Materials for Life — new parts for old

Contents: Reading and questions concerning replacement surgery, with particular reference to hip replacement.

Time: 1 to 2 periods.

Intended use: GCSE Biology, Chemistry and Integrated Science. Links with work on the skeleton, joints, metals and materials.

Aims:

- To complement and revise work on the skeleton and joints
- To show the contribution that materials science has made to replacement surgery
- To develop awareness of the factors that need to be considered and decisions that need to be made, by doctor and patient, before undertaking major surgery
- To provide opportunities to practise skills in reading, comprehension and communication.

Requirements: Students' worksheets No. 506

Notes on some of the questions

Qs 1 and 2 If the operation is carried out before skeletal growth has stopped, a revision operation will be needed before long. Even when skeletal growth has finished, revision operations will be necessary because of loosening. By delaying the operation, the number of revisions can be reduced, and in any case technological advances may by then have reduced the loosening problem.

In addition, operating on the hip will cause growth to stop at the top of the femur. Kim's other leg will continue to grow and this would be expected to lead to a discrepancy in the length of the legs. This can cause a painful limp and may lead to arthritis in other joints such as the knees or the lower spine.

Young children tend to be very active physically and it would be difficult to persuade a child of Kim's age to refrain from taking part in normal activities once the new hip has been fitted. However, to do so could cause premature loosening of the prosthesis, leading to further surgery.

Q.5 Explain the nature of the disease underlying the problem in Kim's hip — that there is arthritis of the hip as a result of abnormal growth of the joint.

The condition is hereditary, so if Kim's parents have more children, they too may be affected. This should be explained to the parents. Kim's children too may be affected by the same condition in certain circumstances. If this is the case, the doctor would normally explain this to Kim's parents, but not yet to Kim.

The risks of the operation must be fully explained to Kim's parents, likewise the requirement for revision surgery in the future.

The need to abstain from vigorous exercise in the future must be explained to Kim and to Kim's parents.

The period of hospital confinement is often alarming and confusing for a child of Kim's age. The operation should be explained to the child and parents, followed by an explanation of what will happen following surgery in terms of when Kim will be allowed to stand, walk, sit, stop using a walking stick, etc.

Q.6

Advantages	**Disadvantages**
Relief from pain	Discomfort of operation and hospital stay
Ability to walk and be active	Risks of operation
	Need for revision operation in the future
	Possibility of failure of operation
	Need to abstain from vigorous exercise
	Possibility of later complications — loosening, infection, etc., and possibility of failure of subsequent operations.

Acknowledgements Figures 1 and 2 are reproduced by permission from *Science* by Graham Hill and John Holman (Nelson). Figure 6 supplied by Dr. G. W. Hastings.

MATERIALS FOR LIFE — new parts for old

This unit is in two parts.

Part 1 is about using materials to make replacement parts for the human body.

Part 2 has discussion points about an example of replacement surgery.

Part 1 What is replacement surgery?

Doctors use replacement surgery when old parts of the body wear out. They replace worn-out or diseased natural parts with artificial parts. Doctors call these artificial parts **prostheses**. You may have some replacement parts in your mouth. Teeth fillings and dentures are the commonest examples of artificial replacements. Figure 1 shows some other common examples.

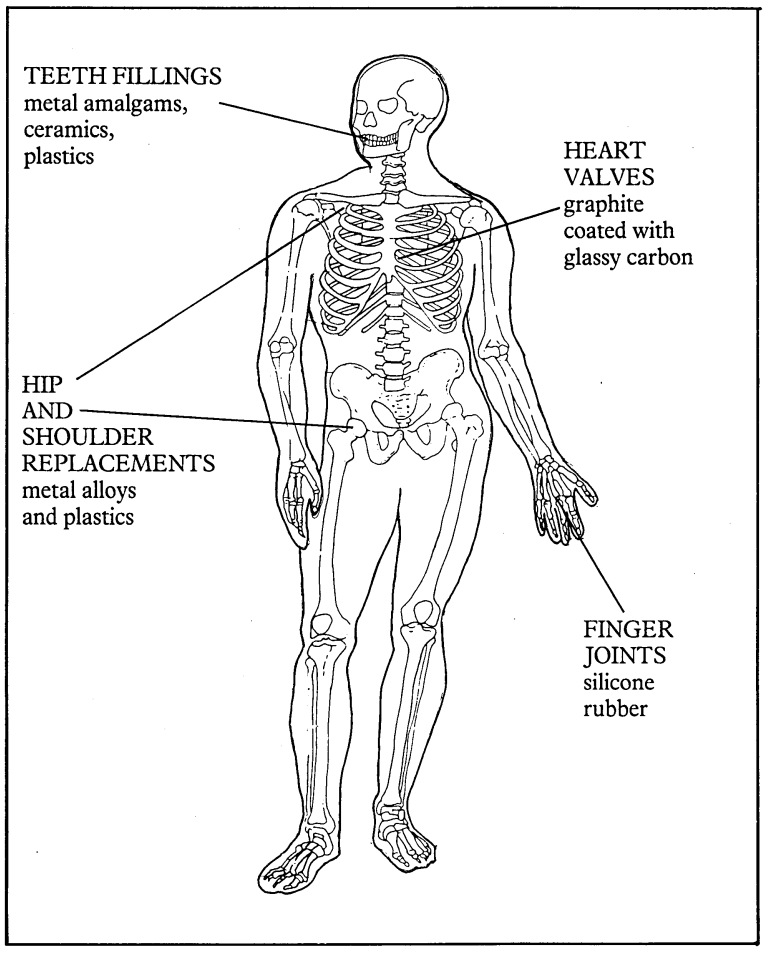

Figure 1 Some examples of artificial replacements

Artificial hips

Doctors have made dramatic progress in the last twenty years in replacing diseased or injured hip joints.

The hip is a ball-and-socket joint (Figure 2). An artificial hip uses an artificial ball, usually made of metal, and a socket, usually made of plastic. Choosing the right materials is tricky, because they must be:

- Corrosion-resistant — otherwise they will be corroded by body fluids.
- Hard-wearing, so they do not wear out.
- Low-friction, so the hip moves smoothly.

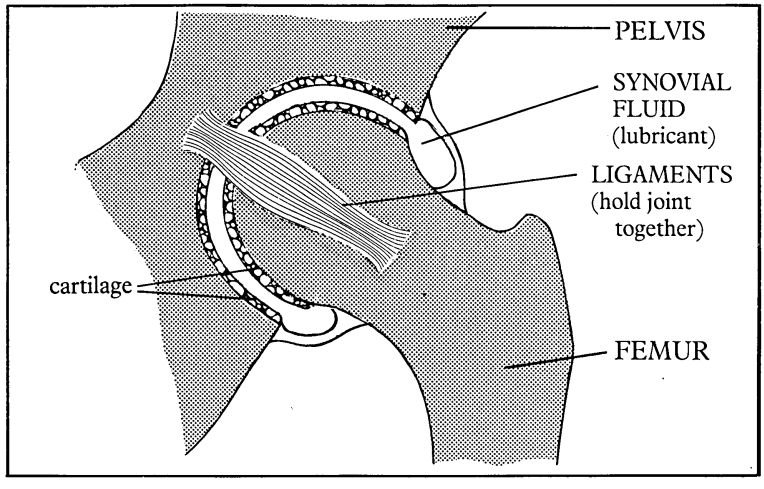

Figure 2 The hip joint

Figure 3 shows how an artificial hip is fitted. A stainless steel ball is fixed into the hollow stem of the femur (thigh bone). This fits into a cup made from a special grade of polythene (ultra high molecular mass polythene, relative molecular mass approximately 4 million). The two parts (ball and cup) of the prosthesis are fixed into the bones with cold-setting acrylic cement.

To reduce the chance of breakage from metal fatigue, different metal alloys are being introduced. One of the most important changes has been the replacement of the metal ball by one made from ceramic. High purity dense aluminium oxide is used, which is nearly as hard as diamond. It is chemically unreactive and has low-friction. This cuts down wear of the polythene cup.

Loosening is a major problem with replacement surgery. In active people, artificial hips may have to be replaced every seven years or so because they have become loose. One way round it is to put bumps on the surface of the prosthesis to help it 'key' to the bone (Figure 4a). Another possibility is to make the artificial part out of a porous material. The living tissue grows into the pores (Figure 4b).

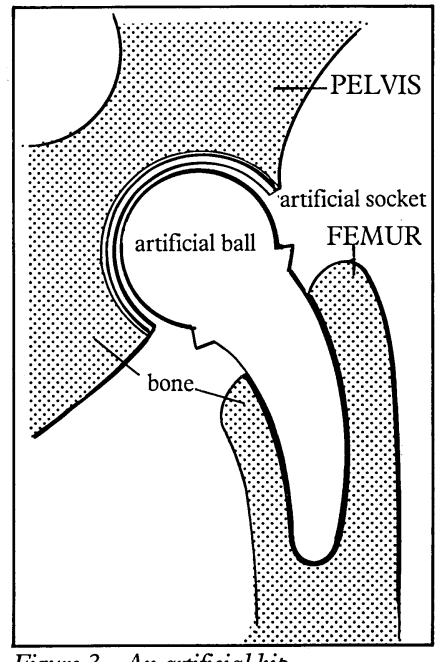

Figure 3 An artificial hip

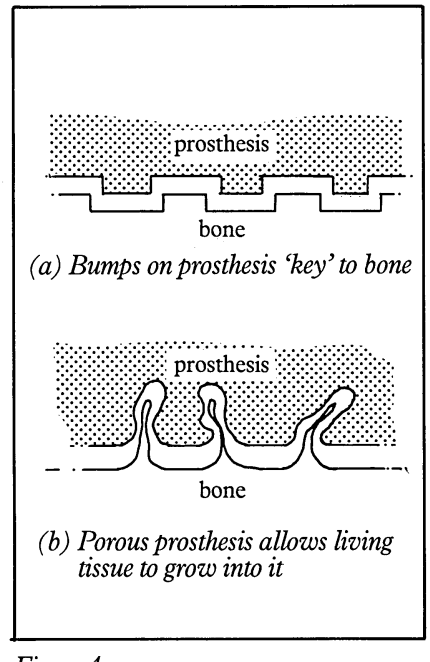

Figure 4

What about the future?

Every year many thousands of people have successful hip replacements. They are freed from pain and can move around much more easily. This reduces burdens on relatives and doctors. The change after the operation is generally dramatic. Most important of all, patients are freed from pain.

Still, there is plenty of room for improvements in replacement surgery.

Doctors are trying out new materials all the time. Titanium is a promising metal. Carbon-fibre reinforced plastic is beginning to be used. This has tough carbon fibres embedded in a matrix of plastic resin (Figure 5). The best hope for the future is to produce materials which are better tolerated by the body, and less 'foreign'. Chemists, materials scientists, biologists and engineers are working on the problem as well as doctors. Their future discoveries will help make life easier for people with worn-out parts in their bodies.

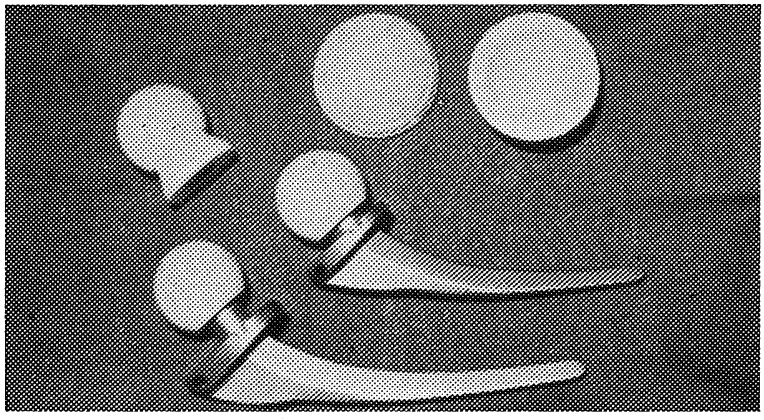

Figure 6 Artificial hips, showing the metal ball and stem, and the white plastic cup.

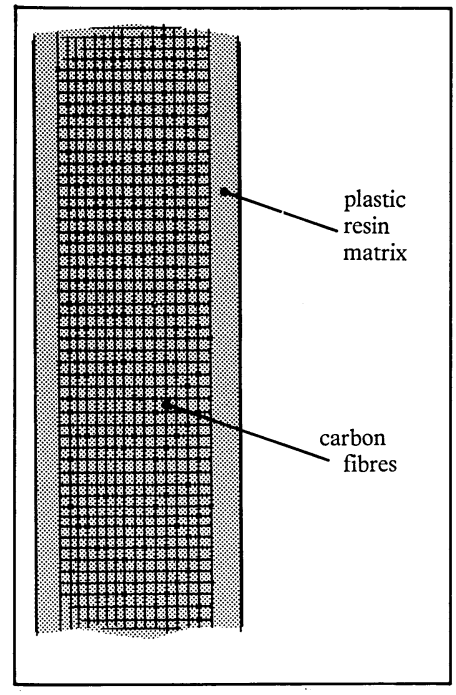

Figure 5 Carbon fibre reinforced plastic

Part 2 Kim — a case for replacement surgery

Kim's case is imaginary, but it is based on real life. Read through the description of the case, then discuss the questions.

The case

Kim was a very active 12-year-old when the hip problem was discovered. Kim has inherited a condition which causes the end of the thigh to be shaped abnormally. This means the ball does not move smoothly in the socket. It is a painful condition, and will probably get worse. Eventually Kim may have to give up sport, and may be confined to a wheelchair. However, it is unlikely that the disease will spread to other joints.

Doctors decided that a hip replacement was necessary but do not want to operate yet. For one thing, they do not want to operate until Kim has stopped growing. For another, the doctors know that at present artificial hips gradually loosen and have to be replaced. By delaying the operation a few years, doctors can reduce the total number of operations Kim will need. Besides, progress in the next few years will probably bring big improvements which may well solve the loosening problem.

Every surgical operation under anaesthetic has a small risk of going wrong. The risk in Kim's case would be no worse than normal. After the operation Kim would be free from hip pain. There might be some problems with mobility, at least at first.

After the operation Kim will need to be careful about taking part in sports. Vigorous activity could loosen the hip, which could lead to another operation. Kim will always need to be aware that the hip will never work quite as well as a natural one.

Questions to discuss

1 *Why do doctors not want to operate until Kim has stopped growing?*

2 *What other advantages are there in delaying the operation?*

3 *What are the* disadvantages *of delaying the operation?*

4 *When Kim comes to have the operation, what materials might doctors use for (a) the ball and (b) the cup of the artificial hip?*

5 *Suppose you are the doctor responsible for Kim's case. You have to explain to Kim and Kim's parents what is wrong with the hip, what you are going to do, and why. What will you say? Is there anything you would choose* not *to tell them? Is there any information missing here which you think you need?*

6 *Before agreeing to have the operation, what advantages and disadvantages will Kim need to weigh up? What further information might Kim want to ask the doctors for?*