Artificial Limbs

Contents: Reading, questions and discussion on artificial legs and arms.

Time: 1 to 2 periods, depending on amount of discussion.

Intended use: GCSE Biology, Human Biology and Integrated Science. Links with work on movement, muscles and nerves.

Aims:

- To complement work on muscles, movement and nerves
- To develop awareness of the problems encountered by people with missing limbs
- To show some of the ways technology can be used to provide effective artificial limbs
- To provide opportunities to practise skills in reading, comprehension and communication.

Requirements: Students' worksheets No. 707

Notes on some of the questions

Q.1 The basic essentials for an artificial leg are a socket for attachment and a strong, rigid shank. The old fashioned wooden leg was little more than this.

An ideal artificial leg must allow for flexing of the knee and ankle when walking, though the knee must not flex too freely or the leg may collapse under weight. The leg needs to be light enough to move easily: modern legs use lightweight materials such as carbon-fibre reinforced plastic.

A very important aspect is the appearance of the leg. A crucial function of artificial limbs is to restore the person's 'body image', and to this end the leg needs to be as natural looking as possible.

Q.3 Obviously the dimensions of the leg need to be tailored to fit the individual person. This fitting is done by highly trained prosthetists. It is particularly important to tailor the socket to fit the stump closely, otherwise looseness and soreness will result.

Q.6 To move each finger separately, under voluntary control, it would be necessary for sensors to collect information from the individual nerves controlling each finger. At present this degree of selectivity is impossible.

Notes on the discussion points

The psychological problems of losing a limb are often as severe as the physical problems. Patients often need a great deal of help in adjusting to their new life-style and altered body image. Generally, people adapt better to losing an arm than losing a leg.

Artificial limbs are the subject of considerable research both in this country and overseas. A promising area for development seems to be the field of sensing and feedback. Artificial hands are being developed which incorporate touch sensors. These can record the position of the fingers and feed this information to a microprocessor which in turn controls the movement of the motor.

Another area of research is the energy source which powers the arm. Batteries have severe limitations of lifetime and output. Possible developments include pneumatically powered limbs, incorporating a self-powered pump for compressing air.

The final discussion point is intended to encourage students to think about their own attitudes to handicap, and their reactions when they meet handicapped people.

Further activities

Artificial limbs are supplied by the Limbfitting Service of the Department of Health. There are thirty Limbfitting Centres around the country, and it might be possible to arrange a visit or visiting speaker by contacting a local centre.

Acknowledgements Figures 1 and 7 supplied by the Department of Health and Social Security Limbfitting Centre, Roehampton; Figure 3 supplied by *The Hemel Hempstead Gazette.*

ARTIFICIAL LIMBS

Artificial limbs may make you think of peg-legged pirates, or Captain Hook with his hook hand. But today's artificial limbs are rather different. Often you don't notice them at all, and they can do many of the jobs of an ordinary limb.

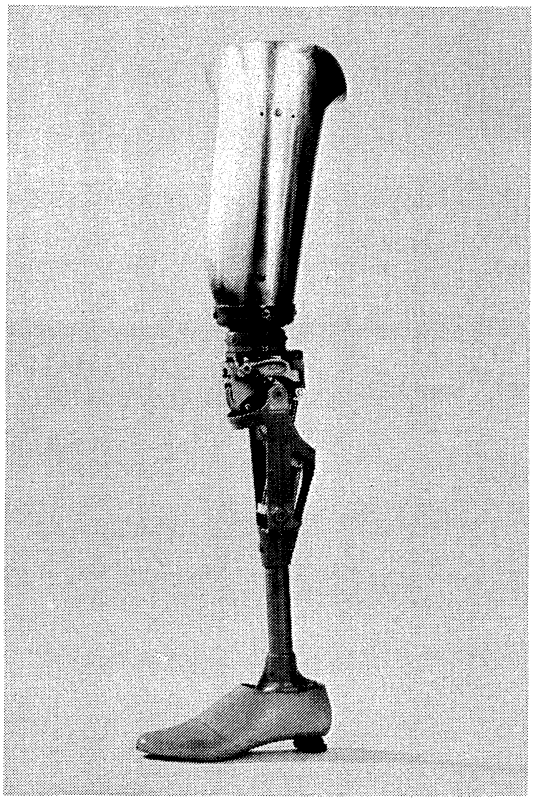

Figure 1 An artificial leg without its outer cover, showing the basic structure

Walk around and think about the jobs your leg has to do. Now try walking with your leg completely stiff. Don't bend the ankle or knee at all. Now think about the essential properties an artificial leg would need.

Answer question 1.

Every year about 5000 people are fitted with artificial limbs for the first time. People need artificial arms or legs for one of two reasons:

- They were born with a limb, or part of a limb, missing.
- They have had a limb removed (amputated).

The most frequent reason for having a limb amputated is disease. A common disease in old people is **arteriosclerosis**. Smoking is a major cause of this disease. In arteriosclerosis the blood vessels get clogged up. The limbs, especially the legs, do not get enough blood supply. If the leg gets infected, there may not be enough blood supply to fight the infection. A serious infection called **gangrene** may develop. The leg may have to be amputated to stop the gangrene spreading.

About 85 per cent of all amputations are done on old people with arteriosclerosis. The remaining 15 per cent are mostly needed after accidents, particularly road accidents. A very seriously damaged limb may have to be amputated because it cannot be repaired.

Question

1 What essential properties would an artificial leg need to have?

Helen — a case study of artificial legs

Helen had just started a degree course at London University in October 1984 when she became ill. She suddenly developed a severe rash on her body, and a high temperature. She was admitted to hospital suffering from a rare disease called *meningococcal septicaemia.*

Helen was extremely ill and needed an artificial breathing machine. Due to complications of the illness, the blood vessels to both her legs and to the tips of her fingers became blocked. She had to have both legs amputated below the knee. The tips of three of her fingers also had to be amputated.

Helen was fitted with her first pair of artificial legs in February 1985. She stayed in hospital until April 1985, learning to walk. She left hospital in May 1985 but continued to have physiotherapy three times a week.

Helen's physiotherapy continued until October 1985. During this time her walking improved so she could walk with two sticks. She went on several outings with the physiotherapist, to help her learn to cope with shopping, escalators and so on. She also worked hard on her hands, because they had become stiff after the operation. She learnt to type, and learnt how to put on her artificial legs.

In October 1985, almost exactly a year after her illness started, Helen returned to university to start again on her degree course.

Figure 2 Helen in 1986 at the University of London

Nigel — a case study of an artificial arm

Nigel was born with his right arm missing below the elbow.

He was fitted with his first artificial arm at 8 months old. This was just a 'cosmetic' arm for the sake of appearance. When he was 18 months old he had his first 'working' arm. This was a split hook which he could open and close.

Since then Nigel has led a normal life and has attended an ordinary school without any problems. He is very active, enjoys sport and has many friends. He plays football for the school team. When he was 13 he was voted 'Athlete of the Year' by his school.

Nigel has two types of artificial arm:

1 A body-powered arm with various attachments. The attachments include a split hook, a canoeing hook, and various gripping appliances which Nigel uses when he is doing CDT at school.

2 A myoelectric, battery-powered arm.

Nigel finds his split hook useful for most things he needs to do. As Nigel grows, he needs to be fitted with new, larger arms at regular intervals.

Figure 3 Nigel wearing his split hook hand, holding medals he won at the Stoke Mandeville Games

How do artificial limbs work?

Artificial legs

Think back to when you were answering question 1. You probably realized the problems of walking with a stiff leg. An ideal artificial leg needs to bend at the knee and ankle, like a real leg. But this can cause problems. If it is *too* easy to bend, the leg may collapse under the person's weight.

The answer is to make a leg that can bend, but with a knee that locks when weight is on it. The knee must be able to unlock and bend easily when the person sits down. Figure 4 shows an artificial leg for a person who has had an amputation above the knee.

After amputation a stump is left, and this fits into a socket in the artificial leg. When the person walks, they swing the artificial leg by using their muscles to move the stump. If both legs are artificial, they may need sticks to help them walk.

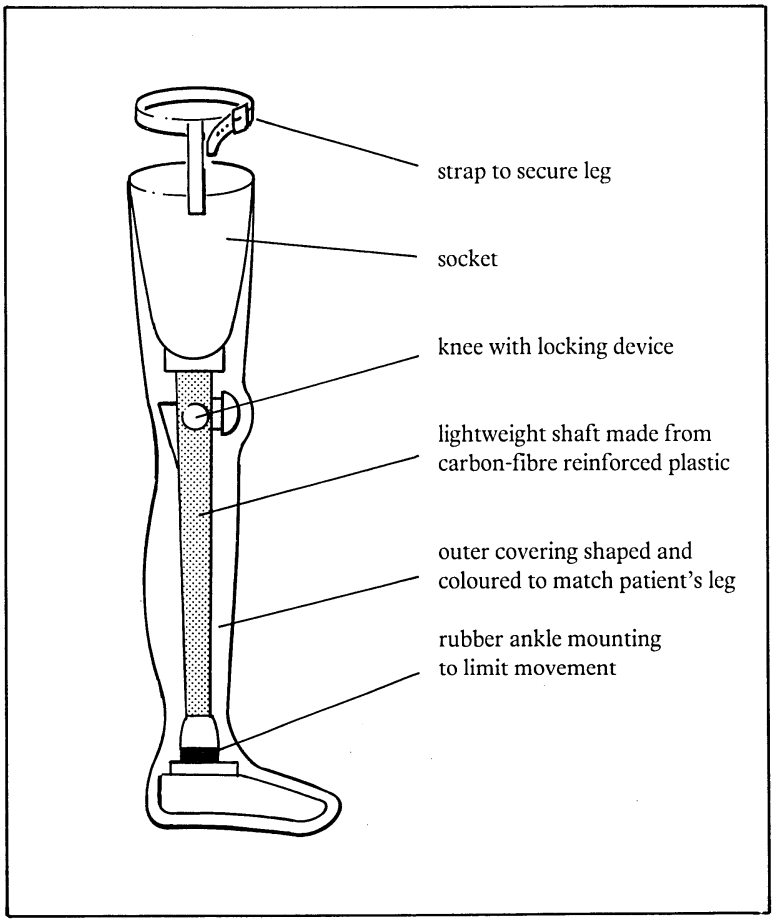

Figure 4 An artificial leg for a person with an above-knee amputation

Questions

2 *Suppose an artificial leg is designed for a* below-knee *amputation. In what ways would it be different from the one in Figure 4?*

3 *Which parts of the leg in Figure 4 would have to be tailored to suit each different patient? Which parts would be standard for every patient?*

Artificial arms

If an artificial arm is to be useful, it must have a hand that can manipulate things. This hand may be powered by the patient's own body, or by electricity.

Body-powered hands

These are usually operated by a strap attached to the shoulder. Figure 5 illustrates the arrangement.

Split hooks are particularly useful, but many other attachments are possible. People can get attachments to suit their particular work or interests. There are special attachments for typing, gripping, hammering and so on.

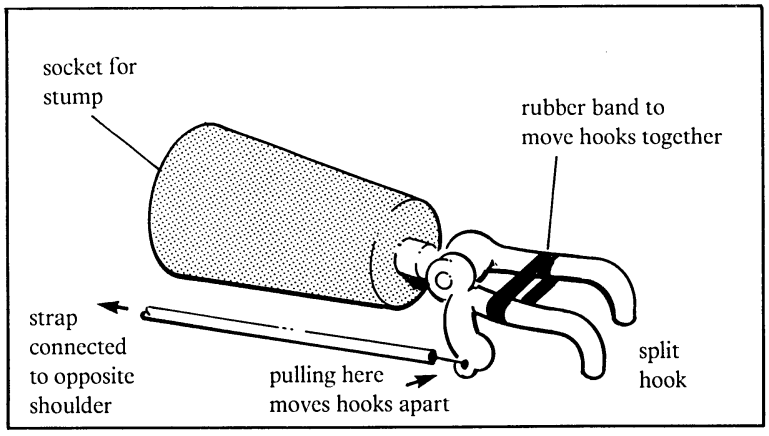

Figure 5 A body-powered hand

The myoelectric hand

When you want to move your own hand, your brain tells the muscles what to do. Messages are sent from the brain to the muscles, as tiny electrical impulses along nerves. The electrical impulses make the muscles contract.

The myoelectric hand uses these electrical impulses to control a battery-powered hand. It is sometimes called a 'bionic hand'. Figure 6 shows the arrangement.

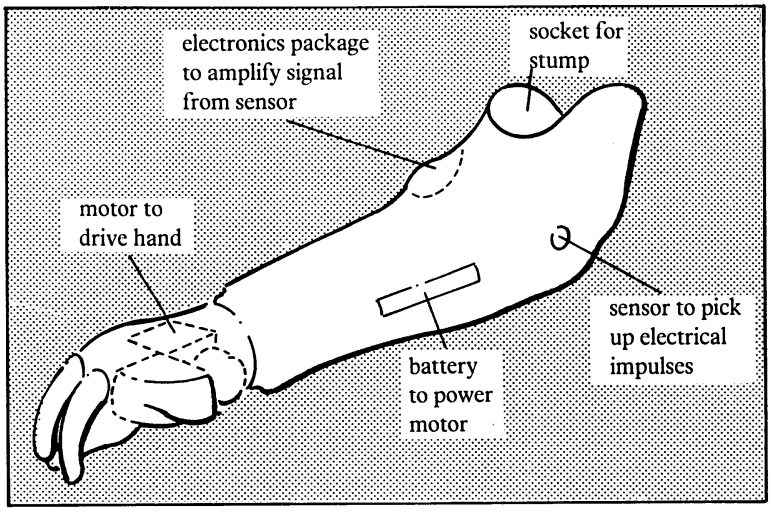

Figure 6 A myoelectric hand

The sensor touches the skin of the stump. It is positioned as near as possible to the muscles which remain in the stump. When the brain sends electrical impulses down the nerves to these muscles, the sensor detects the tiny electric currents. The current is amplified to make it large enough to work a switch. The switch turns on a motor which moves the artificial thumb and fingers. All the person has to do is think and the hand moves.

There are usually two sensors. One can be used to turn the motor on, the other to turn it off. The motor is driven by a small rechargeable battery.

The hand has a flexible plastic covering, coloured to look like the person's own skin. Its appearance is very like a natural hand.

Myoelectric hands can be fitted to very young children. Most children learn how to use them much quicker than adults.

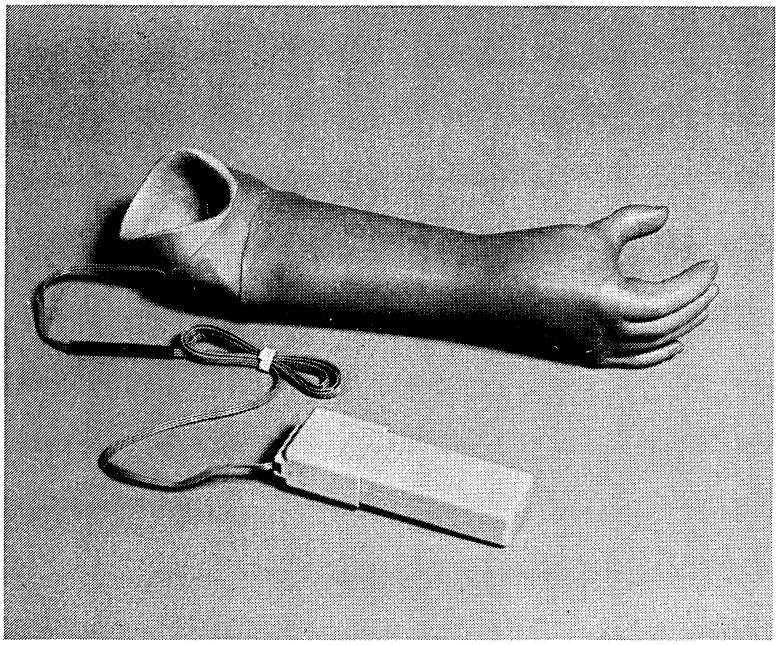

Figure 7 A myoelectric hand

Questions

4 *What advantages does a myoelectric hand have over a body-powered hand? Does it have any disadvantages?*

5 *It is not practical to make electric powered legs. Why not?*

6 *Myoelectric hands can only do a single movement — a grip between thumb and fingers. Why is it not possible to move each finger separately?*

Further points to discuss

- Describe what you think you would feel if you were told you had to have a limb amputated.
- Think of some particular problems about managing with artificial legs. Suppose you need to get out of bed in the middle of the night? What about escalators? Would you be able to manage putting your legs on without help?
- Which do you think it would be easier to adjust to — losing an arm or losing a leg?
- Sometimes people have a limb cut clean off in an accident. When this happens it may be possible for a surgeon to sew the limb back on. What difficulties can you see about doing this operation successfully?
- What major progress do you think there could be in the technology of artificial hands in the future?
- Artificial limbs do not have **senses** like real limbs. What senses would it be useful to build into an artificial hand? Would it be possible to do this? How could it be done?
- How could modern technology help (a) blind people; (b) people who are paralysed?
- A person with artificial legs has said: 'The worst problem that handicapped people have is other people'. What did she mean?