Microbes make Human Insulin

Contents: Reading, questions and discussion on the use of genetic engineering techniques to produce human insulin.

Time: 1 to 2 periods depending upon the extent of discussion.

Intended use: GCSE Biology and Integrated Science. Links with work on hormones, insulin, microbiology and genetics.

Aims:

- To complement work on hormones, microbiology and genetics
- To develop awareness of the problems experienced by diabetics
- To develop awareness of the issue of 'prevention verses cure' in relation to diabetes
- To show the principles of the technique of genetic engineering
- To provide opportunities to practise skills in reading and comprehension.

Requirements: Students' worksheets No. 309.

This unit looks at genetic engineering in relation to a recent technological breakthrough resulting in an improved form of insulin being available for the treatment of diabetes. Students are encouraged to consider a number of issues related to insulin and diabetics as well as genetic engineering.

Notes on questions 5 and 6

Q.5 Insulin from slaughtered animals (pigs and cattle) has a slightly different structure from human insulin. It is interesting to note that another recent development in biotechnology is an enzymic process for changing pig insulin to human insulin. There is market competition between the two large companies which produce human insulin by different methods.

Q.6 Most current applications of genetic engineering are in the pharmaceutical field — for example, in the production of interferon and antibiotics.

Further resources

Further information on diabetes can be obtained from: British Diabetic Association, 10 Queen Anne Street, London W1M 0BD.

Human Insulin from Recombinant DNA Technology is a well-presented booklet with background information, including photographs and a useful glossary. For teachers, but may also be useful for more academic students. Available from: Public Relations Manager, Lilly Industries Ltd, Kingsclere Road, Basingstoke, Hants.

Acknowledgement Figure 2 supplied by British Diabetic Association.

MICROBES MAKE HUMAN INSULIN

The first humans ever to receive a material made by 'genetic engineering' were a group of volunteers at a London hospital in 1980. They were injected with human insulin which had been made by microbes. By 1982 this insulin was in general use. But why is insulin so important, and what is 'genetic engineering'?

The importance of insulin

After eating and digesting a meal, sugars, particularly glucose, pass into the bloodstream. Normally, this extra glucose is stored in the liver as a substance called glycogen, and as fat. When the body needs glucose for energy, the stored glycogen is broken down to give glucose again (Figure 1).

Insulin is the hormone which controls the level of glucose in the blood. It is made in the pancreas. From the pancreas it passes in the bloodstream to the liver. Insulin controls the conversion of glucose to glycogen in the liver. If people do not produce enough insulin they cannot store glucose. Some glucose is lost in the urine. This happens in at least one type of **diabetes**.

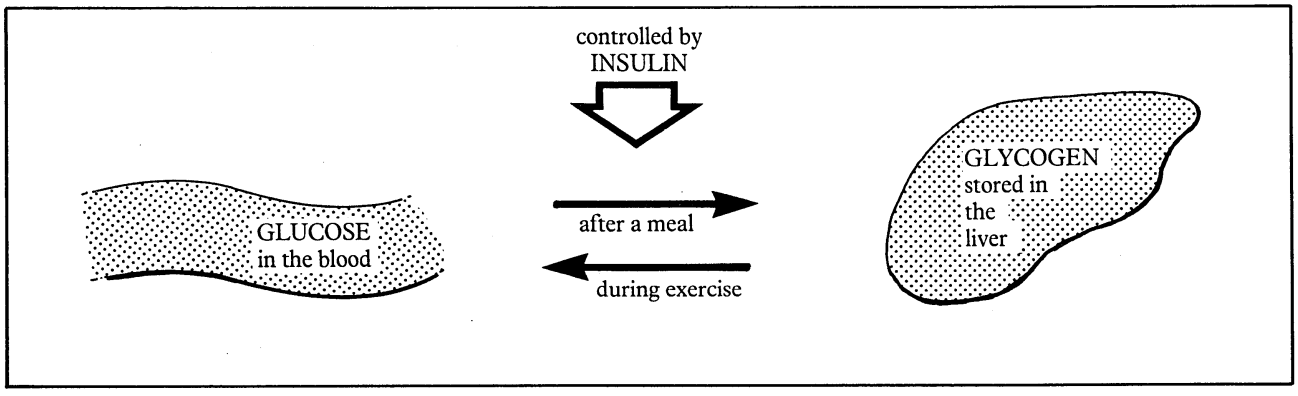

Figure 1 Insulin controls the level of sugar in the blood

Diabetics must follow a carefully controlled diet. They may also need regular injections of insulin. Without insulin, diabetics may become weak and sleepy. They lose weight, and eventually might die, but with insulin they can lead relatively normal lives. Even with treatment, diabetes may cause damage to the eyes, heart and circulatory system in some cases.

Diabetes is the third largest killer in the developed world. At present there are 600 000 diabetics in Britain and 250 000 of these need insulin daily.

The disease is also on the increase. Like heart disease, high blood-pressure and overweight (often called 'Western diseases'), diabetes has become much more common as people's diets have changed. In rich western countries like Britain and the USA, people eat a lot of fat and sugar, and not much fibre. It is thought this may cause some people to suffer from diabetes.

With diabetes on the increase, insulin is needed in larger quantities. Until recently insulin was obtained by purifying insulin from slaughtered pigs or cattle. This animal insulin is slightly different from human insulin. This traditional supply may not be enough for the increasing number of diabetics who require it. And insulin is a valuable product: a daily dose costs about £3 per person.

Answer questions 1 to 3.

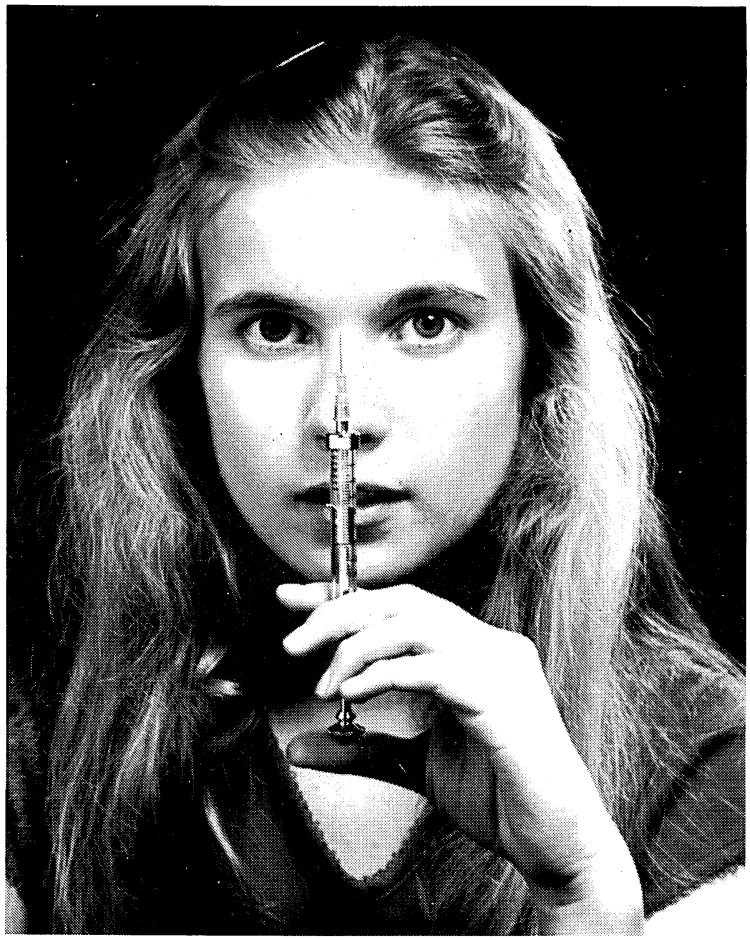

Figure 2 A diabetic girl with her lifeline

Questions

1 *If everyone had a low fat, low sugar, high fibre diet, would diabetes disappear?*

2 *In recent years many people in developing countries have moved from the countryside to live in the towns. This has resulted in a change of life-style. In what ways may their life-style change? What effect could such change have on the number of diabetics in these countries?*

3 *Why must insulin be injected, rather than taken orally? (Remember, insulin is a protein.)*

What is genetic engineering?

Genetic engineering is a specialized technique which has been in use since 1973. As a result of the technique some cells can be given the information to produce substances they would not normally make.

When living things breed, characteristics, such as eye colour, are passed on from one generation to the next. These characteristics are controlled by **genes**, found in the nuclei of all cells. They are made up of a chemical called **DNA**. Many genes are arranged together to form threads called **chromosomes**. Genes control how living things work, what they look like and what chemicals, such as enzymes or hormones, they can make. Insulin is such a hormone. A certain human gene is responsible for producing insulin, which is a protein.

Genetic engineering usually involves taking a gene from a human cell and putting it in a cell of a microbe. Figure 3 shows the method. First the gene that is needed must be searched for and found on the human chromosome. As genes are very small this is difficult. It is done using special enzymes which act as 'chemical scissors' to cut the gene from the chromosome. Next a piece of DNA in a microbe cell is cut. Other special enzymes are then used to put the human gene into the microbial DNA.

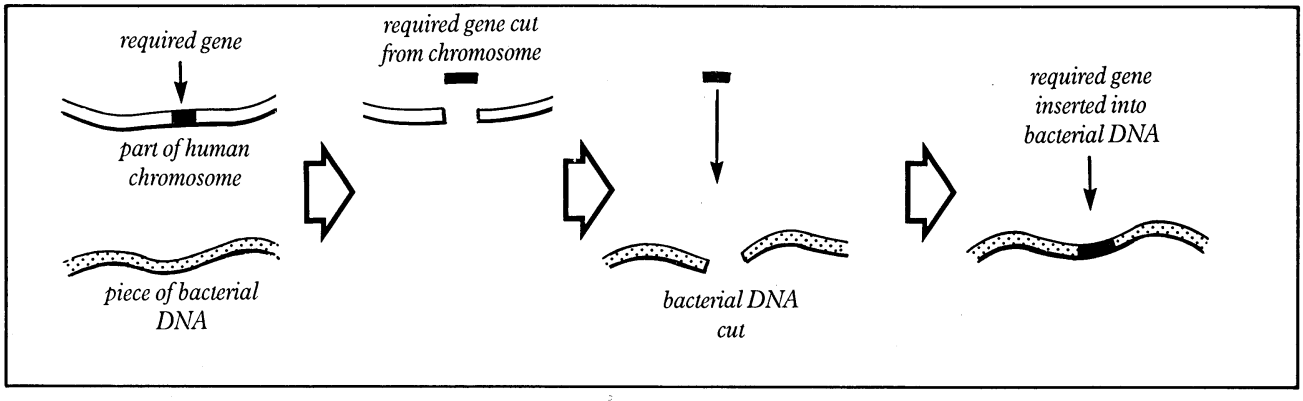

Figure 3 Genetic engineering puts a human gene into a piece of bacterial DNA

The human gene causes the microbe to make a new material, which it previously did not produce. Under suitable conditions microbes divide quickly, so that a lot of this new product can be made in a short time. In this way the gene controlling human insulin production can be put into a bacterial cell, so that the microbe can make human insulin.

Answer questions 4 to 6.

Microbes make human insulin

During the early 1980s genetic engineering was used to 'teach' certain microbes to make human insulin.

But could this new human insulin have long-term side-effects? Has scientific discovery in the form of genetic engineering provided *the* answer — or is it just one of the alternatives? Who will gain most benefit — the diabetics or the companies making insulin? Could this useful technique result in the formation of 'new superbugs' which will cause disease and havoc, rather than improve health? It is thought not, but these are some of the questions which scientists involved with genetic engineering have been asking in recent years.

Questions

4 *Hygiene is very important in any factory producing 'insulin from microbes'. Explain why.*

5 *In what way might human insulin from microbes be better than insulin from slaughtered animals?*

6 *The genetic engineering techniques described here were first used on a 'test-tube scale' in the laboratory. What has to be done before these techniques can be used to produce insulin in large quantities?*

Points for discussion

You might like to discuss these points in groups of three or four.

- Before large companies develop techniques for production they must have a suitable market. Why do you think insulin was the first product from genetic engineering to be made available to the general public?
- Before 'insulin from microbes' became available, diabetics who were vegetarians faced a difficult choice. What was this choice, and why has 'insulin from microbes' helped?
- One possible solution to the diabetes problem would be to put the gene for insulin production directly into the cells of people suffering from diabetes. Would this be (a) realistic (b) desirable?
- Genetic engineering has enormous possibilities. Discuss some other ways it might be used to the benefit of humans.
- Can you see any possible dangers in the future use of genetic engineering?