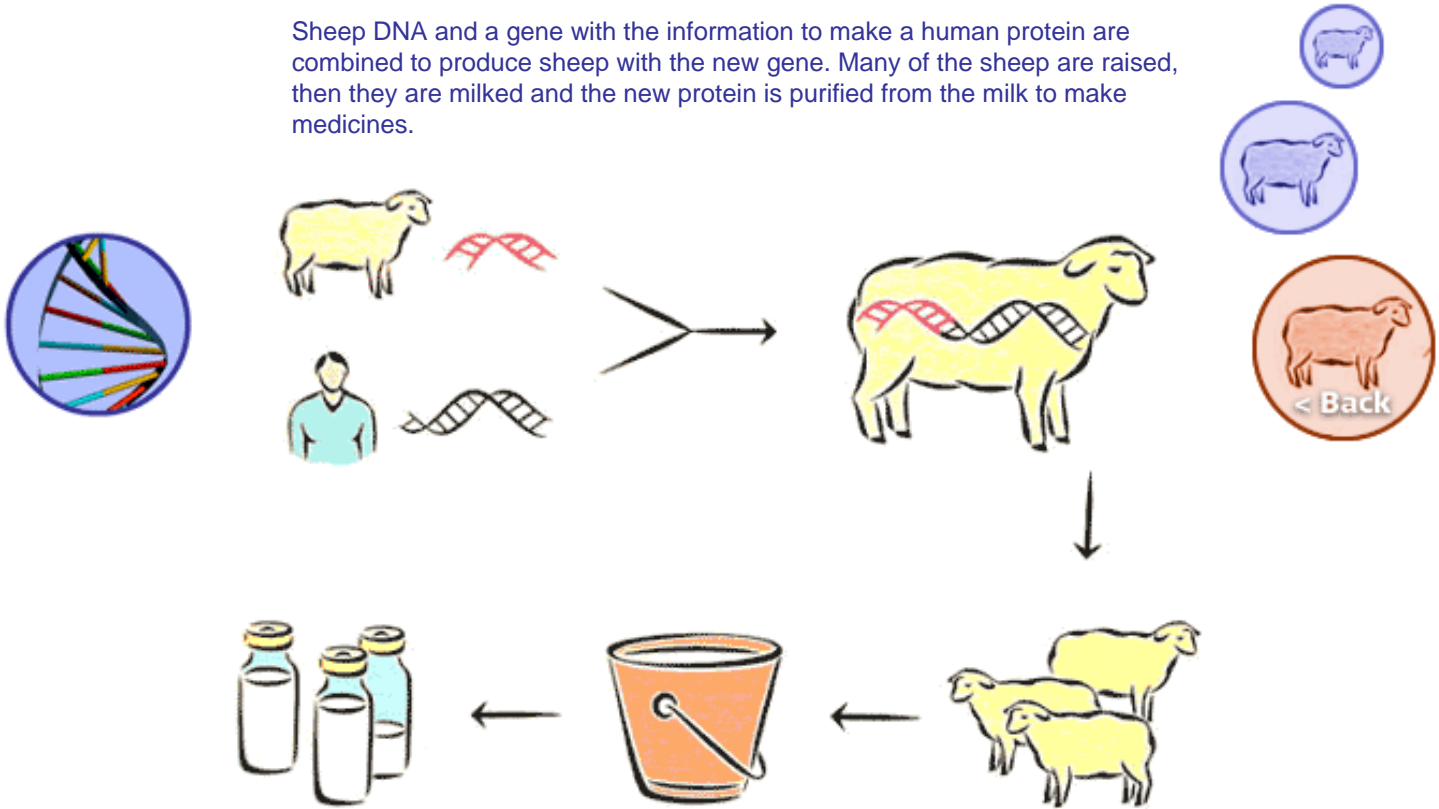
Human proteins that have been produced in cows include human serum albumin, used to maintain fluid balance in the blood; and lactoferrin a protein from breast milk that promotes infant growth. Genetically modified sheep have produced factor IX, a protein essential for blood clotting; natural anticoagulants to be used in heart surgery; and proteins to treat lung and liver disease.



## Production of proteins by pharming

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Sheep DNA and a gene with the information to make a human protein are combined to produce sheep with the new gene. Many of the sheep are raised, then they are milked and the new protein is purified from the milk to make medicines.



## Vaccines

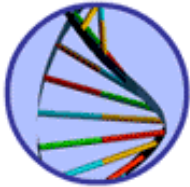
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Most vaccines are: low doses of dead disease - causing microorganisms; inactivated toxins from disease - causing bacteria; or weakened living disease-causing organisms that are unable to cause the severe form of the disease.

A vaccine is recognised by the body as a foreign substance. The cells of the immune system therefore make antibodies which destroy this foreign substance. These antibodies remain in the body and protect against future infection by the naturally-occurring form of the disease.

Vaccines have been and are still used to control a number of life-threatening diseases including measles, polio, tuberculosis and tetanus. However today the vaccines are developed in a very different way from earlier methods. Genetic engineering allows a gene that codes for a protein of a disease-causing organism to be isolated from the DNA of the organism and transferred into bacteria. The bacteria then produce large quantities of the protein that can be purified and used as a vaccine. This approach has also been used with genetically engineered yeast to produce the hepatitis B vaccine.

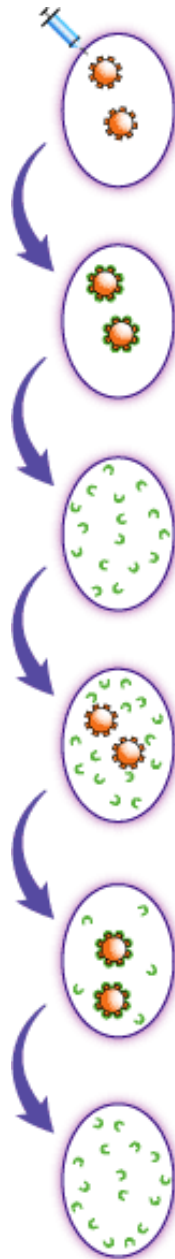
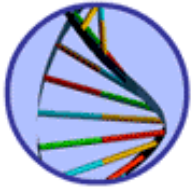
In the future, people could be vaccinated simply by eating a vegetable or a piece of fruit. The fruit or vegetable would be genetically engineered to produce a protein from a disease-causing virus or bacterium. When the fruit or vegetable is eaten, the human immune system would be activated in the same way as it is by traditional vaccines.



# Vaccines

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The process of vaccination relies on finding a way to treat a microorganism so that it will not cause harm to the body but will cause the body's immune system to produce the antibodies. These antibodies will destroy the naturally occurring virus if it enters the body at a later stage.



A Cowpox disease-causing organism is injected as a vaccine. Cowpox is very similar to smallpox but will not cause severe symptoms to humans.

The body's immune system produces appropriate antibodies that react with the foreign molecules.

The disease-causing organism is destroyed and the antibodies remain.

The smallpox disease-causing organism enters the body.

Before it can cause a disease, the antibodies attach to the disease-causing organism.

The disease-causing organism is destroyed and the antibodies remain.

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**Back**

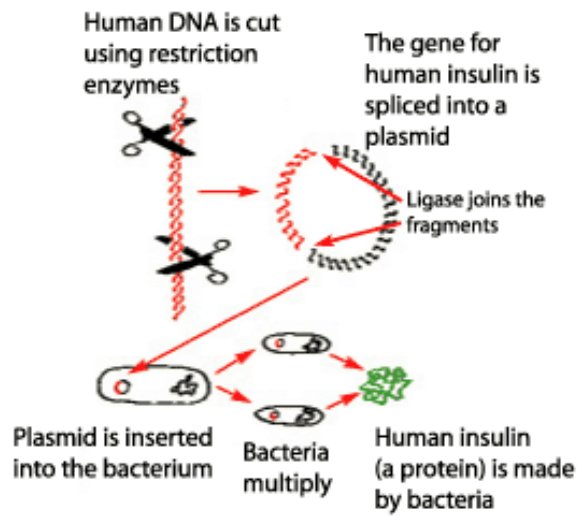
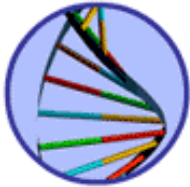
## Production of human insulin

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As well as using genetically engineered bacterial cells, engineered yeast and animal cells are often used to produce the large protein molecules of some hormones.

Image courtesy of University of Technology, Sydney.

### Gene splicing is used to make bacterial cells produce human insulin.



## The human genome project

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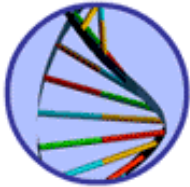
The Human Genome Project is an international project officially begun in October 1990. Its aim is to identify and locate all of the approximately 30,000 genes in human DNA, to determine the sequences of the 3 billion chemical bases that make up human DNA, and to store this information in databases.

The Human Genome Project is providing information about our genes that will greatly affect genetic testing and genetic screening. Genetic testing methods identify the presence or absence of a particular gene in an individual. Genetic screening is the testing of a whole population for the presence of particular genes.

The number of [gene tests](#) available is likely to rise as more is understood about the workings of the genes identified in this project. Tests may become available not just for inherited disorders, but also for genes involved in determining aspects of human behaviour.

The identification of genes that are associated with genetic diseases will enable further research into possible [gene therapy](#) processes.

 **DNA zoom interactive**



## Genetic testing

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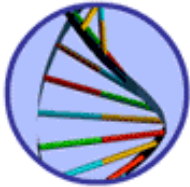
Sensitive medical tests have been developed using biotechnology. Some of these tests examine the DNA in your cells. These tests can diagnose existing diseases, but they can also be used to predict the possibility of the patient developing an illness later in life.

The tests can identify carriers of inherited diseases who do not have symptoms themselves. Or they can be used to diagnose diseases that only affect people later in life. They may also be used to test for diseases in an unborn foetus.

For more information about genetic testing go to  
<http://www.ornl.gov/hgmis/medicine/genetest.html>

**Testing for genetic disorders**  
**Genetic screening and public health**  
**Having a test**

 **Gene probe interactive**



## Testing for genetic disorders

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Until recently, family histories were the only tools available for identifying an inherited disease. These histories can now be combined with gene tests.

Gene tests look directly or indirectly at a person's genetic material: their chromosomes or DNA.

Indirect tests can be carried out by measuring the results of a change (mutation) that is present in your DNA. Such changes can cause an unusual amount or a different size of protein to be produced and this can then be detected or measured. More direct tests look right into the cell at the shape and structure of the chromosomes, or compare the base sequences in sections of DNA.

### Looking at DNA

Small changes in genes cannot be seen using the microscope. Other techniques are used to detect tiny changes in the DNA code. Usually, they involve extracting the DNA from a blood sample of the person being tested and making many copies of it. The treated DNA is then cut into small fragments and the samples compared with other samples from people with and without the mutation.

For some types of DNA tests, probes are used. These are short sequences of DNA that have base sequences that exactly match the mutated or disease gene that is being tested for. If the mutated sequence is present in a sample of a person's DNA the probe will bind onto that piece of DNA indicating the presence of the disease-causing gene. Currently gene tests are available for cystic fibrosis, haemophilia A and B, some forms of muscular dystrophy, Huntington's disease, thalassaemia, Tay-Sachs disease and a number of less well known conditions.

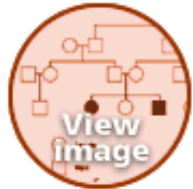
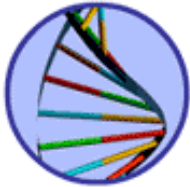
### Looking at chromosomes

Some genetic disorders can be detected by examining a person's cells, using high-powered microscopes to look for changes in chromosome number and structure. When cells divide, chromosomes reproduce themselves and then coil up into compact shapes to make their division easier. In this state the chromosomes can be stained, photographed and arranged for easy identification and comparison. Such photographs are called karyotypes. 'Probing' the chromosomes with fluorescent stains allows a single chromosome to be picked out and abnormalities to be identified. An extra copy of the genetic material of chromosome 21 is responsible for Down's syndrome.

 [DNA zoom interactive](#)

 [Gene probe interactive](#)

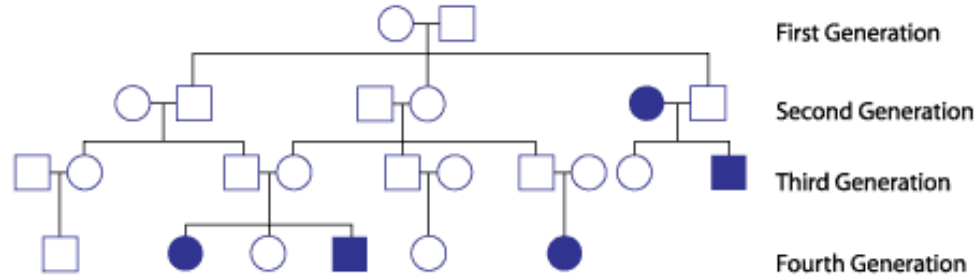
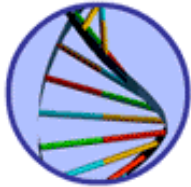
 [When a gene code is altered](#)



## Testing for genetic disorders

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This diagram shows a family history of the occurrence of thalassaemia over four generations.



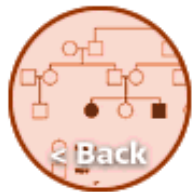
First Generation

Second Generation

Third Generation

Fourth Generation

- Female
- Male
- ■ Person with thalassaemia
- Linking parents
- | Linking parents to children



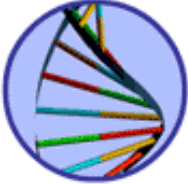
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## Genetic screening and public health

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Screening identifies people with a genetic disorder or an increased risk of having a disorder. Further diagnostic tests to determine the extent of the symptoms and possible suitable treatments can then be made available to them if they wish.

Some communities have chosen to screen for genetic disorders that occur frequently in their population. Here in Australia every newborn child is screened for phenylketonuria (PKU), congenital hypothyroidism and cystic fibrosis. All or some of the symptoms of these disorders can be prevented or their severity reduced if the condition is recognised and treated early in life.



## Having a test

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When you have a gene test, you have choices to make.

- You choose whether or not to have the test.
- You choose who to tell about the results of the test.
- You choose how to live your life with the information provided by the test.
- You choose how much support you need to deal with the choices you must make and the way you may have to change your life style.

Your choices may affect you; they may affect your family. In order to make these choices you need to consider all of the following.

### **Risk**

Gene tests do not always provide a definite 'yes' or 'no' answer.

Sometimes, a gene test will tell you whether you have an increased risk of developing a disorder but it may never happen. If you find out that you have an increased risk, this information may enable you to more closely monitor the condition, or make lifestyle choices to help prevent its development.

### **Choice**

For some disorders, gene tests are available but there is no treatment or cure for the disorder. This is the case for Huntington's disease and Tay-Sachs disease. In these circumstances some people choose to know if they carry the gene, others do not.

Results from a gene test can help people make choices for the future if the result of the test indicates that they will develop symptoms later in life. The result of a test can also give couples information to help them choose whether or not to continue with a pregnancy.

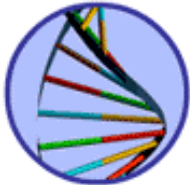
### **Implications**

Gene tests may have far-reaching effects. Understanding the possible implications of a gene test is an important step in the process. Gene tests can identify people who carry mutations in their DNA, but are unaffected by them. The results may only matter when the person has children.

Gene tests can affect more people than the one having the test. Discovering your own genetic make-up may reveal or rely on genetic information about close relatives who do not want to know or reveal this information.

It is also possible for gene tests to inadvertently disclose family secrets involving paternity or adoption.

Once a gene test has been performed, insurance companies may be influenced by any positive results when deciding whether to provide life or health insurance to the person concerned.



## Gene therapy

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Gene therapy attempts to treat or prevent a disease by delivering genetic material into a person's cells.

Currently, gene therapy is an experimental procedure. In the future it may be used to treat ailments such as heart disease, inherited diseases or cancers. In current trials genes are added to the existing DNA of cells, but it may soon be possible to actually replace a mutated gene by cutting it out of the cells' DNA and replacing it with a normally functioning gene. A mutated gene is one in which the base sequence is changed and so it does not perform the task within our cells that we expect it to.

For more information about gene therapy go to  
<http://www.ornl.gov/hgmis/medicine/genetherapy.html>

**The uses**

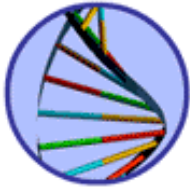
**The challenges**

**The trials**

**Just your genes ... ?**

**One possible future?**

 **Gene splicing interactive**

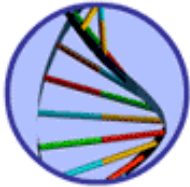


## The uses

[Home](#) > [Human uses](#) > [Gene therapy](#)

Gene therapy is likely to be used in the treatment of many diseases, including:

- inherited disorders such as diabetes, thalassaemia, haemophilia and cystic fibrosis;
- cancers of many different types;
- heart disease; and
- many age related diseases such as arthritis and dementia.



## The challenges

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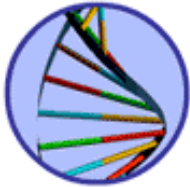
For gene therapy to be effective, a gene must reach the right place in the body and become part of the normal workings of the cells involved.

It is important to:

- find the right gene;
- target the right cells in the body;
- deliver the DNA of the required gene into these cells;
- make sure the DNA is used correctly by these cells; and
- do it all SAFELY.

In gene therapy trials, different carriers have been used to deliver genes into the cells.

- Disabled viruses can transfer genes into a cell efficiently. However, it can be difficult to make a virus totally harmless so some disease symptoms associated with the virus may also develop.
- Non-viral carriers such as liposomes (fat globules) and artificial chromosomes (a sequence of DNA created in a laboratory) can transport large amounts of DNA, but they are not as easily incorporated into the cells' genetic make-up as the DNA transferred in viruses.



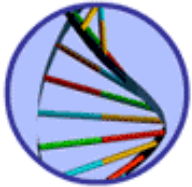
## The trials

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In 1990, a four-year-old American girl named Ashanthi DeSilva became the first person to be treated with gene therapy. Her cells were provided with genes to produce an infection-fighting enzyme called ADA that she lacked. Doctors removed white blood cells from her body, let the cells grow in the lab, inserted the missing gene into the cells using a virus, and then infused the genetically modified blood cells back into the patient's bloodstream. This procedure was not a cure; the genetically treated white blood cells only work for a few months, and the process must be repeated every few months.

Since that trial, more than 3000 people have received experimental gene therapy treatment. At present such experimental therapy is only approved if the patient is terminally ill or very sick indeed with the disease.

Trials have mainly focused on testing the safety of the techniques. To see real benefit, future techniques will need to change more cells, more efficiently, for longer periods of time.

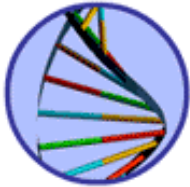


## Just your genes...?

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At present, gene therapy is only used on non-reproductive or somatic cells - that is, anything other than sperm or egg cells.

The genetic change caused by the therapy is not passed on to the patient's children. This is because at present there is insufficient knowledge about the possible consequences on future generations of the use of these therapeutic techniques. However it is possible that, in the future, gene therapies could be developed that would be inherited by the patient's children.

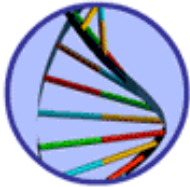


## One possible future?

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Many people fear that gene therapy may lead to genetic enhancement or attempts to 'improve' characteristics such as intelligence, personality or physical features.

Hundreds of genes could be involved in any of these characteristics and these genes interact with the environment in which we develop, so the task involved in genetically enhancing individuals is difficult and complex and not currently possible. However, because this type of genetic engineering may become possible in the future, now is the time to discuss the potential benefits and possible risks of this technology.

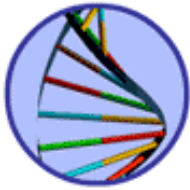


 **What will I choose?**

## Cloning of human cells

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Today transplanting living tissue from person to person is a regular surgical procedure. Successful organ transplants between humans have created an increased demand for donor organs that has vastly outgrown supply. Closing the gap between supply and demand is not easy. The tissue of the donor and the recipient need to be compatible and the tissue needs to be able to be collected in a strict medical environment. Around half of all people who need a transplant die while on the waiting list. This need for organs and tissues for transplantation increases the pressure on researchers to find other ways of providing the needed tissues. These include using human cells in tissue culture and using embryonic or other stem cells to grow new cell types.



**Embryonic stem cells**

**Adult stem cells**

**Bone marrow stem cells**

**Regulations**

 **What or who would you clone?**

## Embryonic stem cells

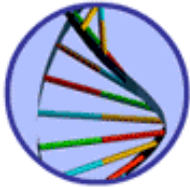
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Embryos contain cells called embryonic stem cells (ES cells). These cells are able to multiply and turn into any sort of cell found in the body. For nearly 20 years ES cells from mice have been grown under different conditions to become nerve, lung, gut, muscle, bone or cartilage cells. In 1998 human ES cells were first removed from a one-week-old embryo. They were separated and reproduced to form clones that developed into several different types of cell.

Continued research on ES cells could reveal more about the changes that happen to cells throughout a human lifetime. One day it may be possible to use clones of human ES cells to generate new tissues or organs.

If the DNA from a person was placed in an egg which was then grown to the embryo stage, the ES cells from this embryo could be used to produce tissues for transplant into the person without any of the usual problems of rejection that are associated with transplants from other donors. However the use of these ES cells involves the production and then destruction of an embryo. This causes many people to question the morality and the ethics of carrying out such procedures.

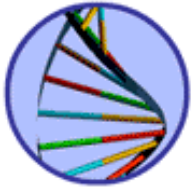
It may eventually be possible to reprogram mature cells to become whatever type of cells are needed. This would mean that using ES cells from embryos would be unnecessary.



## Adult stem cells

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Adult stem cells are found in the brain, pancreas, liver, bone marrow, blood, muscle, skin and some other parts of the body. Each of these sorts of adult stem cells can become any one of the types of specialised cells that are formed in the tissue in which they were found. This is unlike embryonic stem cells which can become any type of cell from any part of the body. However some studies indicate that adult stem cells may, in the future, be able to be reprogrammed to make almost any kind of cell. If the research into the use of these adult cells is successful there will be no need to become involved in the moral and ethical issues that surround the use of embryonic stem cells.



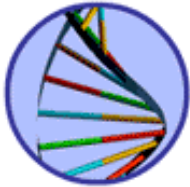
## Bone marrow stem cells

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Bone marrow is found inside the bones, particularly the pelvic bones. It is the 'factory' for the blood, responsible for producing white blood cells (to protect against infection), red blood cells (to carry oxygen round the body) and platelets (to prevent bleeding). Stem cells are blood cells at their very earliest stage of development in the bone marrow, before they have become committed to developing into white cells, red cells or platelets.

How can these stem cells be used?

A patient who has been given high doses of chemotherapy drugs to treat leukaemia (a cancer of the blood) has very few remaining healthy bone marrow stem cells. In the past such patients needed transfusions of donated bone marrow containing stem cells to help them recover after their chemotherapy. Now bone marrow stem cells are taken from the patient before they are treated with the chemotherapy drugs. The stem cells are cloned and returned to the patient after the treatment. The stem cells go on to form healthy, mature blood cells. This overcomes all the problems of transplant rejection that occur with the use of donated bone marrow cells. Stem cells can either be obtained directly from the bone marrow (which involves a general anaesthetic) or the patient can be treated so that the number of stem cells increases in the bone marrow making them spill over into the blood. The stem cells can then be collected directly from the blood.



## Regulations

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In Australia there is a ban on cloning humans. In 1998 the Australian Federal Minister for Health and Family Services supported the United Nations Educational Scientific and Cultural Organization (UNESCO) ban on the cloning and genetic modification of human individuals. Such experiments are said to deny a person his or her genetic individuality, and to deny the human species its heritage of genetic diversity and the ability to survive evolutionary change. However, some people support the idea of cloning humans.

Individuals incapable of having children using other reproductive technologies may wish to create a child that is a clone of themselves. Producing a clone of an individual might also be considered to be a way of providing compatible tissues or organs for transplant into that individual if they had a debilitating or life-threatening illness.

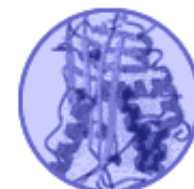
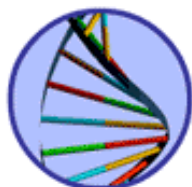
In Australian States and Territories there is also a ban on the genetic manipulation of human embryonic cells. The use of embryonic cells in research is only allowed under exceptional circumstances.

However, cloning technology may soon be available for human benefit to produce whole organs or special tissues from single cells for transplant to humans. It could then be possible to use cells from the body of the same person and correct genetic defects before growing the tissue for transplant back into the donor.

There are moral and ethical issues related to the use of embryonic stem cells to clone tissues and organs, and for the creation of genetically modified human cells. There are also similar issues related to the cloning of whole humans. In response to the debates about these issues a review of regulations is taking place around the world.

Links to discussions of regulations related to research using human cells and links to organisations in Australia responsible for the regulation of this research can be found through

<http://www.health.gov.au/nhmrc/ethics/contents.htm>





## DNA profiles for forensic use

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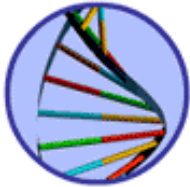
Forensic scientists can analyse DNA samples from crime scenes and compare them with DNA samples from victims and suspects to help solve crimes.

Each of the chromosomes in your cells contains many sections of 'junk DNA'. This does not seem to code for anything in particular, but contains areas called short tandem repeats (STRs). Each STR contains repeats of short sequences of bases, such as catg in catgcatgcatg.

If DNA is analysed for 10 different STRs on different chromosomes, statistically no two people (except identical twins) are likely to have the same number of repeats in all of these STRs.

This means that if the DNA profile (or fingerprint) for 10 STRs for a crime suspect matches the profile for the same 10 STRs from a sample found at the crime scene, it can be assumed that they come from the same person. If the profiles differ for even one of the tested STRs however, this can not be assumed.

 **DNA profiling interactive**



## DNA profiles can reveal family relationships

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DNA samples can be analysed to explore possible paternal and maternal relationships between parents and children. This is because half of each person's chromosomes – humans have 23 pairs – came from their mother and half from their father.

Each of the chromosomes contains many sections of 'junk DNA'. This does not seem to code for anything in particular, but contains areas called short tandem repeats (STRs). Each STR contains repeats of short sequences of bases, such as catg in catgcatgcatg.

When STRs are tested in DNA profiling, they occur in pairs. One chromosome in a pair carries an STR from the person's mother and the other chromosome in the pair carries an STR from their father. A person's DNA profile usually shows two lines for each of the STRs tested because usually the STRs inherited from the parents are of different lengths. Occasionally only one line appears, because both STRs in a pair are of the same length.

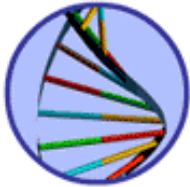
When you compare the DNA profile of a child with the profiles of its genetic parents, you will be able to match one line in each STR area with a line in that area of the mother's profile. You will also be able to match a line in each STR area of the child's profile with a line from the father's profile.

Often only three or four STRs, of very different sizes, are analysed in exploring family relationships.

### **DNA profiling interactive**



### **Have you the right to know?**



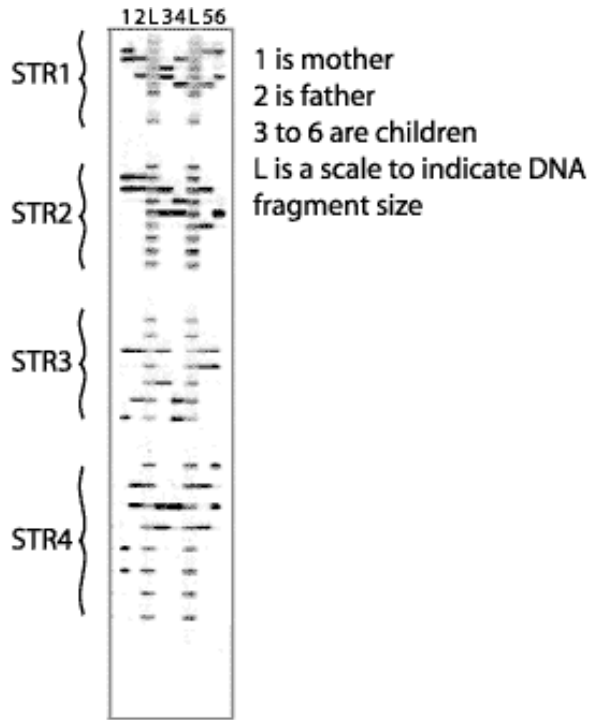
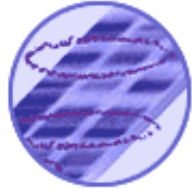
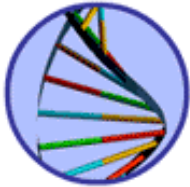
## DNA profiles can reveal family relationships

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All of the children are adopted.

Each person's DNA profile has at least one and usually two bands in each of the four STR areas.

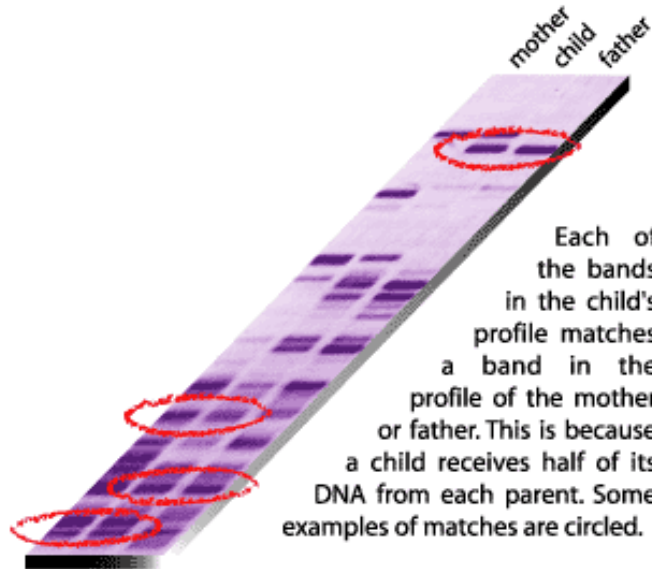
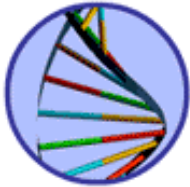
If they were genetically related, the child would have a match with the mother and also with the father in every STR area. None of the children here has a match with the mother and a match with the father in all four STR areas.



## DNA profiles can reveal family relationships

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An example of a DNA fingerprint.



## Regulation of research in Australia

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Since 1975 Australia has had a voluntary system of controls over genetically modified organisms (GMOs). Australia was, in fact, one of the first countries in the world to set up a system that assesses the risks involved with dealing with GMOs, whether in the laboratory, through farming trials, or for general release.

The voluntary system revolves around an independent scientific committee. This committee assesses all work involving genetic manipulation to ensure that it does not pose unacceptable risks to the environment or to people.

The committee is currently called the Genetic Manipulation Advisory Committee (GMAC). The GMAC is a non-statutory advisory committee, which provides expert biosafety advice on the use of novel genetic manipulation techniques in Australia.

### **The need for regulation**

While the GMAC has provided reliable scientific advice about the risks posed by gene technology, and how to manage those risks, the system is not backed up by legislation. This means there is no legally enforceable way to audit or monitor the use of gene technology or penalise breaches.

The Interim Office of the Gene Technology Regulator (IOGTR) was established as a branch of the Therapeutic Goods Administration within the Commonwealth Department of Health and Aged Care in May 1999.

The IOGTR has two primary functions:

- to work with State and Territory Governments, other Commonwealth agencies, and non-government organisations to develop and implement a new national regulatory system for GMOs; and
- pending the establishment of this new system, to provide support and direction to the current voluntary administrative arrangements for GMOs.

### **The Gene Technology Act 2000**

Throughout 1999 and 2000 the States, Territories and the Commonwealth worked together with interested parties, to develop the Gene Technology Act 2000. The Act was passed by the Federal Government in December 2000. The legislation is the Commonwealth's component of a new national scheme for the regulation of GMOs, which will include legislation in every Australian State and Territory.

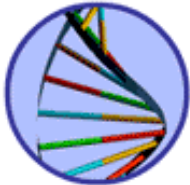
The Act is to take effect from 21 June 2001. Until 21 June 2001, GMAC will continue to provide advice on environmental and human risks associated with genetically modified organisms.


The objective of the Act is to protect the health and safety of people and to protect the environment by identifying risks posed by or as a result of gene technology and by managing those risks. It does this by creating laws for certain dealings (or activities) with GMOs.

Details about the regulatory framework for gene technology in Australia (including information on the Act and Regulations) can be found at the IOGTR Internet site <http://www.health.gov.au/tga/genetech.htm>

### **A scientific, ethical and precautionary approach**

The Gene Technology Act 2000 establishes three key advisory groups to assist the Gene Technology Regulator assess the biosafety of GMOs:



- 
- the Gene Technology Technical Advisory Committee (replacing GMAC) to advise on the science;
  - the Gene Technology Ethics Committee to advise on ethical matters; and
  - The Gene Technology Consultative Community Committee, to advise on community concerns regarding gene technology.

The object of the Act is also to be achieved through the application of the *precautionary principle*. The *precautionary principle* means that, *where there are threats of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*

### **International arrangements**

Working on international forums is one way Australia can encourage other countries to take up comprehensive arrangements to ensure the protection of people and the environment in the development of gene technology.

We need to ensure Australians and other nations act responsibly when exporting or transporting genetic material internationally. Likewise we need to ensure that people importing or transporting genetic material across Australian boundaries act appropriately. Through participation and agreement in an international treaty, countries can develop internationally consistent laws that bind each participating country to a common global approach to a global issue.

### **Convention on Biological Diversity**

Australia is signatory to the Convention on Biological Diversity (CBD) and a member of the Intergovernmental Committee on the Cartagena Protocol on Biosafety. In response to the CBD, an international biosafety protocol is currently being negotiated through this committee. The protocol will govern the 'transboundary movement' (i.e. movement across international borders) of living modified organisms resulting from modern biotechnology, which may have an adverse effect on the conservation and sustainable use of biodiversity.

You can find evidence about the safety of genetically modified products around the world by examining the different regulatory arrangements around the world and the outcomes of other countries' research. While many countries are developing or have just established arrangements for regulating GMOs, some countries rely on self-regulation by industry and scientists. The Australian arrangements under the new Gene Technology Act 2000 set an international benchmark for managing the risks associated with GMOs.

# Biotechnology glossary

## **1080 poison**

Sodium fluoroacetate, a highly poisonous substance used to control animal pests.

## **adult stem cells**

Undifferentiated cells in a tissue. These cells can grow into any of the types of specialised cells in that tissue.

## **anaemia**

A condition that is due to a reduced number of red blood cells or reduced amounts of haemoglobin within them. This results in reduced oxygen carrying capacity and reduced aerobic activity in body cells.

## **antibodies**

Proteins produced by humans and higher animals in response to the presence of a specific antigen.

## **anticoagulant**

Substance that prevents blood from clotting.

## ***Bacillus thuringiensis***

A species of soil bacterium that possesses a gene for a group of insecticides, the Bt toxins. Different strains of the bacterium produce different Bt toxins. The gene has been genetically engineered into cotton plants so that the plants produce the insecticide.

## **bacteria**

A large group of organisms that do not have organelles enclosed in cell membranes and have DNA in both a chromosome and circular plasmids. They have a protein and complex carbohydrate cell wall over a plasma membrane.

## **base sequence**

The order of the chemical units (bases) adenine, thymine, cytosine and guanine in DNA, that codes for a protein and so forms the genetic code.

## **biological control**

The control of a population of an organism by another organism. Generally the controlling organism is a predator or disease-causing organism of a species that is a pest.

## **bioremediation**

A natural process in which environmental problems are solved by the use of bacteria or other microorganisms that break down a problem substance, such as oil, into harmless molecules.

## **biotechnologists**

Scientists who develop useful products using biological processes.

## **biotechnology**

A broad term generally used to describe the use of biology in industrial processes such as agriculture, brewing and baking. Recently, the word has come to refer more to the production of genetically modified organisms or the manufacture of products from genetically modified organisms.

## **biotreatment**

The treatment of a waste or hazardous substance using organisms such as bacteria, fungi and protozoa.

## **Bt**

An abbreviation of the name of *Bacillus thuringiensis*.

## **calicivirus**

The virus that causes Rabbit Calicivirus Disease, RCD, in rabbits. It is spread by mosquitoes and fleas.

## **carriers**

Substances or particles that can transfer genes into a cell. These include viruses, liposomes (fat globules) and artificial chromosomes (sequences of DNA created in a laboratory) that can transport large amounts of DNA.

**cellulose**

A long-chain, branched polysaccharide that forms the cell walls of plants.

**chemotherapy**

The application of chemicals (drugs) to control the growth of cells that form a cancer.

**cholesterol**

A long chain molecule that is absorbed from food in the intestine or produced in the liver. It is needed as a part of blood plasma and of cell membranes.

**chromosome**

A threadlike component in cells that contains DNA and proteins. Genes are carried on the chromosomes.

**clone**

A group of genes, cells or organisms derived from a common ancestor. The members of the clone are genetically identical.

**cloning**

The process of production of a group of genes, cells or organisms that are genetically identical, from a common ancestor.

**congenital hypothyroidism**

An inherited trait that results in reduced activity of the thyroid gland, generally due to reduced production of thyroid stimulating hormone. The trait results in a reduced base rate of the body's chemical reactions, tissue swelling and weight gain. It can cause dwarfism in children.

**CSIRO**

Acronym for the Commonwealth Scientific and Industrial Research Organisation. This is a government-funded organisation that carries out research in science, industry and agriculture.

**cystic fibrosis**

An inherited disease that results in abnormal mucus secretion that produces severe respiratory problems, incomplete digestion and abnormal sweating.

**diabetes**

There are several forms of diabetes. It is a common condition in which the amount of glucose (sugar) in the blood is too high because the body is unable to use it properly. Normally, a hormone called insulin removes excess glucose from the blood.

**DNA**

Acronym for deoxyribonucleic Acid. A molecule of DNA consists of a long chain of deoxyribose, a 5-carbon sugar, and phosphate groups with the bases adenine, thymine, cytosine and guanine. DNA contains the genetic code that controls the production of proteins in living things.

**double helix**

Twin, parallel spirals. The handrails of a spiral staircase form a double helix. Alternating sugar and phosphate groups form a double helix in DNA.

**Down's syndrome**

An inherited condition due to extra chromosome 21 either as a third chromosome 21 or attached to chromosome 13, 14 or 15. Also called trisomy 21.

**electrophoresis**

The process whereby an electric charge is used to separate charged molecules in a mixture according to charge and size. It is routinely used to separate fragments of DNA.

**embryonic stem cells**

Undifferentiated cells in an embryo that are able to multiply and become differentiated into any sort of cell in the body.

**endangered**

A category of organisms with such low numbers in a population that the population is in danger of extinction.

**erythropoietin**

A hormone released from the kidneys and the liver in response to low oxygen concentrations in the blood. It controls the rate of

red blood cell production.

### **factor IX**

A soluble blood protein that forms part of the cascade of the 12 reactions of blood clotting.

### **feral**

A type of domestic animal that lives in wild conditions.

### **fertilisation**

The process of union of male and female reproductive cells (gametes), during the process of sexual reproduction, to form a cell called a zygote.

### **gene bank**

A collection of cells or artificial chromosomes containing known genetic information.

### **gene testing**

Methods that identify the presence or absence of a particular gene in an individual.

### **gene therapy**

The process of replacement of a defective gene in an organism suffering from a genetic disease. Recombinant DNA techniques are used to isolate the functioning gene and insert it into cells.

### **gene**

A segment of a chromosome. Some genes direct the synthesis of proteins, while others have regulatory functions.

### **genetic disorder**

A condition that results from a defective gene or chromosome.

### **genetic engineering**

A technology used to alter the genetic material of living cells in order to make them capable of producing new substances or performing new functions.

### **genetic screening**

The testing of a population for the presence of particular genes.

### **haemoglobin**

The protein found in the blood of most vertebrates and some invertebrates that carries oxygen and small amounts of carbon dioxide.

### **haemophilia**

An inherited disease that is due to a deficiency or lack of certain compounds in the blood. This results in impaired blood clotting and therefore excessive internal or external bleeding.

### **hazardous**

Dangerous.

### **herbicide**

A substance that kills plants. Herbicides are used in agriculture, horticulture and gardening to control unwanted plants. Herbicides can be selective, and kill selected species, or non-selective (broad spectrum), and kill all plants.

### **hormones**

Substances in the blood that are produced by cells of an endocrine gland or by nerve cells in response to a specific nervous or chemical stimulus. They affect the metabolic function of those cells that have the appropriate receptor for the hormone.

### **Human Genome Project**

The project that has identified and located all of the genes in human DNA, determined the sequences of the chemical bases that make up human DNA, and will store this information in databases.

### **human serum albumin**

Soluble blood proteins that make up about 55% of plasma proteins. They are involved in maintaining fluid balance in the blood and plasma volume.

**Huntington's disease**

An inherited disease due to a defective gene on the short arm of chromosome 4. It results in loss of motor control and mental deterioration. The symptoms do not appear until the person is in the 30s or 40s, generally after the most common reproductive age.

**immune system**

The cells, biological substances (such as antibodies), and cellular activities that work together to provide resistance to disease.

**immunocontraception**

A method of reducing fertility of a pest species by controlling or preventing conception and pregnancy. Used in rabbits, it depends on the insertion of genes using the myxoma virus.

***in vitro* fertilisation (IVF)**

Methods of carrying out fertilisation outside the body, usually in a glass container such as a covered laboratory dish.

**inherited disorders**

Conditions that are due to changes in individual genes, or groups of genes or in sections of chromosomes or whole chromosomes. These changes may be passed from parents to offspring.

**inorganic**

Substances that are not organic, that is, are not manufactured in living things.

**insecticide**

A substance that kills insects.

**insulin**

A hormone of vertebrates and invertebrates that promotes the conversion of glucose to glycogen.

**karyotypes**

A description or display of the number and types of chromosomes of an individual.

**lactoferrin**

A protein in breast milk that promotes infant growth.

**mammalian**

Describes the group of vertebrates that have internal development of the embryo, mammary glands that can produce milk, live-born young, a body covering of hair or fur, a four-chambered heart, a well developed cerebral cortex, the ability to maintain a constant body temperature, and, in most adults, a permanent set of teeth.

**marsupial**

A mammal whose distinguishing features include the birth of young at an early foetal stage of development, and generally, a pouch (marsupium) in which further development of the foetus occurs.

**microorganisms**

Organisms that can be seen only with the aid of a microscope. They are also known as microbes.

**mono-unsaturated**

Refers to molecules, such as fats, that have one double bond only. Mono-unsaturated fats can lower blood cholesterol levels. Some oils and margarines, avocados, olives, nuts and seeds contain mostly mono-unsaturated fats.

**muscular dystrophy**

An inherited condition that is due a gene on the X chromosome. It is therefore called a sex-linked gene. It results in the inability to produce a vital muscle chemical resulting in muscle wastage, stumbling, then inability to walk and death by the age of about 20.

**mutation**

A change in the base sequence of a gene so it does not perform its normal task in the cell.

**myxoma**

The name of the virus that causes myxomatosis in rabbits. It is carried by mosquitos and fleas.

**myxomatosis**

A disease of rabbits caused by the myxoma virus. It results in streaming eyes, swelling of the head, difficulty in breathing and eventually death.

**native**

Refers to organisms that have not been recently introduced into an ecosystem.

**nuclear transfer**

The process that involves the removal of the nucleus of a cell followed by the transfer of a nucleus from another cell into it.

**nuclei**

Plural of nucleus, the structure within the cell that contains the chromosomes.

**nucleotide**

The sub-unit of nucleic acids, DNA and RNA, that consists of a 5-carbon sugar, a phosphate group and a nitrogenous base. The bases are adenine, thymine, guanine and cytosine in DNA and are adenine, uracil, guanine and cytosine in RNA.

**organism**

A living thing. The term includes anything that has DNA, from bacteria to vertebrates.

**parasite**

Organism that lives in or on another organism and uses it as a source of food and shelter, so that the host is damaged.

**permafrost**

An area that is subject to permanent ice and snow.

**pesticide**

A substance that kills pests.

**pharming**

The process of farming genetically engineered animals to be used as living pharmaceutical factories. The practice has used cows, sheep, pigs, goats, rabbits and mice to produce large amounts of human proteins in their milk.

**phenylketonuria (PKU)**

An inherited disorder that results in reduced production of phenylalanine hydroxylase. This substance is involved in the breakdown of phenylalanine in food to tyrosine. In children this condition can result in mental retardation.

**pigments**

Chemicals that are coloured.

**plasmid**

A piece of DNA found in bacteria and yeasts that is able to replicate independently of the chromosome. Plasmids are usually circular.

**polymerase chain reaction (PCR)**

The process whereby a segment of DNA is cloned so that its sequence is multiplied many times in a laboratory.

**polyunsaturated fat**

A fat that has more than one double bond in the molecule.

**predator**

Animal that kills another animal for food.

**protein**

A long-chain molecule consisting of amino acids. The type and order of the amino acids in a protein is specified by the DNA in the cell that produces them.

**rabies**

A viral disease of wild animals that can be transmitted to humans through the bite of an infected animal. The disease has not yet been detected in Australia.

**recombinant DNA**

The DNA formed by combining segments of DNA from different types of organisms.

**saturated fat**

A fat that has only single bonds in the molecule.

**social hierarchies**

An arrangement within a group of animals, such as rabbits, where some individuals are dominant over others. The more dominant an animal, the more likely it is to have preferred access to mates and sources of food.

**somatic cells**

Body cells, that is cells other than sperm or eggs.

**species specific**

Refers to something that applies only to members of one species. A poison that is species specific affects only one species.

**staple length**

The length of the individual fibres of cotton. The length of the fibres affects the quality of the fabric that is made from it.

**Tay-Sachs disease**

An inherited disease that results in a build up of a substance called ganglioside in the brain. This causes brain damage.

**thalassaemia**

An inherited disease that results in reduced production of either alpha or beta haemoglobin. Symptoms range from mild to severe anaemia, stunted growth and bone deformities.

**tissue culture**

The process that involves the separation of cells from each other and their growth in a container of liquid nutrients.

**toxic**

Poisonous

**trait**

A feature that is genetically controlled.

**transgenic**

Refers to an organism with one or more genes that have been transferred to it from another organism.

**vaccine**

A preparation that contains either whole disease-causing organisms (killed or weakened), or parts of such organisms, used to confer immunity against the disease that the organisms cause. Vaccine preparations can be natural, synthetic or derived by recombinant DNA technology.

**vector**

A molecule of DNA, usually found in bacteria, that is used to carry foreign DNA into a host cell.

**viruses**

A group of particles that do not have a cellular structure and that consist of a molecule of DNA or RNA surrounded by a protein coat.