

biotechnology: introduction

The Science and Technology Select Committee has released a report claiming that science courses are overloaded with factual content and contain little contemporary science. A survey of student attitudes has found that students want to be taught about, and would like the chance to discuss, today's controversial issues. This resource gives teachers the chance to address these points while covering parts of the National Curriculum for science and citizenship.

What is genetic engineering and how is it done?

Genetic engineering (or genetic modification, GM) is the process of transferring a desired gene or genes into another organism to produce a genetically modified organism (GMO). There are several stages in producing a genetically engineered plant:

1 Isolate the gene that codes for the characteristic you want

A gene probe is used to identify the correct gene in the DNA of the donor organism. This gene is cut out of the DNA using restriction enzymes.

2 Insert the gene into a vector such as a bacterial cell or virus

Bacterial cells have special loops of DNA in them called plasmids. A plasmid can be removed from a cell and a restriction enzyme used to cut it open. A ligase enzyme can then be used to insert the desired gene into the plasmid. The plasmid is then put back into the bacterial cell.

3 Use the vector to transfer the gene into the host

The plant that you want to have the new gene is then infected with the genetically modified bacteria or virus. The host will produce new cells, often as part of a tumour growth, and some of them will contain the genetically modified plasmid with the new gene.

4 Clone the cells that contain the plasmid

Once cells that contain the new gene have been identified they can be cloned to form several identical cells. The new cells can be grown to produce genetically modified organisms that contain the desired gene.

How do science text books view biotechnology?

The standard view of biotechnology is that it is the answer to many of the world's problems, especially those related to feeding a growing world population.

The following examples are often quoted as beneficial uses of genetic engineering:

1. Producing crops that can grow in hostile environments
2. Making plants that are able to resist diseases
3. Producing crops that give a better yield and higher quality produce

However there is a danger in viewing scientific advances as value free. Students must consider both the positive and negative implications of any developments.

GM food and health

As yet there is little evidence to prove that GMOs are harmful, or that they are safe. Different groups disagree on what would be acceptable proof of long-term safety. Genes which make an organism resistant to antibiotics have already been transferred into non-GM plants by accident. If these genes got into disease causing bacteria it could have serious effects on our ability to fight disease.

GM food and the gene pool

Environmental and poverty groups worry about the effects that GMOs will have on biodiversity. It is possible that genetically modified genes could enter a normal plant by viral transfer, or that GM plants will cross breed with normal crops. This may weaken crop plants or increase the pesticide resistance of weeds.

GM food and development

Supporters of GM technology talk of its potential to feed the world by increasing crop yields and allowing more land to be used for productive farming. However, this is an oversimplification of the situation. There is currently more than enough food grown to feed everyone in the world. Hunger is caused by inequalities in access to this food. In fact, genetically engineered crops may reduce poor people's food security. Biotechnology favours large-scale intensive agriculture, but most people in developing countries are small-scale

subsistence farmers. Switching to GM seeds would require them to change their traditional practices and to use more fertilisers and herbicides. For example, many farmers save seeds from one year's crop to plant the next year, but this right is being threatened by GM companies. The introduction of 'Terminator' genes into their products would prevent saved seeds from germinating. Some other 'Traitor' GM crops will only grow properly if an expensive chemical was applied.

GM coffee

ActionAid has focused on GM coffee as a way of highlighting the potential problems that GM crops may bring. Sixty million people rely on coffee for all or part of their livelihood, and 70% of the world's coffee is produced by smallholder farmers.

Coffee beans grow in tight clusters of cherries and they ripen at different times. This has traditionally meant that they have to be picked by hand, providing an income for rural populations in developing countries. Scientists at a company in Hawaii are currently developing a genetically modified coffee that does not ripen until sprayed with the chemical ethylene. This could mean that all the coffee cherries will ripen at the same time.

Big multinational companies will benefit from this ripening controlled coffee as they will be able to grow coffee on huge plantations and harvest it with machinery; thus cutting labour costs, increasing coffee supply and increasing profitability for the company. However, poor farmers could lose their livelihoods and it's unlikely that the price of a cup of coffee will decrease.

Small farmers would be unable to afford the chemicals, seeds and machinery and so would not be able to use the GM technology. World markets are already flooded with coffee and prices are at historic lows. If coffee supplies increased further, it would push prices so low that poor farmers would go out of business. And if coffee can be picked by machines the coffee pickers will lose their employment and only source of income.

The voice of poor farmers

ActionAid is pioneering the use of Citizens' Juries to allow poor farmers to engage in the scientific and ethical debate around GM. Jurors hear evidence from experts on both sides of the argument before deliberating their verdict. In Brazil, 800 small-scale farmers, landless people and poor urban consumers, who are usually excluded from the policy-making process, attended the jury in 2001. The randomly picked jurors voted unanimously to condemn the

cultivation and commercialisation of GMOs and demanded studies into their environmental impact. In India the jury in Karnataka decided by 9 votes to 4 to reject the use of GM crops and demanded that scientists concentrated on agricultural techniques more relevant to their lives.

Who owns GM technology?

A company can register a patent on a food crop if they have made a change that is 'new, innovative, industrially applicable, and necessitates an inventive step'. The current patent system is giving agrochemical corporations unprecedented legal control over the basics of the food chain.

To use a patented food crop costs money; farmers have to buy it from the company that owns it and they are not allowed to save the seeds produced by the crop that they grow. This puts farmers in developing countries at the mercy of corporations. Six corporations currently control 98% of the global market for GM crops.

ActionAid has already drawn attention to the ease at which multinational corporations are able to buy up the right to basic foods by applying for its own patent – on salted chips. If granted, it will mean that people who want to put salt on chips will have to pay for a special licence. This might sound ridiculous, but imagine how poor farmers in developing countries feel when they are asked to pay to grow their food.

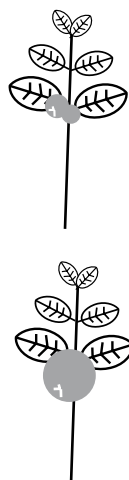
ActionAid believe farmers have the right to save, use, exchange and sell seed, and are launching a campaign on 16th October 2002 to mark World Food Day. This campaign aims to make sure that patent laws are written to protect farmers' rights. To find out more check our website www.actionaid.org

biotechnology: the science bit

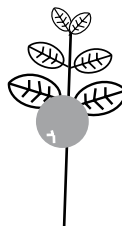
What is genetic engineering? All living things contain DNA made up of lots of different genes. Genes control characteristics of a plant or animal by deciding which proteins it makes. Genetic engineering (or genetic modification or GM) is used to put a gene from one organism into a different one. This will change the proteins it makes and so change its characteristics (the way it looks, acts or grows). The finished product is called a genetically modified organism, or GMO.

Instructions for making a GM plant

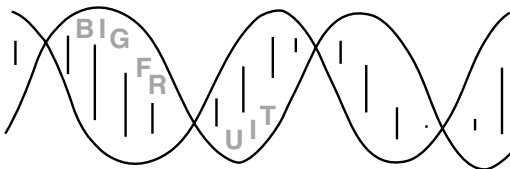
1 Take one plant and decide which new characteristic you want to give it.
This plant needs to produce bigger fruit.



2 Find another organism (plant, animal, bacteria etc) that has the characteristic you want.
This plant produces big fruit.

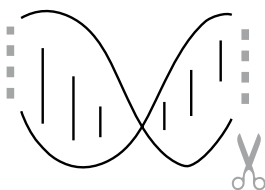


3 Identify the gene that gives the organism this characteristic.

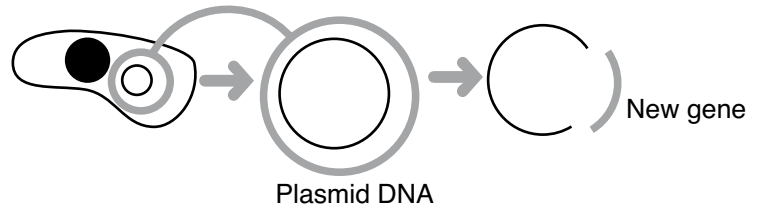


We want this bit

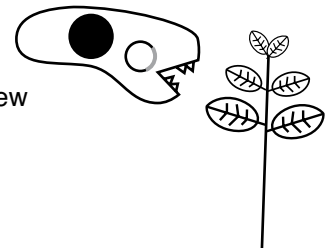
4 Cut this gene out of the DNA using a pair of 'biological scissors' known as a restriction enzyme.



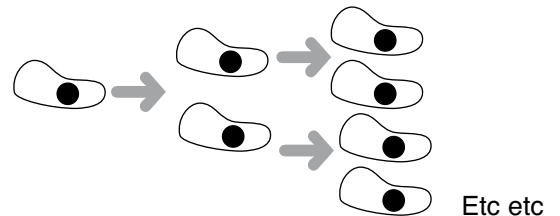
5 Put this gene into a bacterial or virus cell (called a vector) using a 'biological glue' known as ligase enzyme. The gene is often put into a special loop of bacterial DNA called a plasmid.



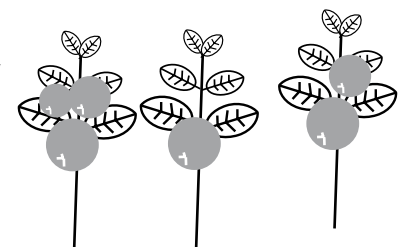
6 Infect the plant with the vector. Some of the plant cells will then contain the new gene.



7 Clone the cells that contain the genetically modified DNA. This is a form of asexual reproduction in which exact copies are made of the cell.



8 Grow the cloned cells to produce genetically modified organisms that contain the desired gene.



Mission accomplished

Benefits of genetic engineering

Genetic engineering has been used to make:

1. Crops that can grow in hostile environments
2. Plants that are able to resist diseases
3. Crops that give a better yield and higher quality produce

Brainstorm – What are the potential benefits of genetic engineering?

Design – You have the chance to develop your own GM plant. What would you make and why?

Sounds like a great idea?

Well maybe, but a lot of people are worried that the GM crops might not be safe to eat or that the technology will damage the environment. Many people think that it is wrong to meddle in nature in any way. Some people think that GM food will solve world hunger, but others think it will make the problem worse.

Think – What is your opinion on GM food at this point? What has influenced your opinion? What have you read / heard about GM in the news?

Write – Note down your opinions on the points above. Do you have enough information to decide? Write down any questions you have or information you need.

GM food, health and the environment

As yet, there is little evidence to prove that GMOs are harmful (to people or the environment) or that they are safe.

Research – Search for information in newspapers, libraries and the internet. Try to find evidence of a range of viewpoints.

Think – What evidence would you need to prove that GM food is safe? How would you carry out your investigation? What would make it a fair test?

GM food and poor people

Companies claim that GM technology can increase crop yields and will allow plants to grow in dry conditions or on salty land that cannot normally be used. Some people therefore think that it will solve the problem of world hunger. At ActionAid we realise that the issue is not that simple. There is actually enough food produced at the moment to feed everyone on the

planet, but 800 million people each year still go hungry. This is because the food is not shared out fairly and so millions of people do not have access to it.

GM foods may make this problem worse. Most people in developing countries grow a small amount of food for their own use. These farmers usually save some of the seeds from one year's harvest to plant the next year. Some companies are developing GM seeds containing special 'terminator genes'. This means that saved seed will not germinate the next year. Farmers will then be forced to buy a special chemical to make the seeds germinate, or buy more seed, or face being prosecuted.

Companies are allowed to do this because the modified seeds are considered to be inventions which can be patented. The patent provides ownership right to the holder for between 17-20 years. To use a patented seed costs money. In some cases, companies have managed to patent a type of seed that a community has used for years. Poor farmers may find themselves being charged for growing their own food.

GM coffee

Coffee is traditionally picked by hand as the berries ripen at different times. Scientists at a company in Hawaii are currently developing a genetically modified coffee that does not ripen until sprayed with the chemical ethylene. This means that all the coffee berries will ripen at once.

Big companies benefit

Grow coffee on plantations

- ↓ harvest with machinery
- ↓ cut cost of wages
- ↓ make more money, or

Grow coffee on plantations

- ↓ grow more coffee
- ↓ sell more coffee beans and products
- ↓ make more money

Poor people lose out

Farmers can't afford chemicals, seeds or machinery and, coffee prices fall because more is grown

- ↓ go out of business
- ↓ go hungry

Coffee pickers lose their jobs to machines

- ↓ no income
- ↓ go hungry



My name is Melkam Ayalew and I'm 20. I support my family in Ethiopia by growing coffee. Even in a good year I only earn about £23 from my whole coffee crop so I make ends meet by growing and selling fruit and sewing clothes. At the moment coffee prices are low so we have to cut back. Sometimes we can't afford breakfast. If GM coffee was developed I wouldn't be able to afford to use it. If it caused coffee prices to drop, we wouldn't be able to survive.

Read – Look back to what you wrote about your opinions at the start. Have you changed your mind in any way?

Debate – Divide the class into two groups. One group argue for GM and one against.

Citizen power

People can make a difference

ActionAid launched a campaign encouraging people to send postcards to the companies involved in researching GM coffee. The postcards asked the companies to stop their research. People also wrote to UK coffee shops telling them that they would not want GM coffee if it came onto the market. Thousands of people took part and managed to convince Starbucks, Coffee Republic, Caffè Nero, Costa Coffee, Prêt à Manger, Whittards of Chelsea and Sainsbury's not to stock GM coffee.

ActionAid believes farmers have the right to save, use, exchange and sell seed, and are launching the 'Seed Rights campaign' on 16th October 2002 to mark World Food Day. This campaign aims to make sure that patent rules are written to protect farmers' rights.

Action - Check out www.actionaid.org for more information

Register - As a campaigner on www.actionzone.cc

Drink - Fairtrade coffee and encourage other to do so too. Fairtrade products make sure that the people who make them get paid a fair price.

Facts

1. 60 million people rely on coffee for all or part of their livelihood
2. 70% of the world's coffee is produced by smallholder farmers.
3. 46% of the land used for growing soya beans is used for GM varieties
4. 91% of the land used to grow GM crops is supplied by one company - Monsanto
5. 68% of the world's GM crops grow in the US
6. Coffee originally comes from Ethiopia

Websites

www.actionaid.org
www.greenpeace.org.uk
www.foe.co.uk
www.bbc.co.uk/genes/index.shtml
www.fairtrade.org.uk
www.integratedcoffee.com/AboutICTI.htm
www.monsanto.com

(Note: these websites have been chosen to give a range of opinions. ActionAid does not necessarily agree with the views on these websites)