

Heart Surgery and Dissection



Current Research

The Biotechnology and Biological Sciences Research Council (BBSRC) is working towards lifelong health and well being by funding research investigating the normal ageing process. Research is being conducted on the effects of diet, physical activity and development on the ageing process to understand risk factors for poor health and identify interventions that can improve well being. A variety of research approaches are being undertaken including the use of mathematical and computer modelling to provide new insights to how systems work as well as the innovative use of imaging techniques. Work on biomaterials and tissue engineering is producing improved medical implants and devices such as pacemakers, as well as a range of substances with anti-infection properties. Throughout this research BBSRC encourages work that adopts the principles of the 3Rs (Replacement, Refinement and Reduction) in the use of animals and aims to improve animal welfare.

A large body of evidence demonstrates that the quality and quantity of food, and dietary choice affects ageing and lifespan. There are also good data that aerobic exercise increases healthy lifespan, improves regulation of glucose metabolism and can reduce age-related deterioration of the musculoskeletal system.

Evidence increasingly suggests that impaired growth *in utero* especially when followed by rapid post-natal growth can seriously impair many aspects of health and may influence the ageing process. The mechanisms by which these early life exposures are mediated are poorly understood.

There is a need to understand how the normal ageing process can act as a risk factor for poor physical and mental health. BBSRC encourages research on molecular and cellular mechanisms by which normal ageing leads to frailty. Key issues include linking changes at the molecular and cellular level to those observed at the tissue and whole organism level.

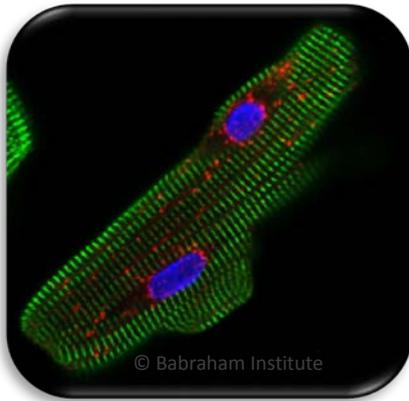
Systems Biology is an approach in which experimental biology is closely-integrated with mathematical or computational modelling in a synergistic way to answer biological questions that would be not be possible by empirical approaches alone. One of the goals of systems biology is to discover new emergent properties that may arise from studying the system as a whole, leading to more rapid and deeper understanding of how the system is controlled and how it responds to external stimuli. This level of understanding will greatly facilitate the future exploitation of biological systems.



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Using non-invasive technologies such as magnetic resonance spectroscopy (MRS) a better understanding of how the heart, lungs and muscles work together will provide scientists with insights into why some people, such as elite athletes, have higher levels of endurance than others. Computer models will be used to better understand why exercise tolerance is limited in sedentary or elderly individuals and as the basis for informing interventions in patients with heart and lung conditions where exercise intolerance is a primary characteristic. <http://goo.gl/SmRE8>





By attaching microscopic carbon fibres to individual heart cells, scientists have been able to make them move as they would inside the beating heart. This made it possible to investigate how cells respond to stretch, and to identify how the cell cytoskeleton and calcium signals interact in a working cell. This will be important in revealing the mechanisms of cardiac failure in an overloaded heart. <http://goo.gl/IgRhZ>



Skeletal muscle plays an essential role in the regulation of whole body metabolism. Loss of metabolic function leads to and/or exacerbates a number of chronic diseases, including coronary heart disease, hypertension, obesity and type 2 diabetes. Every year over 500,000 animals are used to study how the physiology and function of muscle adapts to disease, genetic alteration, altered loading, and pharmacological agents.

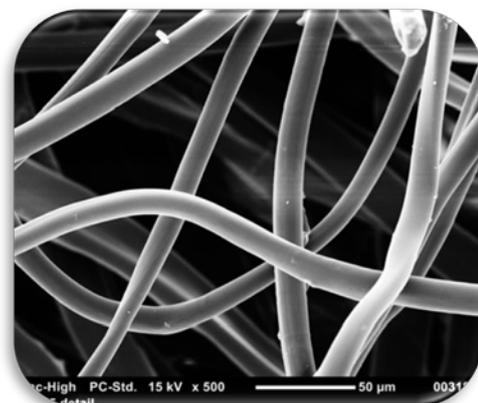
Scientists have recently engineered a model of a muscle that has the potential to create an *in vitro* alternative for the study of muscle physiology and function to reduce the number of animals used in research and make further discoveries. <http://goo.gl/Z94Nx>



Many implantable medical devices can trigger an acute inflammatory response, which in turn can be detrimental to the function of the device, such as stress cracking of pacemakers or a re-narrowing of coronary arteries following a stent implant. This can be triggered either by the initial implantation injury or by the biomaterial itself. Inflammation can be treated with steroids or non-steroidal anti-inflammatory drugs (NSAIDs). However, these drugs frequently lack sensitivity or a specific targeted site of action, which can lead to side effects. A team of scientists have developed a new method for generating model surfaces with bioactive anti-inflammatory properties. These bioactive materials also have anti-microbial activity and could be added to a variety of surgical tools such as stents or stitches to enable wounds to heal quickly and safely. <http://goo.gl/MYAf8>



Researchers are looking to the natural world to create a new breed of exotic materials for biomedicine based on silkworm and spider silk. Silk is a superb material: light, strong, and highly elastic. Scientists studying the fundamental properties of this natural substance in Britain have now formed a number of spin-out companies to develop a new generation of biomedical implants. Silk is also biocompatible, and thus makes an ideal substrate to use inside the human body as advanced biomedical implants. Intimate knowledge of beneficial amino acid sequence and morphology from studying spider silks, has led to the combination of excellent mechanical and tissue regenerative properties. Because the silk implants do not irritate or harm the body's cells, they not only provide tough replacement surfaces but also encourage regrowth of new tissue. <http://goo.gl/R5auP>



© Oxford Silk Group



Practical activity

Total Duration: 1 hour and 25 minutes

Stages one and two can be carried out in one lesson and the repaired hearts refrigerated and saved until the next lesson to complete stages 3 and 4. Alternatively the whole procedure can be carried out in a double lesson.

Learning Outcomes

Students will be able to:

- identify internal and external anatomy of a heart
- dissect a heart and be able to model the techniques of a heart surgeon
- discuss heart diseases and disorders, describe how they occur, and name risk factors and possible preventative measures

Materials

1. Sheep hearts
2. Rubber tubing and syringe
3. Dissecting equipment - trays, pins, forceps, scalpels, blunt and sharp probes, scissors
4. Masking tape/stickers
5. Permanent marker
6. Washing up bowls or access to sinks
7. Curved needles
8. Dental floss or fishing line
9. Ruler
10. Gloves
11. Eye protection
12. Aprons
13. Balance

Optional

14. Slides featuring heart muscle tissue and cardiovascular pathology
15. Camera



Health and Safety

The instructions are for guidance only. Observe Good Laboratory Practice when carrying out these activities. Wear eye protection and lab coats or disposable aprons to protect clothes. Wash hands after handling hearts (use of gloves is not required but can be used to simulate the heart surgery procedure). Disinfect work surfaces with 1% Virkon, wash and autoclave dissecting instruments. Sections 14.6 and 14.7 of the CLEAPSS laboratory handbook provide further details.

Prior learning

Students should carry out a preparatory activity to familiarise themselves with the structures of the heart. Resources such as worksheets, animations and videos can ensure students get the most from the learning session. A variety of worksheets are available online such as

<http://askbiologist.asu.edu/coloring/human-heart> and online animations suitable for class are available such as www.kett6.net/adulteducation/heartanimations.html and www.bhf.org.uk/swfs/hearthealth/structure_of_heart.swf

Teacher Preparation

Order sheep hearts from a biological supply company such as Blades Biologicals Ltd, or obtain hearts from a local butcher. Sheep hearts are easily obtained and allow students with religious concerns over cows or pigs to take part.

When obtaining hearts from butchers, ask for the hearts to be removed with as much of the blood vessels as possible and no damage to the heart. In some instances there may be damage to the heart caused by the meat inspection process and this activity is ideal for incorporating this into the dissection. If the heart is intact, use a scalpel to create a small hole in the wall of one of the ventricles. A slit about 1.5 cm long in the right ventricle on the dorsal side is unobtrusive yet effective. Ensure the hole created passes right through the ventricle wall. Due to the thinner wall of the right ventricle it is easier to ensure the hole has been made correctly and easier for the students to repair.



To prepare for dissection, put the following items next to each dissecting tray: several pins, 1 pair of forceps, 1 scalpel, 1 sharp probe, 1 blunt probe, 1 pair of scissors, 1 roll of masking tape, 1 permanent marker, 1 curved needle, and a supply of fishing line or dental floss (for repairing heart defects). Rinse the hearts to remove excess blood or chemicals and place one heart on each dissecting tray.

Introduction – 5 minutes

Inform the students that they will be learning about heart anatomy, blood flow through the heart, identifying damage to the heart and conducting heart surgery. Share the learning outcomes with the students and recap their prior knowledge of the heart structure and function.

Stage 1 – External anatomy

Duration: 20 minutes

Once students have familiarised themselves with heart anatomy either on-line or by completing a worksheet, it is time to learn to identify the structures on a real sheep heart. It may help students to have a diagram to identify the orientation of the heart and locate the regions correctly.

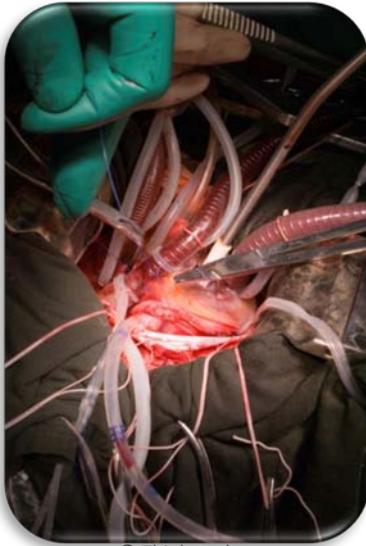
1. Divide students into groups of 2-3 and have them put on gloves, eye protection and aprons.
2. Provide each group with a dissecting tray, pre-washed sheep heart, pins, forceps, scalpel, blunt probe, sharp probe, scissors, masking tape, and a permanent marker.
3. Have each group create a set of 7 pins with identification flags on them using masking tape or stickers and the permanent marker. Label the pins with the following;

1. Left Ventricle
2. Right Ventricle
3. Coronary blood vessel
4. Right Atrium
5. Left Atrium
6. Pulmonary Artery
7. Aorta

If the blood vessels have been retained students may also be able to label the superior and inferior vena cava.



4. Students should identify the dorsal and ventral sides of the heart and place the heart down with the ventral side facing up.
5. Students should label the heart referring to a diagram, if required. Depending on the state of the heart some structures may be harder to identify than others and students should be made aware of this.
6. Once students have labelled the heart anatomy, you should check to make sure each group has correctly identified each region. Students should make a record of the labelling by drawing a diagram or taking a photograph and then remove the pins.



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At this point it may be helpful to take a closer look at the coronary blood vessels and compare those seen on the exterior of the sheep heart with slides displaying cardiovascular pathology. Introduce students to the features that can cause cardiovascular disease through displaying slides demonstrating atherosclerosis or myocardial infarction or models of such disease. You may want to show students the effects of heart disease on the structure of the heart. Discuss with the class the causes of cardiovascular diseases and prevention measures that can be taken to reduce the chance of heart disease.

Stage 2 – Identification and repair of heart damage

Duration: 20 minutes

Students are to assume the roles of cardiologists and determine where and what the damage to the heart is and then perform surgical repair of the injury.

1. Provide each group with a curved needle and a length of dental floss.
2. Students should examine the heart and identify the damaged region. This should be reported to the teacher and a record made by annotating the diagram made in stage 1 or taking a photograph.
3. Once the injury has been correctly identified, the students will repair the holes by suturing the defects. To do this, students will use curved needles and dental floss to sew up the holes. You may want to introduce the students to suturing techniques in more detail at this point.



Suturing – Historically many substances have been used as sutures, including silk which is still in use, though absorbable and non-absorbable synthetic polymers have replaced natural suture materials. Absorbable suture thread is used internally or when sutures cannot be removed at a later date. The disadvantage is that they can cause inflammation or rejection leading to scarring. Non-absorbable threads such as silk are used in stressful environments such as the heart where they will remain permanently. Suturing is carried out with traumatic and atraumatic needles. Traumatic needles have eyes whereas atraumatic needles have attached suture thread. Needles come in a variety of sizes and shapes but most are curved.

Stage 3 – Testing blood flow through repaired heart

Duration: 10 minutes

1. Demonstrate the flow of water through an intact heart. Using a syringe squirt water into the veins and atria and identify the vessels the water exits from. Compare this to a diagram showing blood flow through the heart.
2. Students should squirt some water into the veins to check that the repair has sealed the damage to the heart and check that they have identified the correct blood vessels. The pulmonary vein water should exit the aorta (the larger rubbery arterial vessel) and the vena cava water should exit the pulmonary artery.

Stage 4 – Examining internal anatomy of heart

Duration: 25 minutes

Inform the students that there was a post-operative complication and the internal structure of the heart must be examined as part of the autopsy.

Students should work in pairs with one taking the role of the pathologist and the other the assistant pathologist. The pathologist will be responsible for carrying out the dissection. The assistant will be responsible for recording the appropriate information on the autopsy record sheet, providing equipment to the pathologist and taking photographs or drawing diagrams at different stages of the dissection.

- Use attached autopsy record form.
 - Use ruler to establish scale.
 - Record progress using a camera or drawings.
1. Record the weight of the heart. A typical sheep heart weighs about 250 g. Note any discrepancy.
 2. Measure the width of the heart, across the ventricles at the widest part.
 3. Cut from the bottom to the top of the right ventricle. Open up the right ventricle identifying the right atrioventricular (tricuspid) valve and the attached papillary muscles.
 4. Measure the thickness of the right ventricle wall. Students should see if they can observe their repair internally and identify if the suturing caused any damage or if any of the tendons or papillary muscles were affected by the sutures.
 5. Repeat the cut through the left ventricle and atrium this time identifying the mitral (bicuspid) valve.
 6. Once again record the thickness of the ventricle wall.



Students should be asked to suggest a reason for the difference in size of the ventricle walls and relate it to the function of the heart.

Plenary – 5 minutes

Recap the internal and external features of the heart that were identified. Relate the anatomy of the heart to the heart structure. Discuss the pros and cons of the suturing techniques and materials with the class. You may want to discuss the difficulties in treating cardiovascular disease, treatments available and the benefits of preventative measures.

Based on the lesson: *You Gotta Have Heart: Congenital Heart Defects and Heart Surgery* by Rebecca Johns
www.cdc.gov/.../Johns%20Heart%20Defects%20Lesson%20Plan.pdf

Suppliers

Blades Biological Limited www.blades-bio.co.uk Cowden, Edenbridge, Kent, TN8 7DX tel: 01342 850 242, fax: 01342 850 924

Feedback

Please provide us with feedback so we can improve this practical guide. Email the author: Tristan.Bunn@bbsrc.ac.uk. Copyright BBSRC. Permission granted to reproduce for educational use.



Curriculum

Key stage 3 Science

Applications and implications of science

Examining the ethical and moral implications of using and applying science. The way scientific developments are achieved can raise ethical and moral issues, for example experiments on animals to produce drugs that may prolong human life.

Key stage 4 Science

How Science Works: Applications and implications of science

Pupils should be taught:

- to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions

All pupils develop their ability to relate their understanding of science to their own and others' decisions about lifestyles, and to scientific and technological developments in society.

Scotland: Curriculum for Excellence - Science

Body systems and cells

Learners ... develop informed views on the moral and ethical implications of controversial biological procedures.

Topical science

By considering current issues of science, learners increasingly develop their understanding of scientific concepts and their capacity to form informed social, moral and ethical views. They reflect upon and critically evaluate media portrayal of scientific findings.

AQA Biology GCSE

B3.2 Transport systems in plants and animals B3.2.1 The blood system B3.2.2 The blood

Suggested ideas for practical work to develop skills and understanding include the following:

- dissection of the heart
- use software simulations of the work of the heart and blood vessels
- observation of arteries and veins from slides
- observation of blood smears
- observation of valves in veins preventing backflow of blood using the 'athletic' arm / prominent vein

OCR Twenty First century science suite - GCSE Science A, Biology A

3.3.2 Module B2: Keeping healthy

3.5.1 Module B7: Further Biology

Opportunities for practical work

- heart dissection.

OCR Biology A-level

Module 2: Exchange and Transport

The practical work outlined below may be carried out as part of skill development.

Collection and presentation of qualitative (descriptive) data:

- Make measurements and annotated drawings during a heart dissection;
- Use a light microscope to make annotated drawings of blood vessels.

Links and further resources

Calcium Signalling - Getting to the Heart of the Matter

www.babraham.ac.uk/downloads/royal_soc_interactive.swf

Understanding Animal Research Teachers Zone www.understandinganimalresearch.org.uk/teacherszone/

The NC3Rs is working with the BBSRC to increase investment and awareness in tissue engineering as a means of replacing animal models. www.nc3rs.org.uk/event.asp?id=830

Carry out a heart transplant interactive animation www.pbs.org/wgbh/nova/eheart/transplantwave.html

Anatomy for Beginners. Lesson 2 Circulation (contains scenes of anatomical demonstrations and exhibits on humans and animals which are not suitable for young pupils and some viewers may find distressing)

www.channel4.com/programmes/anatomy-for-beginners/4od#2922325

Autopsy Report form

Date:

Location:

Start time:

Finish time:

Name of Pathologist:

Institution:

Weight of heart:

Width of heart (mm):

Thickness of right ventricle wall (mm):

Thickness of left ventricle wall (mm):

Probable cause of death:

Observations:

With any injuries note the size, shape, pattern, location, colour, direction, depth and structures involved. Note any coronary artery disease or damaged tissues in the heart muscle characterised by an altered colour or texture.

Signed: