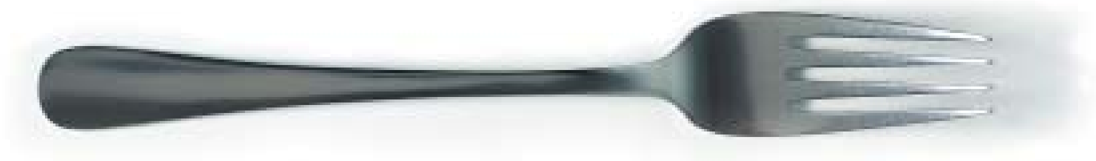
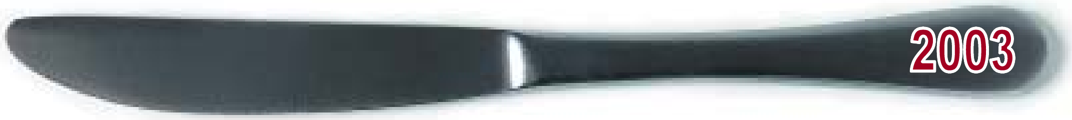


GM food opening up the debate



FOOD
STANDARDS
AGENCY

GM food opening up the debate

2003

Contents

Timeline disclaimer: although checked against a variety of sources, dates will vary according to dates of discovery/publication and usage. This is not a comprehensive list but is designed to provide a guide to the chronology of gene manipulation and a context for the current debate.

Introduction

In July 2002, the Government announced a public debate to help people deepen their understanding of genetic modification. This debate is taking place in the run-up to the Government making decisions on whether to allow genetically modified crops to be grown commercially. The contribution of the Food Standards Agency to this debate is to independently assess people's views on the acceptability of genetically modified food and how this relates to consumer choice.

The aim of this booklet is to provide the basic information you need to take part in this debate. It covers two issues within the Agency's remit, which are to ensure that:

- any such food is thoroughly assessed for safety
- consumers are given as much choice as possible

There is a glossary on page 19 and, to help put genetic modification in context, we have included a timeline that runs throughout this booklet showing how people have been manipulating plants and animals since 10,000 BC.

However, this booklet does not cover environmental issues, such as biodiversity, or economic and social issues. These matters are primarily the responsibility of other Government departments and will be considered in other parts of the wider debate.

What is GM?

GM, which can stand for genetic modification or genetically modified, is the technique of changing or inserting genes. Genes carry the instructions for all the characteristics that an organism – a living thing – inherits. They are made up of DNA. Genetic modification is done either by altering DNA (see page 2 for an explanation of DNA) or by introducing genetic material from one organism into another organism, which can be a variety of either the same or a different species. For example, genes can be introduced from one plant to another plant, from a plant to an animal, or from an animal to a plant. Transferring genes between plants and animals is a particular area of debate.

Sometimes the term 'biotechnology' is used to describe genetic modification. This also has a wider meaning of using micro-organisms or biological techniques to process waste or produce useful compounds, such as vaccines.

Throughout this booklet the abbreviation 'GM' will be used to stand for 'genetically modified'.

10,000–9000 People start planting crops rather than relying on hunting and gathering for food.

6000 In Mesopotamia, Sumerians use yeast – a type of fungus – to make beer and wine.

5000 Farming communities in existence.

4000 Egyptians use yeast to make bread rise.

BC

Why is genetic modification being used?

Genetic modification allows plants, animals and micro-organisms, such as bacteria, to be produced with specific qualities more accurately and efficiently than through traditional methods. It also allows genes to be transferred from one species to another to develop characteristics that would be very difficult or impossible to achieve through traditional breeding.

People have been breeding animals and new varieties of plants for many hundreds of years to develop or avoid certain qualities. Examples include racehorses that are bred to be faster and stronger, and roses, bred to give us a wider range of colours and to make them more resistant to disease. Over many generations, sometimes for thousands of years, the world's main food crops have been selected, crossed and bred to suit the conditions they are grown in and to make them tastier.

For example, cattle are bred according to whether they are for beef or dairy herds. Most of today's dairy cattle are very different from the cattle that were originally domesticated. Over the years, dairy herd breeding has focused on increasing milk yield and on improving the quality of the milk.

But whereas traditional methods involve mixing thousands of genes, genetic modification allows just one individual gene, or a small number of genes, to be inserted into a plant, or animal, to change it in a pre-determined way. Through genetic modification, genes can also be 'switched' on or off to change the way a plant or animal develops.

For example, herbicides are used to kill weeds in fields of crops but they can also affect the growth of the crops they are intended to protect. By using genetic modification, a gene with a particular characteristic, such as resistance to a specific herbicide, can be introduced into a crop plant. When that herbicide is sprayed on the field to kill the weeds, it will not hinder the growth of the crops.

Similarly, genetic modification can be used to reduce the amount of pesticide needed by altering a plant's DNA so it can resist the particular insect pests that attack it. Genetic modification can also be used to give crops immunity to plant viruses or to improve the nutritional value of a plant. In animals intended for food, genetic modification could potentially increase how fast and to what size they grow.

What is DNA?

DNA stands for deoxyribonucleic acid. It is the genetic material contained in the cells of all living things and it carries the information that allows organisms to function, repair and reproduce themselves.

Every cell of plants, micro-organisms (such as bacteria), animals, and people contain many thousands of different genes, which are made of DNA. These

3000–2000 Peruvians select potatoes (from around 160 wild species) with the lowest levels of poisons and grow them for food.

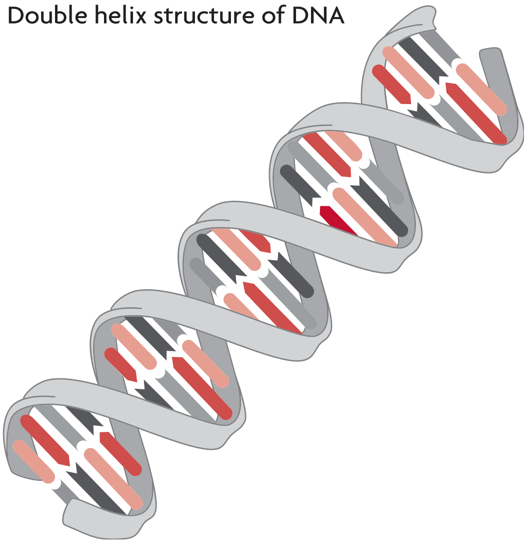
1000–700 Assyrians and Babylonians pollinate date palms by hand.

400 Hippocrates suggests that the fathers' contribution to their children's genetic inheritance is carried in semen.

genes determine the characteristics, or genetic make-up, of every living thing, including the food we eat. When we eat any food, we are eating the genes and breaking down the DNA present in the food.

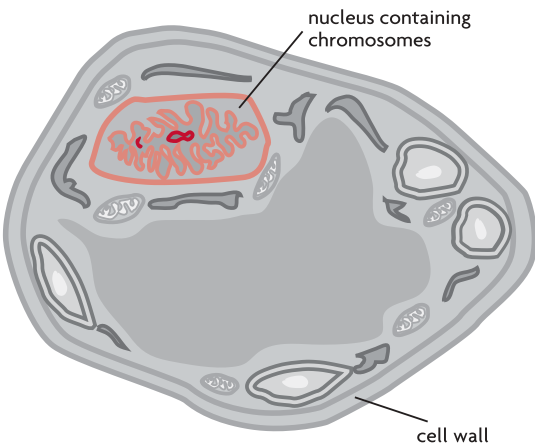
DNA is made up of two separate strands of what are called 'nucleotides'. These are the building blocks of DNA and are twisted around each other in a double helix structure.

Double helix structure of DNA



The identity of a gene and the function it performs are determined by the number of nucleotides and the particular order in which they are strung together on chromosomes – this is known as the 'sequence' of the gene. Chromosomes are the structures in cells that carry DNA.

Plant cell



Late 17th century Cells and plant structures and functions described in detail. First systematic breeding of flowers in the Netherlands. Sexual basis of plant reproduction described, which suggested how different strains of crops could be crossbred to develop new types.

1719 Thomas Fairchild announces first production of artificial hybrid plant by crossing a carnation with a sweet william.

AD

How does genetic modification work?

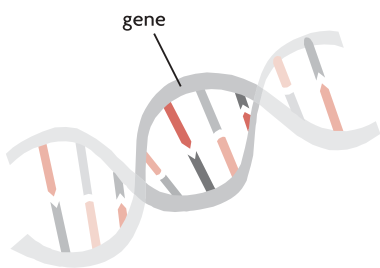
Genetic modification involves inserting or altering an organism's genes to produce a desired characteristic.

Inserting genes

When a plant, for example, is modified by inserting a gene from another plant into it, this is the process:

1. A plant that has the desired characteristic is identified.

2. The specific gene that produces this characteristic is located and cut out of the plant's DNA.



Gene located in plant's DNA

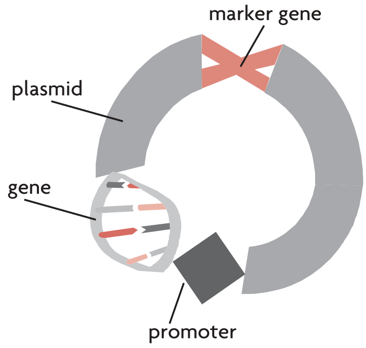
3. To get the gene into the cells of the plant being modified, the gene needs to be attached to a carrier. A piece of bacterial DNA called a plasmid is joined to the gene to act as the carrier.

4. A type of switch, called a 'promoter', is also included with the combined gene and plasmid. This helps make sure the gene works properly when it is put into the plant being modified. Only a small number of cells in the plant being modified will actually take up the new gene. To find out which ones have done so, the gene package often also includes a marker gene to identify them (see Antibiotic-resistant marker genes on page 10).

1727 Vilmorin Company, in France, develops pedigree method of breeding sugar beets and starts research into plant breeding and improving cultivated varieties.

1750–1850 European farmers increase cultivation of legumes (to fix nitrogen in the soil) and rotate crops to increase yields.

1761–66 Joseph Kölreuter uses tobacco plants to carry out the first systematic experiments in crossing varieties. He notes that the resulting hybrid plants often grow more vigorously than their parents.

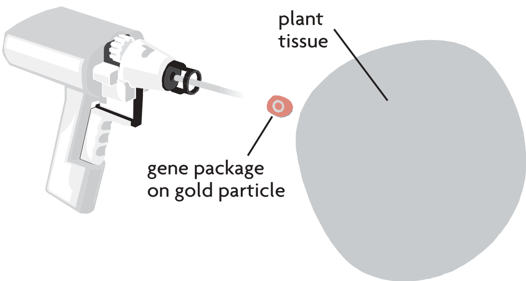


Gene package

5. The gene package is then inserted into a bacterium, which is allowed to reproduce to create many copies of the gene package.

6. The gene packages are then transferred into the plant being modified. This is usually done in one of two ways:

    i) by attaching the gene packages to tiny particles of gold or tungsten and firing them at high speed into a piece of the plant's tissue. Gold or tungsten are used because they are chemically inert – in other words, they won't react with their surroundings.



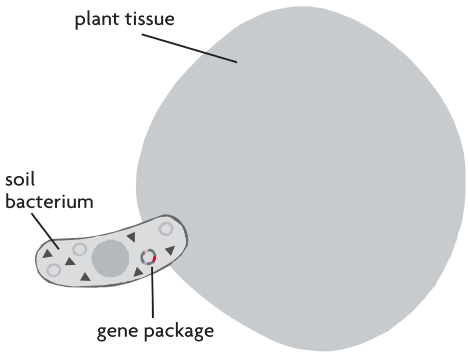
Gene gun firing gold particle with gene package into plant tissue

1819 Patrick Shirreff starts breeding wheat and oats to develop new cultivated varieties and study their differences.

1823 Thomas Knight (1759–1838) confirms evidence of dominance and recessivity in peas. Goes on to create new hybrids in staple British fruit and vegetable crops.

Early 1840s Sutton and Son (now Suttons Seeds) develops varieties of beets, peas and potatoes suitable for growing in Britain.

ii) by using a soil bacterium, called *Agrobacterium tumefaciens*, to take in the gene package when the bacterium invades the plant tissue. The gene packages are put into *A. tumefaciens*, which are modified to make sure they do not become active when they invade the new plant.



Soil bacterium containing gene package invading plant tissue

7. The plant tissue that has taken up the gene packages is then grown into full-size GM plants.

8. The GM plants are checked extensively to make sure that the new genes are working as they should. This is done by growing the whole plants, allowing them to turn to seed, planting the seeds and growing the plants again, while monitoring the gene that has been inserted. This is repeated several times.

Altering genes

Genetic modification does not always involve moving a gene from one organism to another. Sometimes it means changing how a gene works by 'switching' it off to stop something happening. For example, the gene for softening a fruit could be switched off so that although the fruit ripens in the normal way, it will not soften as quickly. This can be useful because it means that damage is minimised during packing and transportation.

Controlling this gene 'switch' may also allow researchers to switch on modified genes in particular parts of a plant, such as the leaves or roots. For example, the genes that give a plant resistance to a pest might only be switched on in the bit of the plant that comes under attack, and not in the part used for food.

In what other ways are food crops altered?

Plant breeders use a range of methods to produce varieties with particular qualities, such as traditional crop breeding and, more recently, chemicals and radiation.

The traditional method of cross-breeding to produce hybrid plants has been used for generations. This involves breeding different combinations of plants repeatedly to encourage sought-after characteristics and breed out the less desirable ones. However, through this method large amounts of genetic material are passed between plant varieties. This makes it more difficult to develop specific characteristics without incorporating other unwanted ones, such as susceptibility to disease.

Before precise genetic modification techniques were developed, plant breeders used a variety of methods to try to generate useful genetic alterations that had not appeared in the plant naturally. For example, one method that became popular in the 'nuclear age' after the Second World War was using radiation to alter the genes of crop and horticultural plants. The rice variety 'Calrose 76' was produced using gamma rays to create a shorter plant, and 'Alamo-X' oats were produced using X-rays to give it resistance to blight.[1]

A type of barley called 'Golden Promise' was also developed using gamma rays. This caused a genetic change in a particular variety of barley so that it produced a shorter plant with a high yield and good malting qualities – important for brewing. Originally sold in 1966, Golden Promise was the main variety grown in Scotland during the 1970s and 1980s.[2]

Chemicals such as sodium azide and ethyl methanesulphate have also been used to alter plant genes. In the 1970s, this type of breeding was particularly popular in the United States of America and sometimes new varieties are still created using chemicals or radiation, especially in developing countries. However, these methods can take a long time to achieve desirable results because the genetic alterations they create are random. In fact, most of the genetic alterations generated by these methods are not useful for plant breeders. In contrast, genetic modification technology creates specific changes.

1 See: www.colostate.edu/programs/lifesciences/TransgenicCrops/history.html (more information on using radiation to generate useful genetic alterations is on the International Atomic Energy Agency's website at: www-infocris.iaea.org/MVD/)
2 Robinson, C. *Genetic Modification Technology and Food*. pp 2. Brussels: International Life Sciences Institute Press, 2001

1890s William Farrer runs a large wheat-breeding programme in Australia, selecting for resistance to disease, especially avoiding rust.

1899 Major international meeting in London on plant hybridisation.

1900–1 It is shown that bacteria can be used to make some important industrial chemicals.

20th Century

When was genetic modification technology developed?

The first GM plants were created in 1983. Since then a range of different crop plants, including soya beans, maize and rice have been created with characteristics such as herbicide tolerance, and the ability to resist attack by insects and viruses.

But the impulse to develop and improve crops, for example to increase yield and strength, which has led to genetic modification technology, can be traced all the way back to the earliest farming communities. The timeline that runs through this booklet traces these developments.

What genetic modification technology is being developed?

Scientists are working to create crops with added nutritional value by changing the fat, protein or vitamin content of the plant.

For example, a type of rice called 'Golden Rice' is being developed with higher levels of beta carotene (which the body converts into vitamin A). This is intended for use in parts of the developing world where vitamin A deficiency is common. Lack of vitamin A can lead to permanent blindness and leave the body less able to fight off illness.

Another example is a potato that has been genetically modified with a gene from an amaranth plant to create a potato that has a third more protein than usual. Amaranth is a South American plant that was originally used by the Aztecs to make flour. Its leaves are also sometimes used as a vegetable.

Researchers are also working on the following:

- producing crops that can grow on land that until now would have been unsuitable. For example, one project involves producing tomatoes that can grow on soil containing high levels of salt

- removing the elements of a plant that trigger allergy or illness in some people. For example, a type of protein in rice can cause dermatitis, but switching off the gene should produce a variety of rice that is much less likely to trigger an allergic reaction

- developing ways of protecting plants against disease, such as mould

Early 1900s Biological staining developed. so scientists can see cell structures more clearly. Noting that different organisms have different numbers of chromosomes, they suspect that chromosomes carry the information for each organism's development.

1902–1916 Several inheritance patterns were identified for human disease, such as: alkaptonuria (1902); albinism (1903); Huntington's chorea (1913); and sex-linked conditions such as red/green colour blindness (1914) and haemophilia (1916).

1905 Chromosomes for sex inheritance identified.

In what ways is genetic modification used in food production?

Genetic modification can be used in a number of ways in food production. These range from modifying the raw ingredients to using genetic modification during processing.

When genetic modification is used as a part of the production process, as in 4 below, the GM material does not end up in the food on our plates. This is similar to other processing techniques, so, for example, when a food processor is used for slicing, no part of the processor ends up in the meal we eat.

These are the different ways that genetic modification can be used in food production.

1. GM food:
A crop, such as a fruit or vegetable, or an animal can be genetically modified. (However, no animal or human genes, or GM animals, have been approved for use in GM food in the EU.)

2. GM ingredients:
Food that comes from a GM crop, such as GM maize, can be processed, for example into flour, and the GM DNA is still present in the food and can be identified.

3. 'GM-derived' ingredients:
Food can come from a GM crop but the DNA can be processed out of the final product – this is called 'GM-derived'. An example of this is soy oil, which is made from GM soya beans. The processing breaks up the DNA so that it can no longer be identified either as GM DNA or conventional DNA in the final oil because it has been broken down into fatty acids. Therefore, soy oil from GM soya beans cannot be distinguished from soy oil from conventional beans.

4. GM processing aid:
A GM organism can also be used to make a product without GM material being present in the ingredients or in the final product. In this case the GM organism is a 'processing aid'. One example is hard cheese production. The enzyme chymosin is the active ingredient of rennet, which is used to curdle milk. Traditionally, rennet has been taken from calves' stomachs, but the demand for cheese is greater than the number of calves available and the chymosin in this rennet does not always produce consistent batches of cheese. Today the gene responsible for producing chymosin can be inserted in bacteria, so the bacteria make the chymosin instead of using traditional rennet. Only the bacteria are genetically modified, not the chymosin, so the cheese has no GM content because the bacteria are not part of the cheese.

1907–17 Thomas Hunt Morgan's team at Columbia University start work on gene mapping the fruit fly. They set the standard for gene mapping, having shown that the gene is the key to the heredity patterns described by Mendel and is how development is controlled.

1920s Hermann Muller reports that X-rays can bring about mutations in animals.

5. GM ingredients in animal feed:
GM crops, such as maize, are also used to feed animals that are later eaten, such as chickens. The GM material is not, however, in the meat that we eat. There are also animal products, such as eggs and milk, that come from animals fed on GM crops. Again, these products do not contain GM material.

How does processing affect the DNA in foods?

DNA is broken up in the same way that food processing can alter or destroy other characteristics of food ingredients, such as texture, during manufacturing. Processing includes all the stages involved in getting food ready for us to eat, from refining raw materials to cooking in our homes.

What happens when people eat GM food?

Human beings have always eaten plants and animals, which means we have always eaten their DNA without it causing any health problems. Given that GM DNA is still DNA, eating it should not pose any greater risk than eating unmodified DNA. Indeed, no one has ever been reported as suffering from illness because the food they had eaten had been genetically modified.

When someone eats GM food it is processed in the same way as non-GM food. When we eat any food, our digestive systems break down the tissue, the proteins, and the DNA in the food. The DNA in GM food has the same structure as non-GM DNA and is broken down in the same way. Most DNA that is consumed, whether GM or not, is broken down in our stomachs and intestines.

Sometimes, the DNA from the food we eat isn't broken down. However, it is unlikely that this DNA will become part of our genetic material by passing into our cells – any non-human DNA should simply be broken down in the cell.[3]

Antibiotic-resistant marker genes

During the process of genetic modification, marker genes are used to check whether particular cells have taken up the modified gene. Antibiotic-resistant marker genes are one type of marker gene. If a cell is resistant to the particular antibiotic, this shows that the cell has taken up the modified gene. Some people have suggested that antibiotic-resistant marker genes could be transferred into the bacteria in our gut, along with the resistance to the particular antibiotic. If this happened, the particular antibiotic, if prescribed to treat an infection, would not work in that person.

The Advisory Committee on Novel Foods and Processes (ACNFP) is an independent scientific committee that advises the Food Standards Agency.[4]

3 For a fuller discussion of these issues, see section 6 (The fate of plant DNA in the digestive system) of the Royal Society's *Genetically Modified Plants for Food Use and Human Health – an Update* (London: The Royal Society, 2002 or at: www.royalsoc.ac.uk.)

4 More information on the ACNFP can be found at: www.food.gov.uk/science/ouradvisors/novelfood/ or by writing to the ACNFP secretariat, Food Standards Agency, Aviation House, 125 Kingsway, London WC2B 6NH

1928 Lewis Stadler describes impact of X-rays and radium on barley mutation.

1941 George Beadle and Edward Tatum show each gene 'codes' (contains instructions for) a particular protein.

1941 Charlotte Auerbach and JM Robson show that chemicals can cause mutations.

1944 Oswald Avery, Colin MacLeod and Maclyn McCarty show that DNA is the genetic molecule – in other words, it is the way genetic information is passed between generations.

In 1996, when the first GM maize was approved as a food, the ACNFP raised the concern that antibiotic resistance marker genes might be transferred from GM plants to the bacteria in our digestive systems. At that time, the ACNFP concluded that there was a low risk of this happening. Since then, further research has shown that the risk of transfer is even lower than originally thought.

However, to remove this risk completely, the ACNFP has recommended that these marker genes should be removed once the original genetic modification has been carried out. There is general agreement among regulators and companies developing genetic modification technology that using antibiotic resistance markers should be phased out.

The European Directive on this issue states that, by 31 December 2004, antibiotic resistant marker genes that may have 'an adverse effect on human health and the environment' should be phased out from GM organisms that could enter the food chain.[5] (European Directives are binding on Member States but national governments decide how they will implement them.) Antibiotic resistant marker genes authorised for research purposes only, and not for the food chain, should be phased out by the end of 2008. This would leave currently approved crops containing antibiotic resistant marker genes on sale. However, this generation of crops is likely to be superseded by newer varieties that do not contain these genes.

Are GM foods assessed for safety?

Every new food that comes on to the market must be approved before it can be sold or consumed in the European Union.

In the UK, these new or 'novel' foods are assessed by the ACNFP. Members of ACNFP have a wide range of relevant scientific expertise and knowledge and include three lay members: two consumer representatives and an ethicist. You can find out more about the work of this committee on the Agency's website at: www.food.gov.uk/science/ouradvisors/novelfood/

The ACNFP's meeting papers and minutes are published on the website and once a year the committee holds an open meeting during which members of the public can ask questions about its work.

The approval process

The manufacturer of any novel product must provide detailed information to a Member State of the EU so it can assess the product for safety. The assessment involves a comparative approach based on the concept of 'substantial equivalence'. This means that a novel food is compared with an equivalent existing food.

5 European Directive 2001/18/EC (Deliberate Release Directive for GMOs into the Environment)

1953 Francis Crick and James Watson announce that DNA has a double helix structure.

1950s/60s Understanding of the structure of genes, and how they work, deepens.

1966 Marshall Nirenberg, Heinrich Mathaei, and Severo Ochoa demonstrate the basis of the 'genetic code'. They show that a sequence of three nucleotide bases (known as a codon) determines each of 20 amino acids, which are the building blocks for proteins.

For example, a GM food might be compared with a non-GM variety, provided it is essentially equivalent. Any differences between the composition of the novel food and the existing food are identified and examined carefully. The Member State then decides whether the novel food is as safe as the existing food and therefore whether it can be considered 'equivalent' to it. Views of all the other Member States are sought before a final decision on approval is made.

This approach is set out in the EC guidelines on the assessment of novel foods and has been endorsed by the World Health Organization (WHO). A detailed description of substantial equivalence can be found in section 4.4 of the document *Safety aspects of genetically modified foods of plant origin* on the WHO website.[6]

The Food Standards Agency is satisfied that these safety assessment procedures, using the framework of substantial equivalence, are sufficiently rigorous to ensure that approved GM foods are as safe to eat as their non-GM counterparts.

The Agency bases its advice on the best scientific evidence available. In the case of GM food, the ACNFP advises the Agency on what that evidence is and what it means for food safety. On this evidence, the Agency has concluded that GM foods and ingredients approved to date pose no additional risks.

Views of other scientific groups

Other scientific and medical bodies have also looked at the subject of GM foods over the past few years. Here are a few examples.

The Chief Medical Officer (CMO) and Chief Scientific Adviser (CSA)

In May 1999, the UK Government's CMO and CSA published the report *Health Implications of Genetically Modified Foods,*[7] in which they concluded:

- Many of the issues raised by GM foods are equally applicable to foods produced through conventional methods.
- There is no current evidence to suggest that genetic modification technologies, used to produce food, are inherently harmful.
- The precautionary nature and rigour of the current procedures used to assess the safety of individual GM foods were reassuring.

6 World Health Organization. *Safety aspects of genetically modified foods of plant origin*. Report of a Joint FAO/WHO Expert Consultation on Foods Derived from Biotechnology, 2000. Can be read at: www.who.int/fsf/GMfood/FAO-WHO_Consultation_report_2000.pdf

7 Chief Medical Officer Professor Liam Donaldson and Chief Scientific Adviser Sir Robert May *Health Implications of Genetically Modified Foods*, May 1999. Can be read at: www.doh.gov.uk/cmo/gmfood.htm

1960s/70s Work on creating high yield varieties of major grains, especially wheat, corn, millet and rice, massively increases production of these crops in many countries. This process is known as the 'Green Revolution'.

1972 Paul Berg creates the first genetically modified DNA molecule.

1973 Stanley Cohen, Annie Chang and Herbert Boyer create the first genetically modified DNA organism.

A Medical Research Council Expert Group on GM foods

In June 2000, this Expert Group produced a report on the range and potential mechanisms of effects that GM foods might theoretically have on human health.[8] The Group concluded:

- Many of the potential effects of GM foods on human health also apply to food or food ingredients produced by conventional plant and animal breeding.
- Current regulatory procedures, using the principle of substantial equivalence, addressed the theoretically possible health risks of known toxins and allergens in GM foods.

The Royal Society

In 2002, the Royal Society updated its earlier report on GM plants for food use and human health.[9] Its conclusions included:

- There is no evidence at present that GM foods cause allergic reactions.
- We have eaten DNA in food throughout our history without any problems so it seems reasonable to assume that this poses no significant risk to human health and eating GM DNA will have no ill effects.

A Food and Agriculture Organization/World Health Organization Expert Consultation on the 'Safety aspects of GM foods of plant origin'

In May 2000, this consultation[10] concluded:

- The application of the concept of substantial equivalence contributes to a robust safety assessment framework. The approach used to assess the safety of the GM foods that have been approved for commercial use is satisfactory.

The Codex Alimentarius Commission's Ad Hoc Task Force on foods derived from biotechnology

The Codex Alimentarius Commission is the intergovernmental body responsible for consumer protection and fair practice in the international food trade. The Task Force has drafted two texts, one on the principles for the risk assessment and another on the guidelines for the safety assessment of foods produced from biotechnology. When adopted, these guidelines will provide an international standard for the safety assessment of GM foods.[11]

8 The background to the Medical Research Council's expert group report and the report itself can be read at: www.mrc.ac.uk/index/strategy/strategy-science_strategy/strategy-strategic_implementation/strategy-highlight_notices/strategy-gm_foods.htm
9 See reference at footnote 3
10 See reference at footnote 6
11 The terms of reference for this Codex Alimentarius task force can be read at: www.codexalimentarius.net/ or by writing to the: Secretariat of the Joint FAO/WHO Food Standards Programme, FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy

Is GM food on sale in the UK?

Three GM foods or ingredients have been on sale or approved for use in foods in the UK:

- GM tomatoes, which were sold only as tomato purée
- GM soya
- GM maize

No fresh GM produce has been approved for sale or consumption in the UK. There have been no animal, fish or human genes approved for use in GM food anywhere in the world.

However, many processed foods in the UK, such as biscuits, cooking sauces, and food coatings, will include GM ingredients at a very low level if they use soya or maize as an ingredient. The same will be true for products imported from countries growing GM soya or maize. So, unless an individual's diet contains no processed foods, they are likely to be eating at least some GM or 'GM-derived' food, even if this is only at a low level. If they have travelled to one of the countries that grow GM crops in the past few years, especially the USA and Canada, it is very likely that they will have eaten food that contains GM material or is derived from it.

Animal feed

Also, as more countries have started using genetic modification technology, supplies of animal feed ingredients to the UK have increasingly contained GM or 'GM-derived' products. Maize, soya and oilseed products are major sources of energy and protein for UK livestock. Imported soya and maize by-products account for around 20% of the raw materials used by UK feed manufacturers and farmers.[12]

More than half the soya bean crop grown worldwide is GM, and increasing proportions of maize and oilseed rape crops are GM – figures are given in the table on page 17.[13] Some animal feed is therefore likely to contain ingredients derived from GM crops, but it is not possible to say how much because the exporting countries do not routinely separate their GM and non-GM crops. As an indication however, 30% of the US maize crop is GM, while 75% of US soya and 95% of Argentine soya planted in 2002 were GM.[14] Some animal products, including meat, milk and eggs, therefore come from animals that have eaten GM feed, either here in the UK or in their country of origin.

The amount of animal feed consumed by different types of livestock varies according to their diet. Cattle and sheep eat a higher proportion of grass in their diets, as opposed to pigs and poultry, which eat more maize and cereals.

12 Estimates from the Grain and Feed Trade Association
13 James, C. Global Status of Commercialized Transgenic Crops: 2002. ISAAA Briefs No. 27: Preview. Highlights of this report can be seen on the Crop Biotech Net site at: www.isaaa.org.kc/
14 Sources: Food Standards Agency, Grain and Feed Trade Association, US Department of Agriculture and American Soybean Association

1983 Four separate groups of scientists create GM plants; three groups insert bacterial genes into plants and one inserts a bean gene into a sunflower plant.

1980s GM crop plants start being developed with useful characteristics such as herbicide tolerance and insect and virus resistance.

Late 1980s/Early 1990s China first to put GM crops on sale, namely a virus-resistant tobacco and a tomato.

1990 Genetic modification used to make chymosin, an enzyme used in making hard cheese.

However, the diets of all species of livestock are supplemented by manufactured compound feeds, particularly during the winter. The choice of what feed to use is determined by factors such as the age and species of the animal and the availability and price of feeds.

How much GM food is on sale in Europe?

Currently, food ingredients from varieties of GM soya, maize and oilseed rape have been approved for food use in the European Union although very little is actually used. These include oils and syrups that contain 'GM-derived' material, and flours and starches. These ingredients *could* be used in a wide range of processed foods, from vegetarian burgers to biscuits and sauces, in the same way ingredients from non-GM crops are used.

However, many food manufacturers and supermarkets have said that they are excluding ingredients from GM crops from their products. This started in the late 1990s, when people became more concerned about genetic modification.

Some GM products, such as chymosin (see page 9), may be used in food manufacturing as 'processing aids'.

Will the label tell me if the food is GM?

In the EU, if a food contains GM DNA or protein, this must be indicated on the label. The same applies when eating out. If any food or drink contains GM DNA or protein, then a notice indicating this should be displayed.

The law on labelling of GM foods is based on the ability to measure differences in composition between GM and non-GM ingredients. On this basis, certain ingredients do not need to be labelled. For example, refined vegetable oil because this has exactly the same composition as oil obtained from non-GM crops and is therefore indistinguishable from it. Any intentional use of GM ingredients at any level must be labelled. However, there is no need for small amounts of GM ingredients that are accidentally present in a food to be labelled, if they make up less than 1% of the product.

The current labelling rules are, however, being extended to cover all food and animal feed that contain any material that comes from GM sources, whether or not any GM material is present in the final product. This includes products such as oils but not food made with the help of genetic modification technology, such as hard cheese. These products, and products such as meat and milk from animals fed on GM feed, will not need to be labelled. The new rules, which were agreed in December 2002 and are awaiting implementation, are compared with the current rules in the table overleaf.

1993 Monsanto uses genetic modification to make bovine somatotropin protein supplement to increase cows' milk yields.

1994 The FlavrSavr tomato is introduced, marking the start of widespread use of genetically modified crop plants in the USA.

1995 Bt corn (corn modified with a bacterium gene to give it insect resistance) goes on the market in the USA.

Labelling rules in the EU

Categories	Examples	Current situation	New rules
1. Products made from GM crops, but no GM material present	Highly refined maize oil, soya bean oil, rape seed oil, alcoholic beverages	Labelling not required	Labelling required
2. Products made from GM crops and GM material present	Maize, soya bean sprouts, tomato, maize flour	Labelling required	As current
3. Labelling of food made using genetic modification technology	Cheese produced with the help of chymosin from GM micro-organisms	Labelling not required	As current
4. Labelling of food made from animals fed on GM animal feed	Milk, meat and eggs	Labelling not required	As current
5. Threshold for approved GM varieties	Approved maize and soya	Threshold is set at 1%	Threshold agreed at 0.9% in December 2002 but may be subject to change pending discussions in the European Parliament. There will also be a threshold of 0.5% for non-EU approved varieties
6. Food sold in catering outlets	Restaurant menus and takeaways	Optional (compulsory in UK where GM material is present in final food in line with current labelling rules)	Labelling required, although detailed rules yet to be developed

1996 Roundup Ready Soybeans (soya beans resistant to Roundup herbicide) introduced in the USA.

1996 GM tomato paste approved in the UK, first GM herbicide tolerant soya beans (Roundup Ready Soybeans) and insect protected maize approved in the EU.

1997 EC Novel Foods Regulation (258/97) comes into effect, requiring a safety assessment for novel and GM foods before they go on sale.

Which countries are growing and eating GM crops?

As of December 2002, the countries growing GM foods are: Argentina, Australia, Bulgaria, Canada, China, Colombia, Germany, Honduras, India, Indonesia, Mexico, Romania, South Africa, Spain, Uruguay and the USA. Other countries are also likely to be using GM ingredients in processed foods.[15]

People living in countries growing GM crops are likely to be eating some GM food. A large proportion of the world's soya and maize crops are used in processed foods, so it is likely that most people will be eating at least some GM or 'GM-derived' food, unless they do not eat any processed foods.

What proportion of the world's crops are genetically modified?

Worldwide in 2002, GM crops were grown in 58.7 million hectares, an area equivalent to two and a half times the area of the UK and representing 18% of the total land under cultivation across the globe. GM soya, almost all of which was herbicide tolerant, and GM maize, two-thirds of which was insect resistant and one-third herbicide tolerant, accounted for more than 80% of this area.

The table below shows the worldwide proportion of soya, maize, oilseed rape and cotton crops, which are the four main crops that are GM:

Global cultivation 2002	Total (hectares)	GM varieties (hectares)
soya bean	72 million	36.5 million (51%)
maize	140 million	12.4 million (9%)
cotton	34 million	6.8 million (20%)
oilseed rape	25 million	3 million (11%)
Total for the above 4 crops	271 million	58.7 million (22%)

(Sources: ISAAA 2003.)[13]

GM foods in the USA

The United States of America (USA) grows two-thirds of all GM crops and a wider range of GM crops than any other country. The first GM food to be approved in the USA was a type of tomato that had been modified to delay softening. It was approved for use in 1991, and came on the market in 1994. In the USA, GM crops such as soya bean, maize and oilseed rape (respectively known as corn and canola in the USA) are used in a wide range of processed foods.

15 See footnote 13

1998 First GM labelling rules introduced to provide consumers with information about the use of GM ingredients in food.

2000 Initial draft of human genome published.

2004 Golden rice – a rice that can make beta-carotene which our bodies turn into vitamin A – is grown in parts of the world where people are deficient in this vitamin. Potatoes that contain extra protein go on sale.

The future… ?

These GM foods are approved for sale in the USA (at October 2002):

Used in processed products	Fresh foods	Examples of processed products likely to contain GM or 'GM-derived' material
Canola (oilseed rape)	Cantaloupe	Biscuits
Corn (maize)	Radicchio	Sauces
Cotton (for cottonseed vegetable oil)	Tomato	Food coatings, such as batter
Flax (for linseed oil)	Potato	Confectionery
Soy beans	Squash	Cereals
	Papaya	Tinned fish in oil
	Sugar beet	Chocolate
	Rice	Ready meals
	Sweetcorn	Margarine
		Cooking oils

Is genetic modification used to produce anything other than food?

Genetic modification technology has a variety of potential and actual uses. In medicine, for example, genetic modification is widely used to produce blood clotting factors for haemophiliacs, so they no longer face the risk of infection from contaminated blood products. Genetic modification technology is used to alter bacteria so they produce blood-clotting proteins. These blood products contain no GM ingredients and are identical in composition to blood products derived from natural sources. Insulin to treat diabetes mellitus is produced using genetic modification techniques, as is human growth hormone.

Genetic modification is also used outside agriculture and human health in industrial processes and for cleaning the environment. For example, some chemicals can be manufactured using GM enzymes, and toxic chemicals in contaminated land and water can be broken down into harmless substances using GM bacteria.

2005 Salt-tolerant tomatoes developed that can be grown on land that can't normally be used for agriculture because of high salt level in soil.

The future... ?

2005 Sunflowers resistant to white mould marketed.

2005 Complete human genome published.

By the end of the decade?

- Decaffeinated coffee and tea plants (already patented)
- Disease-resistant grapes
- Plant-based vaccines: food crops genetically engineered to produce edible vaccines

Glossary

Allergen	A substance that causes an immune response (allergic reaction).
Amino acids	A group of compounds that make up the building blocks of proteins.
Bacterium	A single-celled organism (singular of 'bacteria'). Bacteria are classified according to shape or whether or not they need oxygen.
Biodiversity	The range of living things in their natural environments.
Biotechnology	Use of micro-organisms or biological techniques to process waste or produce useful compounds, such as vaccines.
Chromosome	The cell structures that carry DNA. Human beings have 23 pairs of chromosomes in each cell.
DNA	Deoxyribonucleic acid, or DNA, is the genetic material contained in the cells of all living things. It carries the information that allows organisms to function, repair and reproduce themselves.
Genes	Genes are made up of DNA. They carry the instructions for all the characteristics that a living thing inherits.
Genome	The full set of chromosomes for any species, including humans. As a result, it is sometimes referred to as the genetic 'blueprint'.
Herbicide	A chemical that kills plants, sometimes designed to kill specific weeds.
Hybrid	A cross between two organisms that are genetically different.
Micro-organism	A living thing that can be seen only by magnifying it, such as bacteria.
Nucleotide	The building blocks of DNA. Two strips of nucleotides twist around each other to form the double helix structure.
Organism	Any living thing.
Plasmid	A piece of bacterial DNA that is independent of the bacterium's main chromosome.
Promoter	Piece of DNA that helps ensure that a modified gene works properly.
Protein	A complex molecule consisting of a particular sequence of chains of amino acids. Proteins are essential constituents of all living things.
Substantial equivalence	A concept that allows a novel food to be compared with a similar existing food.
Toxin	A poison.

Where can I go for further information?

For details of FSA activity on the GM food debate visit the Agency's dedicated microsite at: **www.food.gov.uk/gmdebate**

Further details about GM food can be found on the Food Standards Agency website at: **www.food.gov.uk**

For information on the environmental aspects of GM crops, visit the DEFRA website at: **www.defra.gov.uk** or the following websites, the Scottish Executive at: **www.scotland.gov.uk**, the Welsh Assembly at: **www.wales.gov.uk**, the Department of the Environment in Northern Ireland at: **www.doeni.gov.uk**

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This booklet was produced by the Food Standards Agency – a UK-wide, independent Government agency, providing advice and information to the public and Government on food safety, nutrition and diet.

The Agency was created to protect the interests of consumers and its guiding principles are to:

- put the consumer first
- be open and accessible
- be an independent voice

The Agency's advice is based on the best scientific evidence available from independent expert advisory committees, and all its advice is made public.

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