General Certificate of Education
Advanced Level Examination
January 2012

General Studies (Specification A)

GENA4/PM

Unit 4 A2 Science and Society

Case Study Source Material

For use with **Section A**

- The material consists of five sources (A, B, C, D and E) on the subject of **genetic development**. These sources are being given to you in advance of the Unit 4 examination to enable you to study the content and approach of each source, and to consider issues which they raise, in preparation for the questions based on this material in Section A.

- A further Section A source (F) will be provided in the examination paper.

- Your teachers **are** permitted to discuss the material with you before the examination.

- You may write notes in this copy of the Source Material, but you will not be allowed to bring this copy, or any other notes you may have made, into the examination room. You will be provided with a clean copy of the Source Material at the start of the Unit 4 examination.

- You are not required to carry out any further study of the material than is necessary for you to gain an understanding of the detail that it contains and to consider the issues that are raised. It is suggested that three hours' detailed study is required for this purpose.

- In the examination room you are advised to spend approximately one hour and fifteen minutes reading a previously unseen extract and answering a range of Section A questions based on all the source material.

Case Study Source Material on:
Genetic Development

Source A

Figure 1: GM Crops: Top Ten Facts and Figures

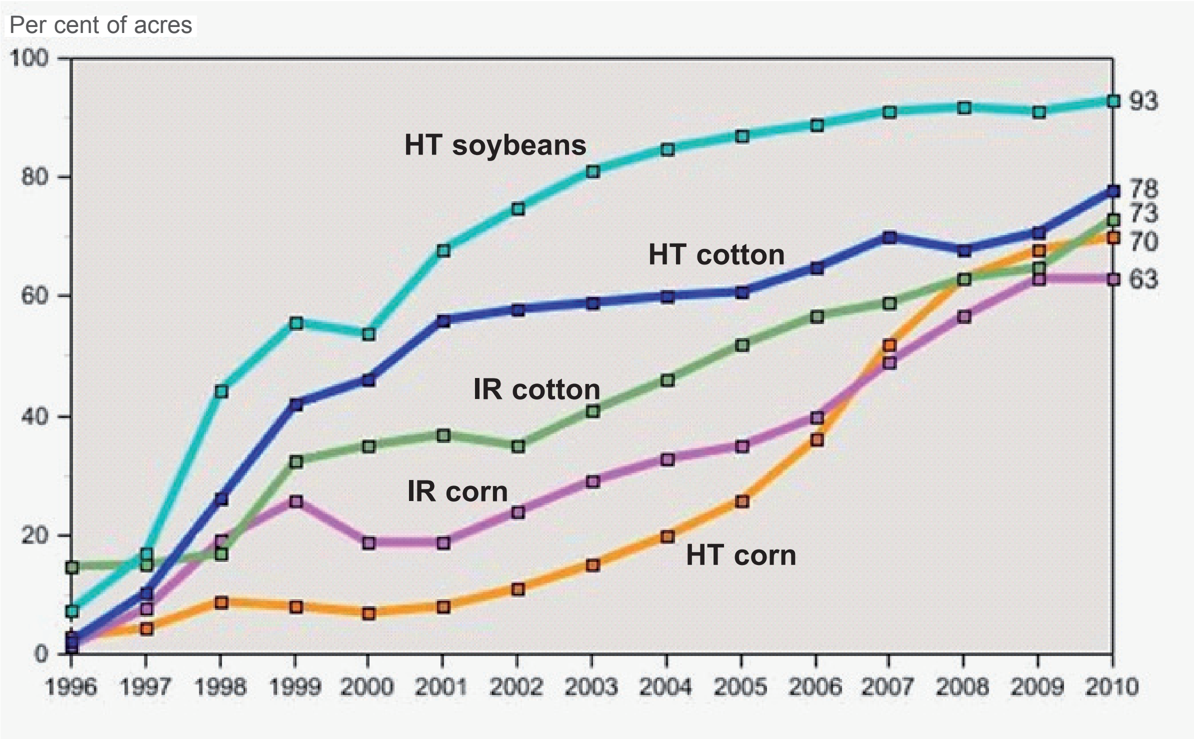
- The first commercial GM food was the FlavrSavr tomato developed in the early 1990s in California.
- GM crops have been grown commercially since 1996. Since then the GM market has grown 74-fold and spread to 25 countries. The global value of the GM crop market was $7.5 billion in 2008.
- There were 125 million hectares of GM crops in 2008, nearly 7% of the total cultivated land area and an increase of nearly 10% on the 114 million hectares in 2007.
- The top three GM crops in 2008 were soybeans (53%), maize (30%) and cotton (15%).
- 90% of GM crops, and almost all GM food crops, are grown in 4 countries – the US, Argentina, Brazil and Canada. The US produces nearly 50% of all GM crops.
- There are over 13 million farmers cultivating GM crops, the vast majority smallholders in China and India growing GM cotton.
- Almost all commercial GM crops are genetically altered for one or both of two main traits: herbicide tolerance (63%) and insect resistance (15%).
- In the US, 12 million hectares of GM crops were used for biofuels in 2008.
- According to industry research, in 2007 GM crops saved 15.6 million tons of CO_2 through reduced herbicide and pesticide use and reduced tillage, the equivalent of removing 6.3 million cars from the road.
- Future GM crops likely to be commercialised by 2015 include rice, aubergine, potatoes and wheat. Drought resistant and nutritionally enhanced crops are also expected in the near future.

Source: adapted from James Tulloch, 'GM Crops: Top Ten Facts and Figures', 7 October 2009

http://knowledge.allianz.com/en/globalissues/safety_health/new_technology/gm_crops_factsheet.html

Figure 2: Adoption of Genetically Engineered Crops in the US

US farmers have adopted genetically engineered crops widely since their introduction in 1996, notwithstanding uncertainty about consumer acceptance and economic and environmental impacts. Soybeans and cotton genetically engineered with herbicide-tolerant traits have been the most widely and rapidly adopted crops in the US, followed by insect-resistant cotton and corn.



Key:
IR = insect resistant
HT = herbicide tolerant

A random selection of US farmers was asked if they planted corn, soybeans or upland cotton seed that, because of biotechnology, was resistant to herbicides or insects or both. According to the National Agricultural Statistics Services (NASS) this table represents 81-86% of all corn planted acres, 87-90% of all soybean acres, and 81-93% of all upland cotton-planted acres (depending on the year).

Source: adapted from ERS/USDA Data, ‘Adoption of Genetically Engineered Crops in the US’, 1 July 2010

www.ers.usda.gov/Data/biotechcrops

Turn over ▶

Figure 3: Global area of genetically engineered crops 1996-2006

Herbicide tolerance (HT) continues to be the most common transgenic trait. Herbicide tolerance is available for all of the major GM crops, including soybean, maize, rapeseed and cotton. In 2005, the first herbicide tolerant sugar beets were approved in the US, Australia, Canada and the Philippines. Herbicide tolerant rice and wheat already have been developed but currently are not in use.

Insect resistance (IR) is the second most common genetically modified trait. Herbicide tolerance and insect resistance often are introduced simultaneously to a crop in one transformation event.

Combined herbicide tolerance and insect resistance was the fastest growing GM trait from 2004 to 2005. Crops with these traits were grown on over 6.5 million hectares in the US and Canada and comprised seven percent of the global biotech area. The recent expansion of crops is mainly due to the increasing IR maize and IR cotton production in China, India and Australia.

Global area of genetically engineered crops, 1996 to 2006: by trait (million hectares)

Trait	HT	IR	IR/HT	VR/Others	**Total**
1996	0.6	1.1	--	<0.1	**1.7**
1997	6.9	4.0	<0.1	<0.1	**11.0**
1998	19.8	7.7	0.3	<0.1	**27.8**
1999	28.1	8.9	2.9	<0.1	**39.9**
2000	32.7	8.3	3.2	<0.1	**44.2**
2001	40.6	7.8	4.2	<0.1	**52.6**
2002	44.2	10.1	4.4	<0.1	**58.7**
2003	49.7	12.2	5.8	<0.1	**67.7**
2004	58.6	15.6	6.8	<0.1	**81.0**
2005	63.7	16.2	10.0	<0.1	**89.9**
2006	69.9	19.0	13.1	<0.1	**102.0**

Source: ISAAA, Clive James, 2006.

HT	Herbicide tolerance
IR	Insect resistance
VR	Resistance to virus diseases

Source: adapted from GMO Compass, ‘GM traits statistics: transgenic crops by trait’, 19 January 2007

www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/145.gmo_cultivation_trait_statistics.html

Figure 4: How to feed the world in 2050

- Around 300 experts and scientists on agriculture and food security gathered in Rome for the first day of the meeting of the Food and Agriculture Organisation (FAO) to discuss how to feed the world in 2050.
- The meeting will inform discussions at the world summit on food security due to be attended by heads of state.
- World population is expected to soar by 34% to 9.1 billion by 2050.
- The population growth (nearly 3 billion people) will take place entirely in developing countries, mostly in urban areas.
- Global agriculture will also have to cope with the effects of climate change such as more extreme weather conditions, reduced water availability and an increase in pests and diseases.
- To secure world food supplies by 2050, the FAO calculates that $44 billion a year in aid will need to be invested in agriculture in developing countries. Nearly $8 billion is currently being spent.

Source: information taken from Liz Ford, 'How to feed the world in 2050', *The Guardian,* 12 October 2009

www.guardian.co.uk/society/katineblog/2009/oct/12/agriculture-food-security

Source A continues on the next page

Figure 5: GM crop sceptics ‘emotional’, Government food watchdog claims

A protest against GM crops:

The study – published as the Government embarks on a major review of the current restrictions on GM crops – suggests that opponents are motivated by “ideological” considerations while others take a “pragmatic” line.

It portrays those against the controversial technology as being sceptical about science in general, relying on “emotive language” to make their case, often drawn from “popular press slogans”.

- According to the research, the attitudes of those who took a “cynical approach” to GM technology are also “clearly underpinned” by a general scepticism towards science.

- Anti-GM campaigners dismissed the report as ‘patronising’ and an attempt to ‘pigeonhole’ opposition to GM developments.

- Opponents fear that the so-called ‘GM Dialogue’ will be an attempt to soften up public opinion towards efforts to lift restrictions on the technology.

- The Department for Environment, Food and Rural Affairs (Defra) said that the findings would inform the Government’s food strategy although rules on labelling and approving GM crops are set at European level.

- While almost 40% of the people in Britain are undecided about the benefits of GM, according to recent findings from the Office for National Statistics, 31% are against with only 17% in favour.

- Previous plans to grow GM crops commercially on a large scale in Britain were scrapped after official trials showed that the method of growing would harm the environment. This followed a concerted campaign and a backlash by consumers who refused to eat so-called “Frankenstein foods”. Permission to grow GM crops in Britain now has to be sought on a case-by-case basis.

- But a recent Government report highlighted warnings from manufacturers that it is becoming increasingly difficult to keep GM products out of the food chain.

Source: adapted from JOHN BINGHAM,
“GM crop sceptics ‘emotional’, Government food watchdog report claims”,
The Telegraph, 26 November 2009

www.telegraph.co.uk/foodanddrink/foodanddrinknews/6653594/GM-crop-sceptics-emotional-Government-food-watchdog-report-claims.html

Source A continues on the next page

Figure 6: Changing the tune on GM

- Tesco's chief executive, Sir Terry Leahy, has said that consumer attitudes are changing and that the retailer may be ready to get behind GM.

- Sir Terry uttered some important sentences at the annual City Food Lecture in London last week. *"In some ways it may have been a failure of us all actually to stand behind the science,"* he said.

- Genetic modification is a highly divisive issue. But it is time to re-launch the debate and focus purely on the science. Let's leave the mud-slinging and scaremongering to the side for the moment.

- At a time of rising commodity and food prices, and food scarcity, can we really afford GM prejudice? We need crops that grow in salty soils, crops that can resist drought, crops that can provide micronutrients to populations at risk of malnutrition.

- According to Sir Terry, there seemed to be a growing appreciation that GM was likely to play "*a vital role in feeding the world, in adapting to climate change and indeed in producing some of these more nutritional products – foods – that people will need".*

- At the same event, Peter Kendall, president of the National Farmers Union added that there was need for real scientific debate and not the media scaremongering that has been seen so far.

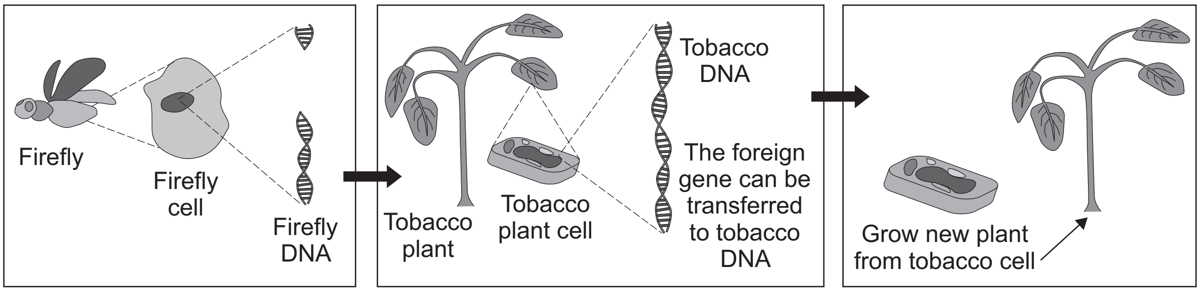
Source: adapted from Stephen Daniells, 'Changing the tune on GM', 16 February 2009

www.foodnavigator-usa.com/Science-Nutrition/Changing-the-tune-on-GM

Figure 7: Anti GM propaganda

Source B: Genetic engineering

Genetic engineering allows the transfer of genes between different organisms



During the latter stages of the 20th century, humans harnessed the power of the atom, and not long after, soon realised the power of genes. Genetic engineering is going to become a mainstream part of our lives sooner or later. There are so many possible advantages and disadvantages involved in genetic engineering.

Advantages include:

- Disease could be prevented by detecting people, plants or animals that are genetically prone to certain hereditary diseases. Also, infectious diseases can be treated by implanting genes that code for antiviral proteins specific to each antigen.
- In future animals and plants may be ‘tailor made’ to show desirable characteristics. Genes could also be manipulated in trees, for example, to absorb more CO_2 , thus reducing the threat of global warming.
- Genetic engineering could increase genetic diversity, producing more variant alleles which could also be crossed over and implanted into other species. For example, it is possible to alter the genetics of wheat plants to grow insulin.

However, there are also disadvantages:

- Eco-systems are extremely complex and inter-related systems consisting of many species linked in the food chain. Some scientists believe that introducing genetically modified genes may have an irreversible effect with consequences as yet unknown.

- Genetic engineering brings science closer to many moral issues, particularly involving religion, which questions whether humans have the right to manipulate the laws and course of nature.

Genetic engineering may be one of the greatest breakthroughs in recent history, alongside the discovery of the atom and space flight. However, governments have legislated to control what sort of genetic engineering experiments are done. In the UK, there are strict laws prohibiting any experiments involving the cloning of humans but examples of some of the experimental ‘breakthroughs’ include:

- The production, in 1982, of insulin by inserting the human gene into bacterium Escherichia coli (E.coli) – the first application of genetic engineering approved for humans.

- Research at the Roslin Institute in Scotland led to the cloning of a sheep called ‘Dolly’: the first mammal cloned from an adult cell in 1996.

- Golden rice, a genetically engineered form containing beta-carotene and developed in 2000, offers a possible solution to widespread Vitamin A deficiency.

The major breakthrough was the discovery of the structure of DNA in the 1950s. Through progressive studies and scientific research, more advances in this area are being made possible, with the above examples only showing some of the potential of genetic engineering.

Source: adapted from ‘Genetic Engineering Advantages & Disadvantages’, *biology online*, 28 April 2006

www.biology-online.org/2/13_genetic_engineering.htm

Source C

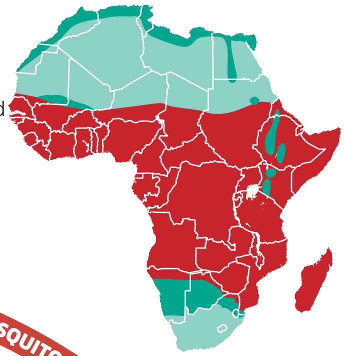
Created by genetic engineering, a mosquito that can't catch malaria

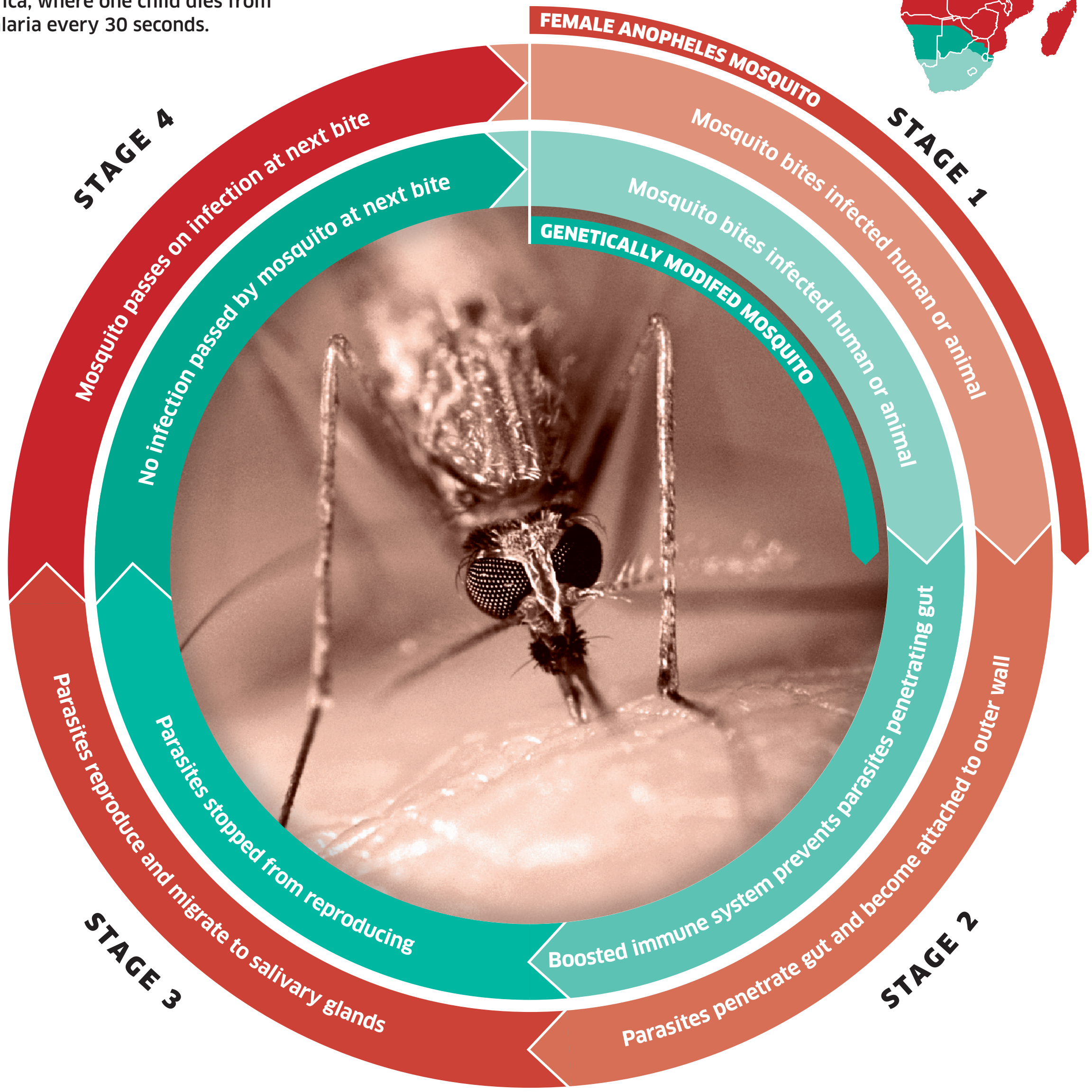
HOW TO DISABLE A KILLER

By creating a genetically modified mosquito, scientists have interrupted the life cycle of the malaria parasite and rendered the insect incapable of transmitting the disease, which infects 250 million people a year and causes one million deaths. Ninety per cent of those fatalities occur in Africa, where one child dies from malaria every 30 seconds.

Malaria in Africa

- Malaria-free areas
- Areas where malaria has been largely eliminated
- Malaria transmission areas





Created by genetic engineering, a mosquito that can't catch malaria

It looks ingenious. If you can't eradicate malaria in humans, why not do so in mosquitoes? It would accomplish a goal of which scientists hardly dared dream: a malaria-free world. The achievement of Michael Riehle and his team at the University of Arizona is impressive. But by their own admission, they have done the easy bit – create a genetically modified mosquito that cannot transmit malaria.

To help with controlling the disease, the GM mosquito must first be proved safe for release into the wild and, second, must be given some advantage that renders it superior to natural populations so it can drive them out. That is much harder to do.

Despite these caveats, and the dreadful toll malaria still exacts, there are reasons to celebrate. Action against malaria – spraying of insecticide, distribution of bed nets and use of anti-malaria drugs – has increased dramatically in the last decade as global funding has expanded 50-fold to over $5bn in 2009. In coastal areas of Kenya, cases of severe malaria in children have fallen by 90% in five years. Similar falls have been reported from other locations such as the Philippines, Mexico and Algeria.

Sub-Saharan Africa, which bears 70% of the disease burden, presents a much tougher challenge. But in the global malaria community – where gloom prevailed a decade ago – the buzzword now is elimination. As *The Lancet* noted this month, "previously cautious malariologists, released from a 40-year collective depression…have been invigorated".

Talk of elimination may be premature – the funds required to chase down the last few cases of a disease are several orders of magnitude higher than those needed to control it – as the polio eradication campaign has proved. But that we can envisage the end of a disease that still kills in biblical proportions is itself a remarkable advance.

Source: adapted from Jeremy Laurance, 'Created by genetic engineering, a mosquito that can't catch malaria', *The Independent*, 16 July 2010
www.independent.co.uk/life-style/health-and-families/health-news/created-by-genetic-engineering-a-mosquito-that-cant-catch-malaria-2027818.html

and

Jeremy Laurance, 'Eradicating this biblical plague is becoming possible', *The Independent,* 16 July 2010

www.independent.co.uk/opinion/commentators/jeremy-laurance-eradicating-this-biblical-plague-is-becoming-possible-2027819.html

Source D: Cloned cows spark investigation

The Food Standards Agency (FSA) is investigating reports that dairy or meat products from the offspring of cloned bulls have entered the UK food chain. There's no evidence that this poses a risk to the public, but food producers need to ensure they meet the law on cloned or 'novel' food.

The cloned cows were Holsteins

Cloned cows: why the fuss?

A row has erupted over whether milk from genetically modified (GM) cattle is safe. Here, two experts battle it out.

For: Johnjoe McFadden

Dolly the sheep represented a novel type of cloning that is capable of generating virtually limitless copies of adult animals. These copies are not necessarily genetically engineered, but the process of cloning does allow for genetic tweaking, for instance, to generate cows that produce more milk.

It is this type of GM clone that tends to worry lobbyists. It's unnatural, they say. But take a look at the list of any ingredients on any processed food and you will find hundreds that are unnatural. And natural isn't necessarily good. Some of our most prevalent chronic diseases are related to our consumption of perfectly normal constituents of our diet, such as fat, or salt.

Given the lack of scientific evidence for GM food's harmful effects, opponents point the finger at the arrogance of scientists who think they can tamper with nature's plan. But nature doesn't have a plan and humans have been tampering with nature for a long time. Modern wheat is a hybrid of three different wild grasses. Nectarines are the progeny of a cross between a plum and a peach.

Of course, we should tread carefully – but that doesn't mean that we shouldn't tread at all. GM animals have fewer environmental concerns than GM crops. GM pollen can be carried by the wind: a cow can't. Biodiversity is also less of an issue for livestock bred for years to be genetically homogeneous.

Much of the antagonism towards GM food has more to do with an underlying feeling that if we drink milk from a GM cow we will ourselves become genetically engineered. In reality, what we actually consume is a bag of chemicals and we won't become genetically engineered because of drinking milk from GM cows.

Johnjoe McFadden is professor of molecular genetics at the University of Surrey

Against: Graham Harvey

The health implications of drinking the milk of cloned cows are likely to be negligible. Of greater concern is what such developments say about the way we run our food system. The usual justification for such technologies is that they will provide a greater degree of food security at a time of market volatility and climate change.

In fact the opposite is the case. Britain's best protection against climatic extremes is systems which incorporate greater genetic diversity. Already our food supply is perilously dependent on the narrow genetic base of a limited number of crop varieties, all of which require high inputs of pesticides and fertilisers. Livestock cloning threatens to effect a similar reduction in the genetic base of our food animals.

The UK used to breed a wide variety of cattle. Most have been marginalised as farmers concentrate on a few, such as the high-yielding Holstein that dominates milk production. Cloning within the Holstein breed will further reduce the genetic base. Yet there's evidence that the Holstein may be the wrong animal for climate-proofing our food supply.

The new team at the Department for Environment, Food and Rural Affairs (Defra) has indicated that it views new technologies such as cloned livestock as useful tools in the effort to build security into our food supply, but a clear consensus is emerging among agricultural scientists in favour of farming systems. We need bio-diverse polycultures. The cloning of cattle won't add stability to our food system. It's more likely to move us nearer the precipice.

Graham Harvey is the author of *The Carbon Fields*

Source: adapted from JOHNJOE MCFADDEN and GRAHAM HARVEY
'Cloned cows: why the fuss? A row has erupted over whether the milk from GM cattle is safe. Here, two experts battle it out'
The Guardian, 2 August 2010

Turn over ▶

Source E

Genetic revolution could save time, money – and lives

DNA, the molecule of inheritance, contains the full “recipe” for a human being. It is written in a digital code of four “bases” or chemicals strung along the length of a molecule. The full sequence of these four bases (designated A, C, G and T) decides a person’s genetic make-up and is unique to each individual.

Sequencing DNA molecules was first developed at the Laboratory of Molecular Biology by Nobel Prize winner, Fred Sanger. The Sanger technique became the basis of the technique that led to the unravelling of human DNA by the international consortium known as the Human Genome Project. Now a new technique has been developed by Professor Stephen Quake at California’s Stanford University. This is able to carry out the same task on just a single molecule of DNA – making it far easier and cheaper than before.

Quake’s discovery comes just ten years after the first draft of the human genome was announced in 2000. President Clinton said in a live satellite link between the White House and Downing Street that the breakthrough represented a triumph of science and reason. “Today, we are learning the language in which God created life,” he said.

Many scientists may have winced over his use of the G-word but few would have argued about President Clinton’s sentiment of this being a monumental moment in human history. For the first time, we were able to begin to read our full set of genetic instructions – the digital recipe for a man or a woman locked in our DNA.

Initially, the cost of deciphering the entire 3 billion letters of a person’s DNA ran into hundreds of millions of pounds. Now it is down to £31 000 and falling fast. The importance of this cannot be underestimated. If the genome project were ever to bear fruit for ordinary patients and the National Health Service, the cost of deciphering someone’s DNA had to fall rapidly.

The aim is to bring about some kind of “personalised medicine”, where a therapy or drug treatment is tailored to a patient’s particular genetic make-up. Already, there are drugs like the anti-cancer drug, Herceptin, that work best on people with a specific genetic make-up. Another genetic test that can identify certain mutations in a gene called HNF1-alpha can make sure that individuals affected can be given the right sort of treatment rather than the standard insulin injections offered to diabetics.

With the NHS under financial strain, the question is whether it will ever be able to afford the cost of DNA sequencing – even if this may save money as well as lives in the long run. There are also issues relating to privacy, health insurance and human health. As Professor Quake reminds us, “the technology is not going to let people escape these ethical and policy questions.”

Source: adapted from: Steve Connor, ‘Revolution could save huge amounts of time, money – and lives’, *The Independent,* 11 August 2009

www.independent.co.uk/opinion/commentators/steve-connor-revolution-could-save-huge-amounts-of-time-money-ndash-and-lives-1770271.html

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