

## Stryker

# Replacing Damaged Joints

### The Wonderful Mechanics of the Human Body

The internal components of the human body are contained in a framework of some 206 bones called the skeleton. The skeleton is flexible, with joints that allow us to move. There are many different types of joints including:

- Hinge joints such as the elbow, knee, and ankle. Hinge joints allow the body parts to bend and straighten
- Gliding joints that allow two flat bones to slide over each other. There are gliding joints in the foot and wrist.
- Ball and socket joints allow twisting and turning movements. In a ball and socket joint, one of the bones has a rounded head which is the ball. The other bone has a cup-like area that is known as the socket. The shoulder and the hip are in this category.

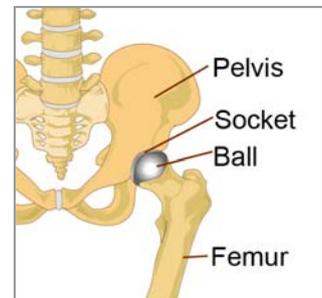
Joints in which bones come into contact with each other must be lubricated in order to reduce the friction between the moving parts. The body produces its own lubricant, which is a jelly-like substance called synovial fluid. Of course, other physical components are involved in movement of the joints. These are ligaments, cartilage, tendons and muscles. While ligaments normally connect one bone to another, tendons connect bones to muscles. Tendons are sometimes called sinews. For example, your fingers are moved by muscles. However these muscles are not in your hand; they are in your lower arm. There are separate muscles for each finger and when they contract they pull tendons that are connected to the bones in your fingers. If you open and close your fingers you can easily see these tendons at work in your wrist, especially if your arm is pointing towards the light.

Muscles can pull but they cannot push and so they usually occur in antagonistic pairs.

In this lesson, we look at two synovial joints, the hip and knee. We discuss the modern technology that allows the components of these joints to be replaced with artificial components, a process that has given a new lease of life to many people throughout the world. Any device that replaces a human body part is called a prosthesis (from the Greek for 'addition') and when it is inserted in the body it is called a prosthetic implant. The surgical process involved is called arthroplasty (from Greek, meaning making an image of a joint).

### How Does the Hip Work?

The hip joint allows your entire lower body to move forward and backward, from side to side and to rotate right and left. The hip joint also acts as a shock absorber for the upper body as you move about or lift things.



The hip is a ball-and-socket joint between two separate bones – the thighbone, which is called the femur, and the pelvis. The pelvis has two sockets called acetabula, one is on each side of the body. The head of the thighbone is shaped like a ball and fits into the socket. The socket has a lining of cartilage that allows the joint to rotate smoothly and also acts as a shock absorber. The synovial fluid which reduces the friction between the ball and the socket is produced by a membrane that covers the joint. A set of ligaments connects the thighbone to the pelvis. These ligaments keep the hip from moving outside of its proper range. The actual movement is powered by muscles of the hip. These muscles and ligaments together also help you to remain stable.

### What Can Go Wrong?

Normally, the first sign of a hip problem is the onset of pain. There are many possible causes, the most common of which is arthritis, which literally means 'inflammation of a joint'. There are over 100 types of arthritis, but two of the most common are osteoarthritis (osteon is the Greek word for 'bone') and rheumatoid arthritis. Rheumatoid arthritis is an autoimmune disease. Such diseases occur when tissues are attacked by the body's own immune system.

Of course, the hip can also be damaged by a fall or an accident. If the person also happens to suffer from osteoporosis, which literally means 'porous bones', the hip can very easily be fractured. Osteoporosis occurs when bones lack protein and minerals such as calcium. They then become very fragile and break easily. Although many inflammatory diseases such as arthritis can be treated by medication, very often the situation can only be relieved by replacement of the hip.

## What Is a Hip Implant?

Total hip replacement is a surgical procedure in which the femoral head (the 'ball') and the acetabulum (the 'socket') are replaced by specially designed artificial parts. When the first implants were carried out in the 1960s, the components were made of stainless steel. Since then, other metals, such as cobalt and titanium, have been used. The most modern implants, such as those produced by Stryker, are ceramic.

## The Amazing Knee Joint

Our knees also support body weight and allow us to carry out a range of movements. We could not walk, run or jump without them. Although the knee joint is often described as a hinge joint, in fact it is much more complex than the name implies. Four bones are involved. We have seen that one end of the thigh bone (femur) is located at the hip. The other end forms part of the knee, and is attached by ligaments to the shin bone, called the tibia. One of these ligaments is the anterior cruciate ligament which is well known these days from widely publicised football injuries. Another bone, called the fibula, is parallel to the tibia. The fourth bone is the knee cap, which is called the patella. The proper functioning of the knee depends on several tendons and muscles. The muscles at the front are the quadriceps and those at the back are the hamstrings. We commonly say that we bend or straighten the knee. The medical terms for these actions are flex and extend. However, the knee also turns as it moves so the joint is more correctly called a pivotal hinge joint or a compound joint. The knee is very prone to injury and to diseases such as osteoarthritis and rheumatoid arthritis. Many injuries can be treated by surgery but sometimes, due the extent of the injury or general wear and tear, the components of the knee must be replaced.

## Replacing the Knee

Knee arthroplasty can be carried out as a partial or a total replacement. Like the hip, the process involves replacing the damaged joint surfaces with artificial components made of metal, plastics, or ceramics. The damaged or worn surface at the end of the femur and the top of the tibia are replaced with specially designed pieces. These can either be pressed into place (called 'press-fit'), which allows the bone to grow into the plate coating or be fixed in place with bone cement.

## Stryker

Stryker Corporation is one of the world's leading medical technology companies with a very large range of products in orthopaedics and a significant presence in other medical specialties. Stryker works with respected medical professionals to help people lead more active and fulfilling lives.

As a global leader in the development of orthopaedic products and services, Stryker is committed to researching and developing new ways to address people's needs – including the use of new materials that make replacement joints operate more like the natural joint – and developing products that make orthopaedic surgery and recovery simpler, faster and more effective.

Stryker is dedicated to the principle of "responsible science," and ensures that its products and procedures are fully tested and clinically proven to help people lead healthier, more active lives.

Stryker Orthopaedics is located in New Jersey, USA and has manufacturing facilities in Raheen, County Limerick and in Carrigtwohill, County Cork.

Stryker manufactures replacement joints, endoscopy products, surgical equipment and other medical devices. Stryker employs 18,000 people worldwide and 1300 in Ireland.

*You can find this and other lessons on [www.sta.ie](http://www.sta.ie).*

*Find out more about the work of Stryker on*

*[www.stryker.com](http://www.stryker.com).*

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### Teaching Notes

#### Syllabus References

The relevant syllabus references are:

##### Leaving Certificate Biology (p. 39)

- Macroscopic anatomy of a long bone: medullary cavity, compact bone, spongy bone, and cartilage.
- Function of the following: cartilage, compact bone, spongy bone (include red and yellow marrows).
- Classification, location and function of joints: immovable, slightly movable, free-moving or synovial.
- Role of cartilage and ligaments in joints. Role of tendons.
- General relation of muscles to the skeleton – antagonistic muscle pairs as exemplified by one human pair.
- [Disorders of the musculoskeletal system: one example of a musculoskeletal disorder, from the following: arthritis and osteoporosis; one possible cause, prevention, and treatment.]

*This lesson is particularly relevant when discussing the topic of Science and Technology in Society.*

#### Learning Outcomes

On completion of this lesson, students should be able to:

- Name and describe some human skeletal joint types.
- Identify the main components of joints.
- Name the bones in the hip and knee joints.
- Identify some of the diseases that cause joint dysfunction.
- Outline the purpose of implant surgery.
- Describe some of the replacement components.

#### General Learning Points

The following points can be used to review the lesson content and to inform discussion.

- Bones are generally not fused together and while they provide a skeletal structure for the body they also allow movement.
- Bones are generally linked by means of strong flexible ligaments.
- Tendons connect bones to muscles. Muscles can pull but cannot push and so they are often found in antagonistic pairs.
- Any device that replaces a human body part is called a prosthesis.
- There are three main kinds of joints: hinge joints, gliding joints and ball-and-socket joints.
- Joints are lubricated with synovial fluid, without which the ends of articulated bones would wear away.
- Arthritis is inflammation of joints and is usually very painful. Arthritis in knees or hips can limit mobility.
- Modern knee and hip replacements can restore mobility and improve a person's quality of life.
- Hip replacement is currently the most successful orthopaedic operation with 97% of patients reporting improved outcome.

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### Student Exercises

#### Group work

You will need access to further information about arthritis (e.g. book, leaflets or Internet).

Arthritis is the single biggest cause of disability in Ireland and as such is a significant burden on the health service. The majority of Irish people over 55 show some X-ray evidence of arthritis; it is estimated that arthritis affects about one sixth of the population. There are many forms of arthritis and although the disease is generally associated with old age many younger people can also suffer from it.

In your group produce a poster aimed at young people to raise awareness of arthritis and to recommend simple steps to reduce the risk of getting the disease. The following may help:

Although it may not be possible for everyone to avoid arthritis there are ways to reduce your risk of the disease:

- Keep your weight within normal limits.
- Be sure your diet includes the recommended amount of vitamins C and D.
- Strengthen leg bones and muscles by taking exercise.
- Avoid injuries whether from work or sports. Early bone injuries greatly increase the risk of arthritis in later life.

#### True/False Questions

- a) Synovial fluid is the transparent liquid in the eye.
- b) The main bones in the lower arm are the tibia and the fibula.
- c) Ceramic coatings are commonly used in replacement ball-and-socket joints.
- d) Osteoporosis is a weakening of bone due to loss of calcium.
- e) Arthritis is inflammation of a joint.
- f) Arthritis can be cured by medication.
- g) Tendons connect bones together.
- h) A layer of cartilage on the inside of a hip joint prevents friction between the bones.

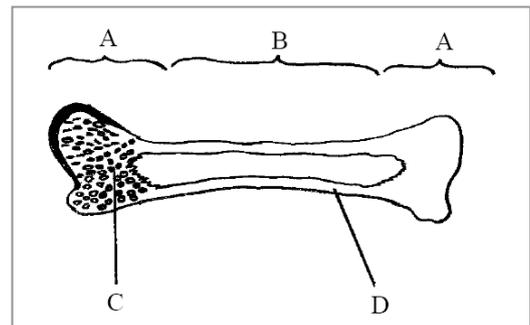
- i) The synovial fluid which reduces the friction between the ball and the socket is produced by the membrane that covers the joint.
- j) Muscles can push or pull.

*Check your answers to these questions on [www.sta.ie](http://www.sta.ie)*

#### Examination Questions

##### Leaving Certificate Biology (HL) 2009, Q. 4

- a) The diagram shows a longitudinal section of a long bone.
  - (i) Name the parts of the diagram labelled A, B, C, D.



- (ii) Where are the discs in the human backbone?
  - (iii) What is the function of the discs in the human backbone?
- b) Give a role for each of the following in the human body:
    - (i) Yellow bone marrow.
    - (ii) Red bone marrow.

##### Leaving Certificate Biology (HL) 2008, Q. 15 (a)

Answer the following questions in relation to the human musculoskeletal system.

- (i) Give three roles of the skeleton.
- (ii) Explain what is meant by the axial skeleton.
- (iii) Give a function for each of the following: 1. Red marrow, 2. Cartilage, 3. Tendon.
- (iv) Explain what is meant by an antagonistic muscle pair and give an example in the human body.
- (v) Suggest a treatment for a named disorder of the musculoskeletal system.

**Leaving Certificate Biology (HL) 2006, Q. 15 (a)**

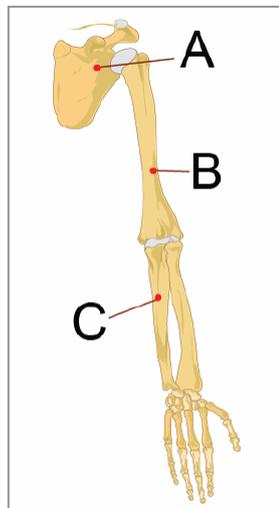
- (i) Draw a diagram to show the structure of a synovial joint. Label three parts of the joint that you have drawn, other than bones.
- (ii) Explain the functions of the three parts that you have labelled.
- (iii) Name a disorder of the musculoskeletal system.
- (iv) Give a possible cause of the disorder that you have named in (iii) and suggest a treatment for it.

- A newborn baby has over 300 bones and the average an adult has 206 (208 if the sternum or breast bone is counted as three bones). This is because a number of bones fuse together as a person grows.
- The biggest bone in the body is the femur, and the smallest is the stapes in the middle ear.
- In an adult, the skeleton comprises around 14% of the total body weight and half of this weight is water

**Leaving Certificate Biology (OL) 2010, Q. 15 (b)**

The diagram shows the bones of the human arm.

- (i) Name the parts labelled A, B and C.
- (ii) What structures attach a muscle to a bone?
- (iii) Which upper arm muscle contracts to raise the lower arm?
- (iv) What is meant by the term antagonistic pair in reference to muscles?
- (v) Name the type of joint at the elbow.
- (vi) Apart from movement, give one other function of the skeleton.
- (vii) Suggest one reason why the bones of birds are almost hollow.



**Did You Know?**

- The femur is the longest bone in the body.
- It is claimed that the earliest recorded hip replacement was carried out in Germany in the 1890s, using ivory to replace the femoral head.
- The first metallic hip replacement was carried out in 1940 at Johns Hopkins hospital. The material used was an alloy cobalt and chrome.
- People with extra long ligaments can bend joints further than usual. They are known as double jointed..
- The shoulder joint is the most flexible joint in the body since it allows movement in any direction.

**Biographical Notes**

**Sir John Charnley (1911 – 1982)**

Sir John Charnley was a British orthopaedic surgeon who pioneered a new approach to hip replacement operations. He used stainless steel femur heads and polyethylene sockets that were fixed in place with a bone cement known as PMMA (polymethyl methacrylate), a transparent thermoplastic. As a schoolboy, he excelled in science but chose medicine as a career. He was knighted in 1977.

**Revise the Terms**

*Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.*

acetabula, acetabulum, antagonistic pair, anterior cruciate ligament, arthritis, arthroplasty, autoimmune, ball and socket joint, bone, bone cement, calcium, cartilage, ceramic, cobalt, compound joint, extend, femur, fibula, flex, friction, gliding joint, hamstrings, hinge joint, ligament, membrane, mineral, muscle, osteoarthritis, osteoporosis, patella, pelvis, pivotal hinge joint, prosthesis, prosthetic implant, protein, quadriceps, rheumatoid arthritis, skeleton, stainless steel, synovial fluid, tendon, tibia, titanium, total hip replacement.

*Check the Glossary of Terms for this lesson on [www.sta.ie](http://www.sta.ie)*