STEM Futures

STEM Works!

Northern Ireland Curriculum

Learning for Life and Work through Technology and Design (can also be adapted for Science)

Key Stage 3

Straight to the Heart of It

Overview

Pupils take on the role of product designers in a company that specialises in advanced medical robotics. They design and make a prototype nanobot that can enter the bloodstream to clear built-up cholesterol from the arteries. They then program and control their nanobot to carry out a simulated medical intervention.

NOTE: The use of Scratch software in this resource offers schools the opportunity to use the Exploring Programming Desirable Features for Using ICT. However, Scratch also provides opportunities for the Online Collaboration Desirable Features. C2k have provided additional advice on using Scratch online should you wish to have pupils engaged in online collaboration (this can be found at the end of this document). Alternatively you could save your project as a Scratch file on your school network rather than uploading pupils' work to the Scratch website. Scratch can provide pupils with opportunities to develop and assess the Cross-Curricular Skill of Using ICT.

Mapping to the Statutory Minimum Requirements	These activities allow pupils to:	
	• Develop skills in design by: - identifying problems; - generating, developing, modelling and evaluating design proposals; and - giving consideration to form, function and safety; and • Develop skills in control through: - incorporating computer-based control systems in products; and - understanding how these can be employed to achieve desired effects.	In the context of the following key element: Developing Pupils as Contributors to Society: • Explore the precautionary principle: the moral duty to assess the risk of the impact that new technologies may have on the human body **(Ethical Awareness).**

Health and Safety Warning

CCEA has assessed the health and safety risks associated with these activities. However, we strongly recommend that all teachers leading these activities carry out their own health and safety assessment, taking into account the ability of the students, the school's resources and its quality of equipment, etc.

Contents

Key Questions

- What is a nanobot?
- What is it used for?
- Do you know of any other medical device designed to solve the same problem?
- What if nanobots were capable of crossing the barrier of the brain?
- Why is good design crucial in the development of this device?
- Why are the materials used to manufacture nanobots very important?

Prior Learning

- the design process
- knowledge of different types of materials
- understanding the uses of different materials
- research techniques
- drawing skills, including 2D and 3D sketching
- recognising, naming and describing common 2D and 3D shapes
- use of CAD
- model-making and adhesives

Learning Intentions	Success Criteria
Pupils are learning: • ways in which they can experiment with ideas, materials, technologies and techniques; • how products are currently designed and how this design process may develop in the future based on advances in technology; • about the practical application of computer-based systems and control; • that technological advances can have an impact on society; • about computer control systems and how to use them effectively; and • that algorithms (an effective problem-solving method that uses a finite number of instructions) are used in technology so that a variety of inputs can give rise to a variety of outputs.	**Pupils will:** • respond creatively to design briefs; • develop specifications for products; • work in pairs to address all aspects of the design brief; • apply their knowledge of technologies to design a prototype nanobot; • develop effective algorithms for computer control systems that create information for a nanobot; and • understand the impact of ideas and advances in technology.

Skills Development

Thinking Skills and Personal Capabilities	Cross-Curricular Skills
Being Creative: • deliberately pursue unusual and different solutions; • respond to trying out and developing new ideas; and • turn mistakes and setbacks into new approaches. **Thinking, Problem-Solving and Decision-Making:** • systematically and logically produce valid, well-defined, computer-based system solutions to the problem presented.	**Using ICT:** • input more complex sequences of commands to solve a problem relating to a nanobot; • group sequences of procedures together to ensure the nanobot effectively reaches the targeted area of the cardiovascular system; • discuss how they could improve their commands and procedures and make any necessary modifications to ensure the nanobot is programmed to move with accuracy; and • showcase their work by uploading the completed cardiac nanobot simulation. **Using Mathematics:** • explore ideas, make and test predictions and think creatively when making connections between 2D and 3D shapes; • use mathematical knowledge and concepts accurately, such as direction and turn; • systematically check their work to ensure their procedures are fit for purpose; and • use mathematics to solve problems and make decisions to ensure their algorithms are effective and efficient.

Assessment Opportunities	Cross Curricular Skills Assessment Tasks available
	Using ICT: Straight to the Heart of It (Online Collaboration) Straight to the Heart of It (Exploring Programming)
	Communication: Straight to the Heart of It (Reading: Research) Straight to the Heart of It (Discursive/Persuasive Writing) Straight to the Heart of It (Talking and Listening)

Activity 1

Meet the Nanobot

Introduction:

Share with the class the Health and Life Sciences sector profile which is available in the Sector Profiles section of the STEM Futures folder and online at: www.nicurriculum.org.uk/stem

Ask each group to discuss the sector and record the following:

- one thing they already knew about the sector;
- two things they have learned; and
- one thing that has surprised them about the sector.

Invite your class to consider the following:
Imagine you visit your doctor because you have a high temperature. Instead of giving you a pill, the doctor refers you to a special medical team. They implant a tiny robot, called a nanobot, into your bloodstream. The nanobot detects the cause of your fever, travels to the appropriate system in your body and provides a dose of medication directly to the infected area.

Ask the pupils to discuss in pairs:

- How would you feel about this?
- What might be the advantages and disadvantages of this treatment:
  - to you;
  - to society; and
  - to the economy?

Explain that this is not science fiction; scientists and engineering teams throughout the world are developing nanobots that could one day treat anything from cancer to heart disease.

Organise the class into five groups. Encourage the pupils to appoint roles within their groups, for example recorder and reporter. Provide each group with a large sheet of paper and Cards 1 and 2 from **Resource 1**, and divide the remaining cards among the groups (two cards per group). Allow time for the pupils to discuss the information they have received and jot down their thoughts on the paper provided. They should include:

- what surprises, shocks or particularly interests them;
- what they will remember easily and why; and
- any questions they still have.

Invite the groups to rotate their cards and sheets of paper, and encourage them to add to each other's ideas. Continue until each group has considered all of the information. Ask the reporter from each group to feed back based on the sheet that they have finished.

Activity 2

Initial Research

Present the scenario **(Resource 2)** and design brief **(Resource 3)** to the class, ensuring that they understand they will be taking on the role of product designers/engineers who specialise in designing nanobots. Together discuss the role of product designers/engineers and the qualifications they need.

Organise the pupils into pairs, and ask each pair to research nanomedicine around the world, including local universities and hospitals where possible. Encourage them to formulate their own questions to research. You could also provide prompts, including:

- What is a nanobot?
- What could nanobots be used for in medicine?
- Why would some scientists and engineers want to develop medical nanobots?
- Who might oppose the use of medical nanobots?
- What are the challenges for engineers?
- Is it okay for nanobots to remain in the human body when they have completed their task? (Possible responses include *remain dormant in the body; need to be retrieved, otherwise they might cause other problems/infections; biodegradable manufacture.*)
- How reliable do nanobots have to be? (*Are computers completely reliable? What about computer viruses?*)

See the Useful Websites section which is available in the online version of this resource at www.nicurriculum.org.uk/stem

Activity 3

Moving Forward

Recap on the scenario in **Resource 2**. Explain to your pupils that, at the end of the project, they are going to present their ideas to an audience, who will take on the role of cardiac doctors and cardiac patients. Encourage them to record their progress digitally at regular intervals; this will help with their presentations.

Agree together that the pupils' next task is to consider the design of their nanobot, taking into consideration factors such as how it needs to move through the body.

As a class, discuss how living things in the world around us are adapted to move in their environment. Examples include fish, such as rayfish, whale shark and salmon, propelling themselves through water. You could also explore the movement of crustaceans, insects and animals, such as crabs, ants and rabbits. Allow the pupils to research these adaptations and methods of movement further.

Give each pair of pupils some time to use role-play to re-express themselves as nanobots. Encourage them to think about the challenges a nanobot would face in the human body. This can inform their creativity and help ensure that they are motivated to formulate ideas. Using this experience along with their research, they can then begin to agree the design features of their nanobot.

Allocate flip chart paper to each pair of pupils. Remind them that every idea is worthy of consideration.

Encourage the pupils to sketch all their ideas, including the more extreme ones, and annotate them.

Activity 4

Prototype Design

Explain to the pupils that they are going to decide on their final design. Remind them to consider the importance of the materials used in the production of a nanobot. **(Resource 4)** provides background information on materials used for nanobots.) Other important considerations include:

- function;
- safety;
- ergonomics; and
- aesthetics.

Provide time for the pupils to discuss and evaluate their ideas from the previous activity in pairs. Encourage them to agree on the strongest design ideas for their nanobot. Ask them to annotate their final design, justifying their decisions.

Allow each pair to complete their final drawing using formal drawing techniques or ICT tools, such as Computer Aided Design (CAD). Invite them to indicate the specification for their prototype, taking into account that they might make it from card, Styrofoam or other malleable materials. *Note: Pupils could use paper/cardboard engineering to produce their nanobot prototype. It also allows for the development of the Cross-Curricular Skill of Using Mathematics.*

Recap on geometric shapes used in mathematics, focusing on 3D shapes such as cubes, spheres and cuboids.

Demonstrate the relationship between 2D and 3D shapes by connecting up a 2D net of one of the shapes provided in **Resource 5**. Give the pupils time to experiment with the various shapes provided. Allow each pair to decide which nets would be most appropriate for *their* nanobot design. Encourage them to describe the 3D shapes in terms of faces, vertices and edges, responses should include:

	Vertices	Edges	Faces
Cylinder	0	2	3
Truncated Icosahedron	60	90	32
Sphere	0	0	1
Torpedo	0	0	1

In pairs, invite the pupils to use their final drawing and specification to develop their prototype.

NOTE: The nets of 3D shapes included in Resource 5 have been selected because they are suitable for the nanobot design task. Each resource sheet shows an example of the finished shape.

Activity 5

Nanobot Programming

Organise the pupils into their pairs, and provide them with a copy of **Resource 8**. Allow time for them to create their nanobot sprite by taking a digital image of their prototype design and incorporating it into Scratch. An image for the background sprite of the heart appears in **Resource 9**.

Then encourage the pupils to program their nanobot sprite to complete two different procedures within the heart graphic, taking care to observe the guidance in **Resource 8**. Remind them to test their program to ensure that it works correctly and modify it if necessary.

Where appropriate, you could encourage your pupils to add embellishments, such as additional sprites and extra programming scripts, to enhance their program's appearance. For example, they could draw or sketch a representation of the heart and scan or photograph it. Next, they could use a program such as Photoshop to create a digital image, then incorporate it into their program. Scratch is able to resize images to fit within the background dimension constraints.

NOTE: For this activity, the pupils use ICT to explore programming – in this case, Scratch software. For details of Scratch, see Resource 6. For details of a cardiac nanobot simulation that illustrates how Scratch can be used for this unit, see **Resource 7**.

Activity 6

Evaluation and Presentation

Pupils should evaluate both their prototype and their simulation with reference to the tasks provided with the design brief, noting reasons for their choices. Recap on the importance of the choice of material for production.

Afterwards, have each group present their design solutions, preferably to a real and relevant audience. You could request a link with a relevant STEM ambassador through the STEMNET initiative which is co-ordinated by W5. STEM ambassadors can act as role models and help inspire and engage young people about the value of STEM in their daily lives. For further information, please contact Mary Carson at W5 (marycarson@w5online.co.uk) or visit their website at www.w5online.co.uk/stemnet.

The pupils could make their pitch to their STEM Ambassador via video conferencing using the Elluminate software available through C2K. For advice and support to get started please contact the C2K Service Desk.

You may want to watch an episode of Dragons' Den as a class to provide them with an example of how to conduct a pitch, or, if possible, work in collaboration with the English Department to develop pupils' presentation pitches.

Increase the emphasis on STEM careers by providing time for pupils to research STEM career opportunities, including in the Health and Life Sciences sector. Resources are available within the 'Futures – Skills & Employability/CEIAG' section of the STEMWorks website at www.nicurriculum.org.uk/stem

As a class, discuss why they have used a computer program to accompany the design of their cardiac nanobot. Responses should include:

- a nanobot needs to be programmed precisely to navigate through the complex blood vessels and to administer drugs or carry out intricate surgery; and
- the simulation is based on leading research, and before scientists and engineers can manufacture a viable nanobot they need to trial prototypes until they are confident that the product is safe and fit for purpose. Simulations are an effective way of trialling new product designs.

Allow the pupils to engage in the following ethical discussion:

Life and death decisions that are made by unseen synthetic agents have far-reaching implications.

They could do this online in a virtual learning environment, such as Fronter. You could provide thought-provoking prompts, such as references to:

- the misuse of nanobot surgeons, including crimes such as murder; and
- the repercussions of the nanobot crossing the blood/brain barrier.

NOTE: **Resource 10** provides pupil stimulus material to support this whether a learning and teaching activity or as part of the STEM Futures: Straight to the Heart of it CCEA Pre-approved (Exemplar) assessment tasks for Using ICT and/or Communication.

Resource 1 (1 of 2)

Nanotechnology Cards

1 The typical human body contains 100,000 kilometres of blood vessels. That is equal to two and a half times the distance around the Earth.	**2** A nanobot moving through the bloodstream would face similar forces to a person swimming in treacle.
3 A nanometre is one billionth of a metre. There are about 7 billion people in the world; if each person was 1 nanometre wide and they all stood side by side, the line would be just seven metres long.	**4** A typical sheet of paper is over 100,000 nanometres thick.
5 If you were shrunk down to the nanometre scale, you would be able to see the atoms that make up different materials. You could also rearrange them like building blocks to make new materials.	**6** Nano is the ancient Greek word for dwarf.

Resource 1 (2 of 2)

Nanotechnology Cards

7

In the time it takes you to lift a comb to your head, your hair has grown one nanometre

8

Some new bandages contain nanoparticles of silver to promote healing and act as an antiseptic.

9

Nanobots have to be flexible and tiny enough to be able to travel around the veins and arteries of the human body. Design features must include the capability to carry medication/miniature tools.

10

Scientists and engineers need to consider what will happen to the nanobot once its task is complete. Things to consider include the materials used to make the nanobot.

11

A nanobot is a miniature, remote-controlled robot capable of propelling against the bloodstream in order to carry out medical treatment.

12

Nanotechnology is engineering at molecular level or, in other words, on a very small scale.

Resource 2

Straight to the Heart of It

Scenario

As product designers for university spin-out company VISION 20/20, you are exploring ways to take cardiac treatment to the next level. You are going to develop a medical nanobot. This nanobot will be capable of entering the bloodstream to clear built-up cholesterol from the arteries by delivering drugs to disperse fatty deposits on the artery walls. If successful, it will revolutionise the prevention and treatment of cardiovascular disease – ultimately saving lives and cutting healthcare costs.

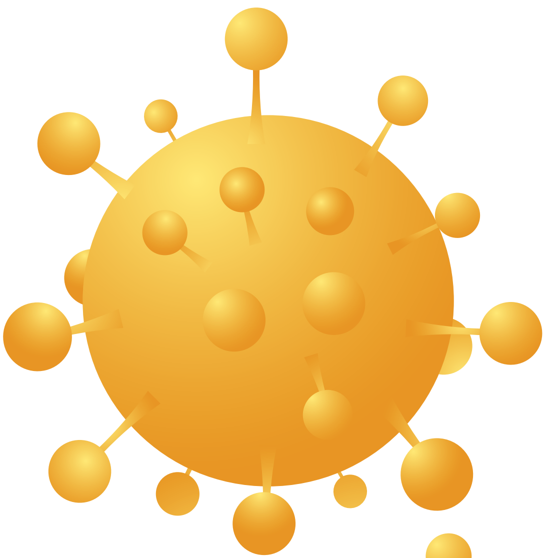
Resource 3

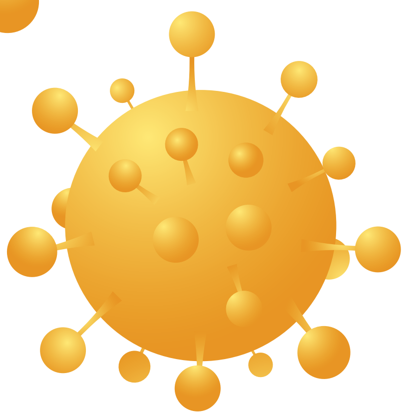
Design Brief

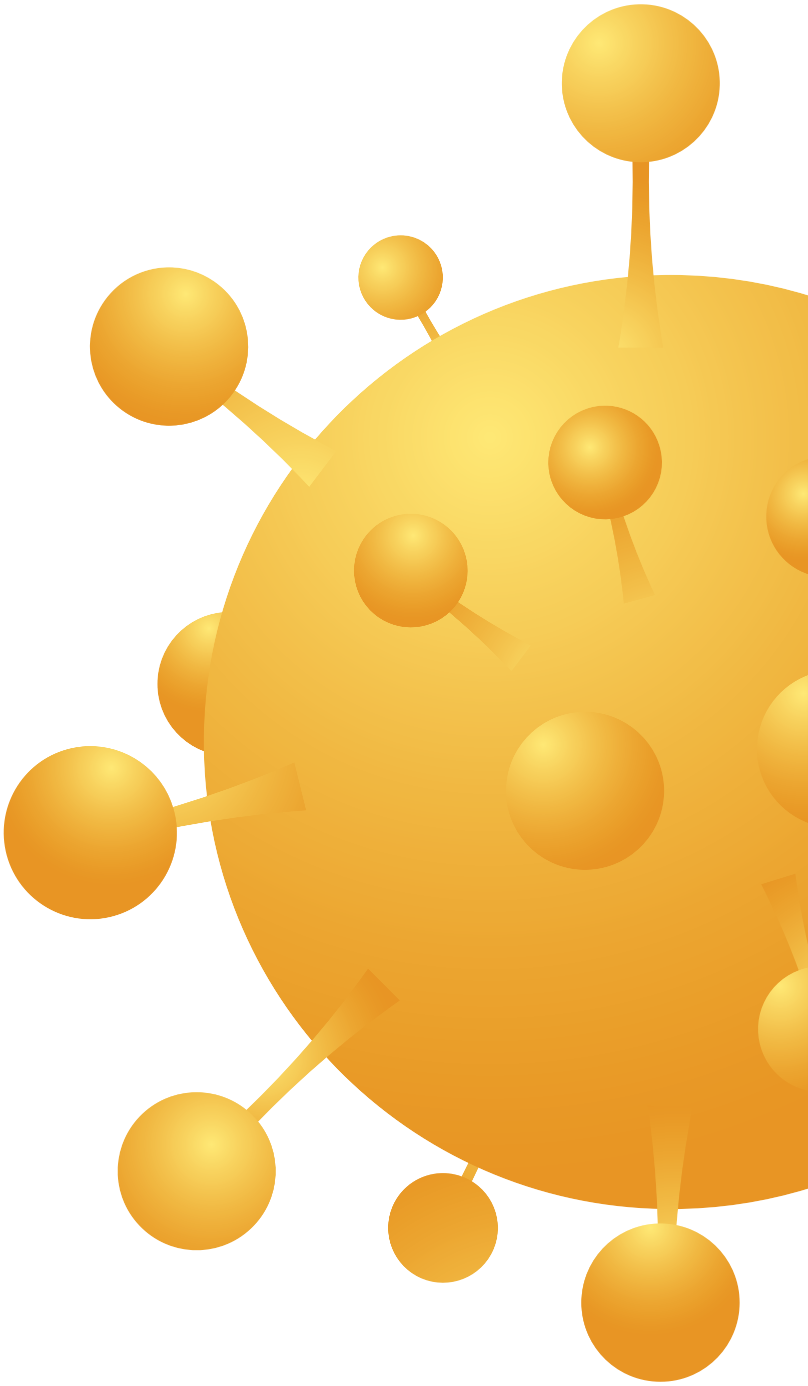
Design a prototype of a nanobot and a program that enables it to enter the bloodstream to clear built-up cholesterol and disperse drugs.

Your task is to:

- research information on the nanobot and understand its potential within medical science;
- experiment with ideas and arrive at an ergonomically pleasing prototype model for a nanobot;
- research and understand the materials that would be used to manufacture your idea;
- design a computer program to use with it; and
- evaluate your idea and present it to your peer group, considering how you could market it and advertise it to the medical industry.







Resource 4

Nanobot Manufacture
(Teacher's Notes)

Materials

Surgeons currently use stainless steel, titanium, silicone, glass and ceramics to provide external prosthetics and internal replacement parts for the human body because of their non-reaction with body chemistry.

The chosen materials can be coated in silver to provide protection and aid antiseptic qualities.

Internal Components

The nanobot is likely to be autonomous.

The most important element is the **power source**, used to power all of the systems in the nanobot. When deciding on an effective power source, the designers will need to look at the nanobot's ability to carry its own power supply as a battery or high capacity cell.

Alternatively, instead of a discrete power cell, the nanobot could employ induction power transfer:
While power is induced into special generators in the nanobot, it is active and performs its duty.
When the induced power is removed, the nanobot stops functioning.

A special coded power signature could allow the nanobot to be energised only inside a hospital or clinic area. This way, it would remain under the control of the surgeon or specialist.

The nano device will need to move within a fluid (the blood in the circulatory system). As well as navigating to the intended site for the procedure, it will need to remain there until its task is complete. **Propulsion** systems exist in the real world to promote 'station keeping' – that is, the ability to remain fixed in one place while the device struggles against the ebb and flow of the fluid in which it sits. The nano device may also require an anchoring system to grip the cell walls in order to perform its function, so it can conserve energy for other areas requiring treatment.

The designers must think about the method of propulsion, especially regarding possible damage to blood cells and other components of blood. See the Useful Websites section for some links about methods of propulsion through water.

The **control/processing unit** must be able to co-ordinate the whole system to deliver the correct procedure for the patient.

An **analysis unit** needs to be able to identify the bad cholesterol from the good cholesterol, as well as identifying plaque build-up in blood vessels and administering the correct dose of a medication where it can be most effective.

There will also need to be separate devices for **medication** and **surgery.**

Scale Model Sizes

The following discussion refers to units of measurement smaller than the millimetre (mm):
The micrometre (μm) is one thousandth of a millimetre (1000 μm = 1 mm).

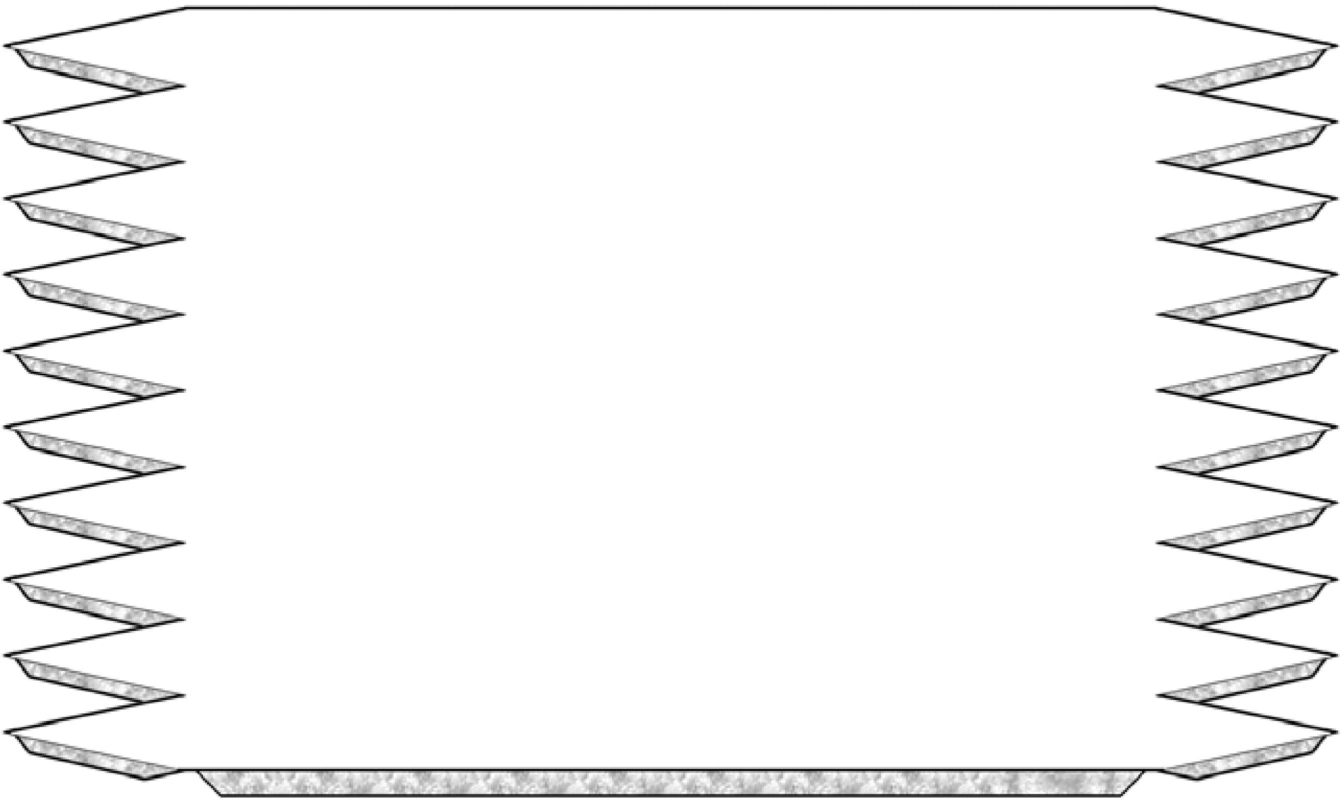
The smallest blood vessels in the human body are the capillaries, typically 7–10 micrometres in diameter. To illustrate this for your pupils, it would be possible to fit about 100 of our nanobots across the diameter of a capillary.

The nanobot itself would be over 400 atoms wide, 600 atoms long and up to 600 atoms high. If each atom was one millimetre cubed, the scaled size of the nanobot would be about the same volume as a kitchen cupboard or a small fridge.

The 2D nets of 3D shapes in the resources section have been designed so that pupils might, if they choose to, incorporate moveable parts to simulate the procedures that their nanobot might carry out.

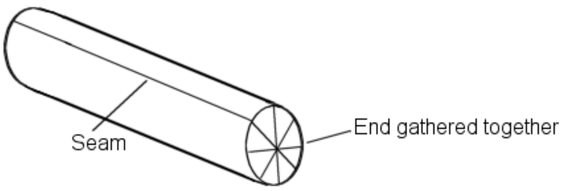
Cylinder

Enlarge image to fit A3 paper



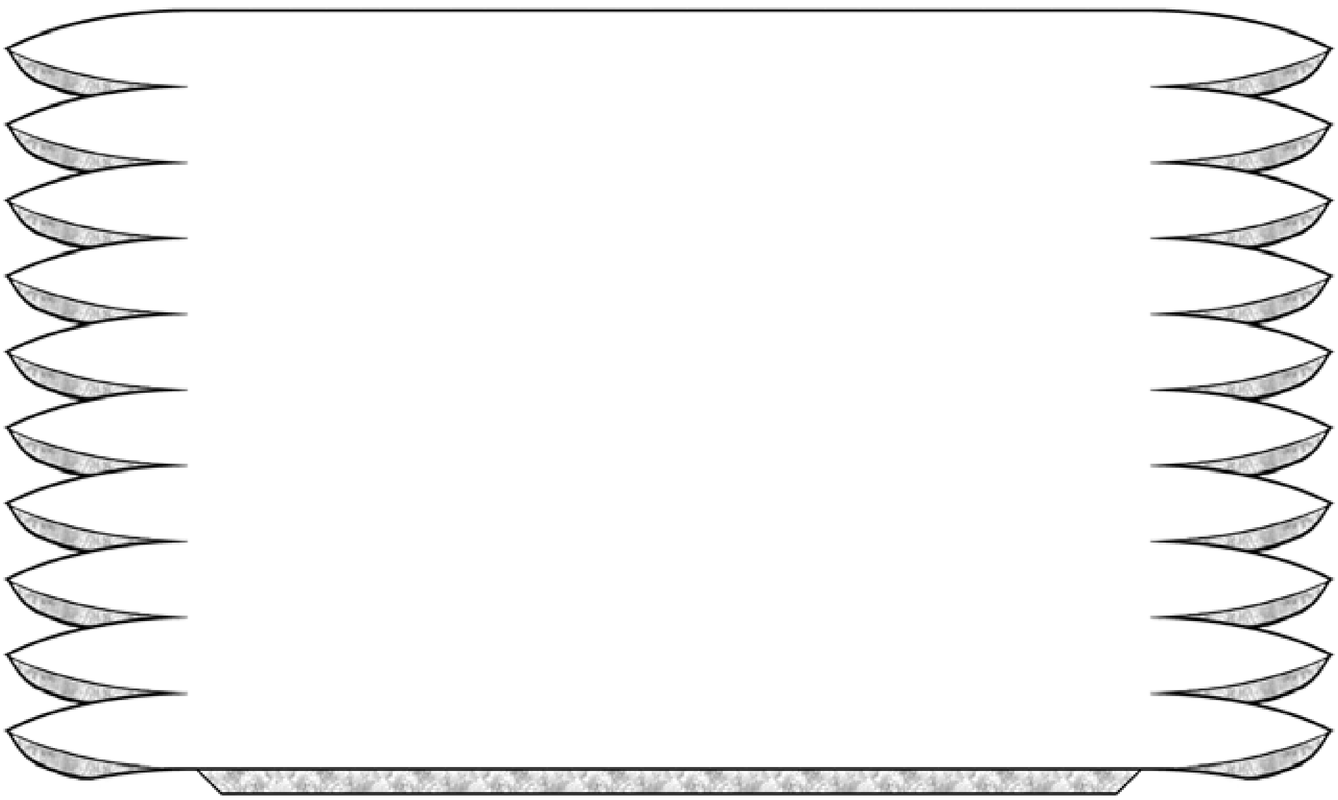
- Where there are cloudy grey panels, apply a suitable glue or some double-sided tape.
- Cut out the whole shape, paying attention to the paper 'fingers' at the top.
- ONLY cut along the THICK black lines, the cloudy panels are tabs to help you shape the nose.
- Roll the paper and use glue or double-sided tape to make a tube first.
- Once the tube is formed and secure, glue or tape the cloudy panels under the neighbouring finger.
- The ends should be flat like a piece of cut dowel.

Finished Example



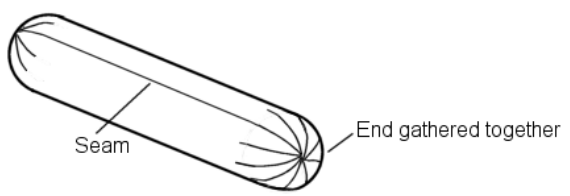
Torpedo

Enlarge image to fit A3 paper



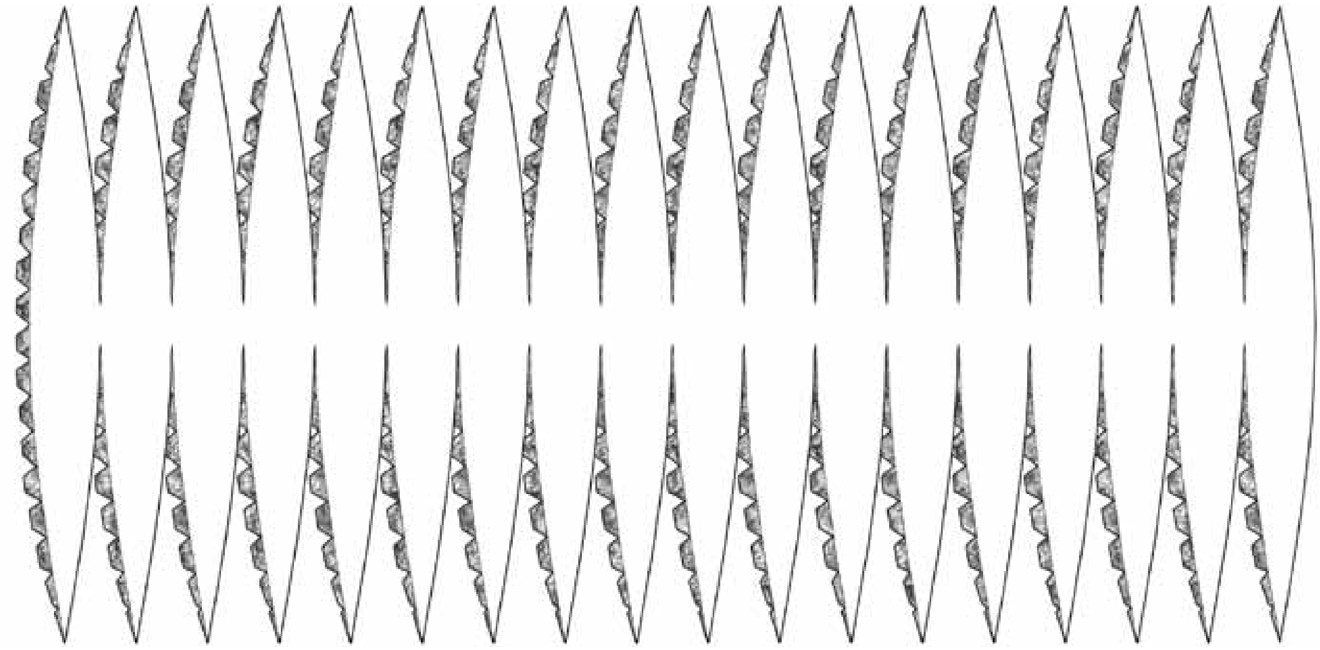
- Where there are cloudy grey panels, apply a suitable glue or some double-sided tape.
- Cut out the whole shape, paying attention to the paper 'fingers' at the top.
- ONLY cut along the THICK black lines, the cloudy panels are tabs to help you shape the nose.
- Roll the paper and use glue or double-sided tape to make a tube first.
- Once the tube is formed and secure, glue or tape the cloudy panels under the neighbouring finger.
- A curve should form which will round the ends to look like a torpedo.

Finished Example



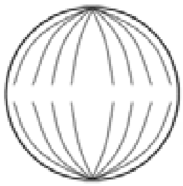
Sphere

Enlarge image to fit A3 paper



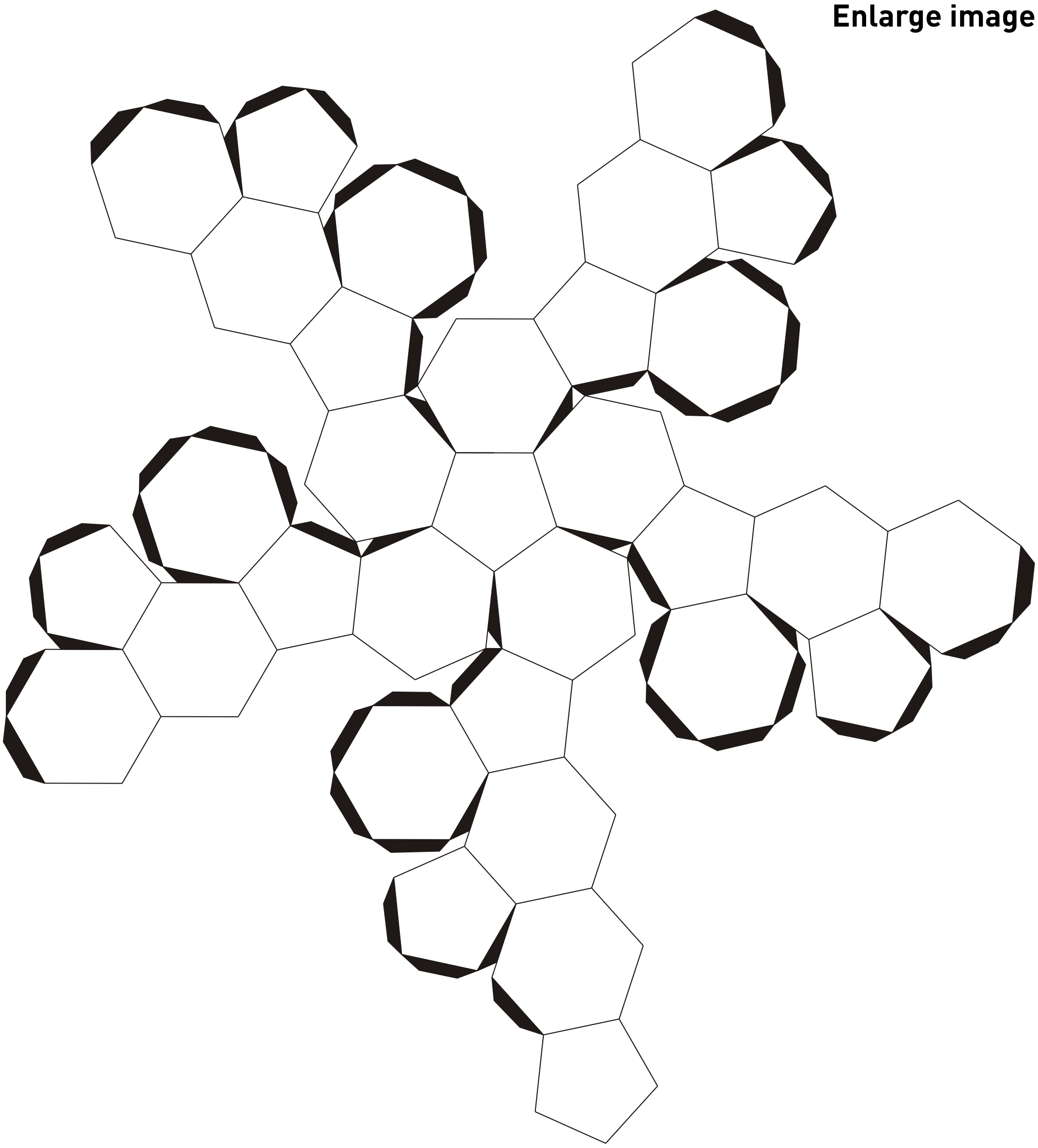
- Where there are cloudy grey panels, apply a suitable glue or some double-sided tape.
- Cut out the whole shape, paying attention to the thin black lines and thick black lines.
- ONLY cut along the THICK black lines, the cloudy panels are tabs to help you glue the paper or card into shape.
- Carefully stick the tabs in behind the paper and as the pieces stick, they will take the shape of the curve.

Finished Example



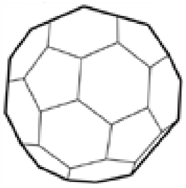
Truncated Icosahedron

Enlarge image to fit A3 paper



- Where there are cloudy grey panels, apply a suitable glue or some double-sided tape.
- Cut out the whole shape, paying attention to the thin black lines and thick black lines
- ONLY cut along the THICK black lines, the cloudy panels are tabs to help you glue the paper or card into shape.
- You need six (6) copies of this outline to complete a full spherical model with 30 sides.

Finished Example



Resource 6

Using Scratch Software
(Teacher's Notes)

Scratch is available on the c2k system.
To access support documents including, a 'Getting Started' guide, video tutorials and pupil resources go to: http://scratch.mit.edu/; and click on support.

Alternatively, you can access the support materials from:
http://www.ccea.org.uk/primary_ict_accreditation/
click on Technical Support; and scroll down to Scratch.

Resource 7

Example of a Completed Nanobot v1 Program (Teacher's Notes)

For an example of a completed cardiac nanobot program developed for this unit, seehttp://scratch.mit.edu/projects/Matchstalkman/1363344 and http://scratch.mit.edu/projects/procedurewriter/2765129

This program presents a background graphic showing the four chambers of the heart. Blue arrows indicate the flow of de-oxygenated blood, and red arrows indicate the flow of oxygenated blood.

Written labels identify the sources and destinations of the blood flow.

During the program, the steady, rhythmic beat of a heart can be heard. (For their own programs, encourage your pupils to create their own sound effect or download a royalty-free sound effect.)

The nanobot is a small, grey disc in the bottom left corner of the screen.

A blinking red lamp indicates that the nanobot is awaiting instructions.

A solid yellow lamp indicates that the nanobot is administering medication.

A solid green lamp indicates that the nanobot is administering surgery.

Visual prompts indicate the status of the two procedures.

The control keys for this program are E, H, P and S:

- **E**nergise nanobot to begin its procedures
- **H**eart muscle medication injection
- **P**roceed to next location
- **S**urgically repair the heart.

The operator presses these four keys to interact with the program and cause the nanobot to move around the heart chambers.

You can reset the program at any time by clicking on the red octagon, then clicking on the green flag in the top right corner of the screen.

Resource 8

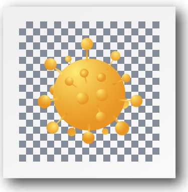
Cardiac Nanobot Simulation Brief

Guidance:

- Create a background sprite to represent the heart and its structures. **(You may create your own, copy or use the graphic shown in Resource 9.)**
- Create a nanobot sprite, based on your own design, to carry out your program instructions (see below*).
- Write a program to cause your nanobot to perform two procedures within the heart graphic:
  - administration of a medication to an area of the heart; and
  - surgery to repair a damaged part of the heart.

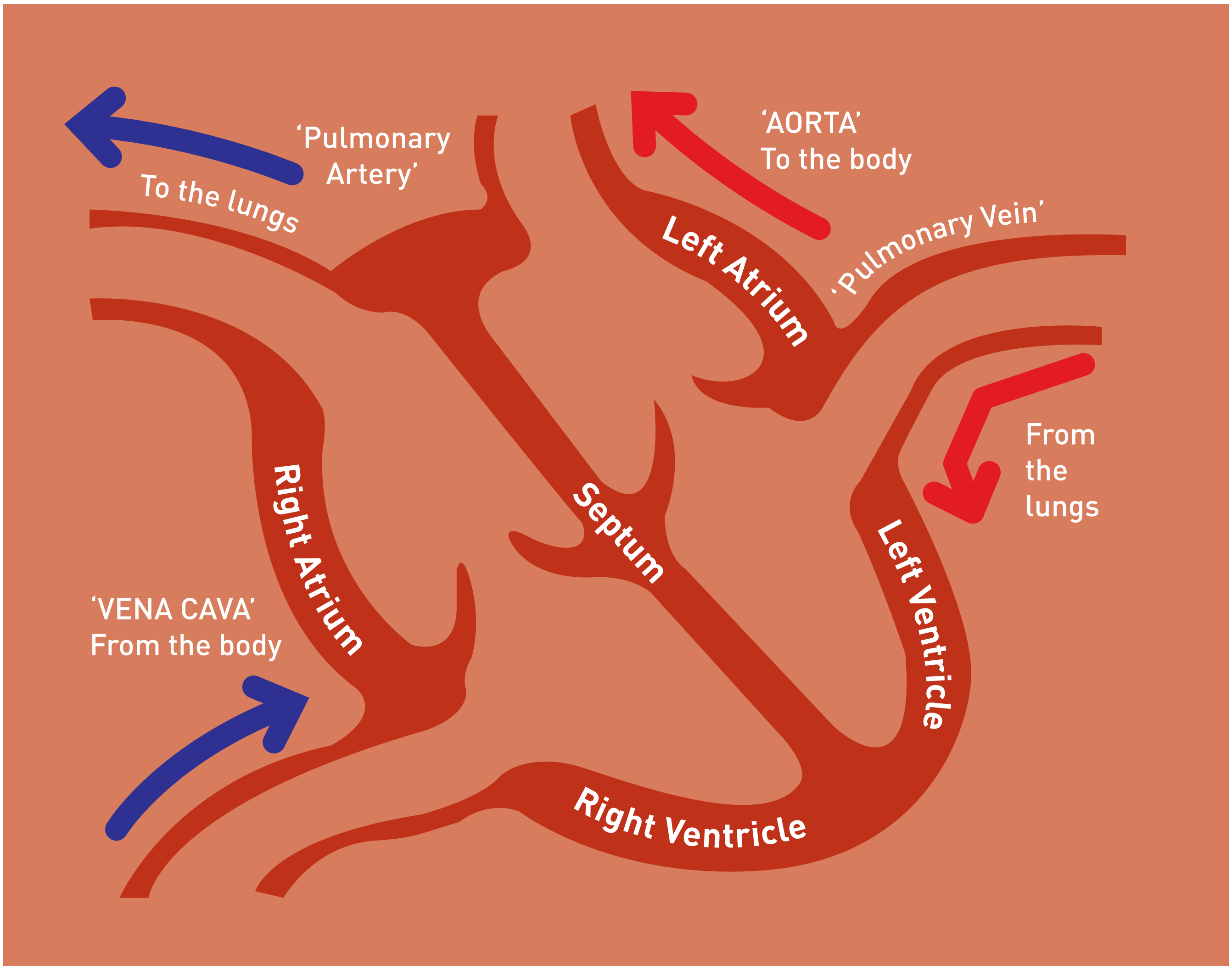
Note that the nanobot must simulate movement through the circulatory system of the heart without crossing any muscle walls or membranes.

Your program should include some visual indication to show the procedures have been successful.

*Creating a Sprite from Your Nanobot Design	
	Open a digital image of your nanobot design in Photoshop or another image editing program.
	Remove all of the pixels surrounding your nanobot, and crop the image so that only your nanobot remains.
	Resize the image so that it is 25 pixels wide by 25 pixels tall. Save this image with a new name as a JPEG or PNG file.
	You can also import your image into Scratch and edit it there, then save it as a sprite. Use the eraser tool to remove all of the pixels that you do not want in the final sprite. (This may mean removing the pixels between parts of your design.) When you save the new sprite, these areas will be transparent against the background graphic.

Resource 9

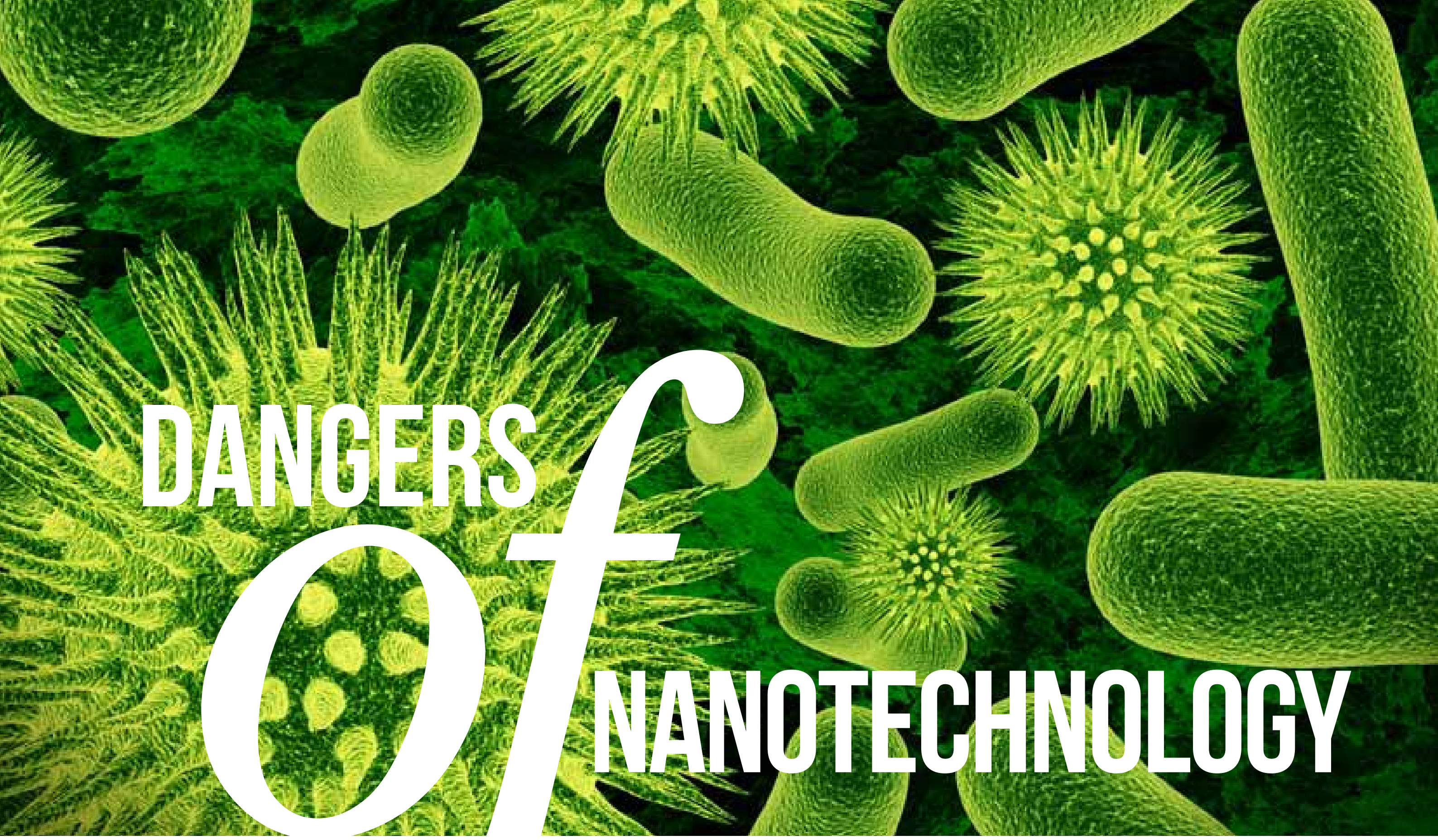
Heart Sprite Background Graphic



You can also download this as a PNG or BMP image suitable for use in Scratch from our website at www.nicurriculum.org.uk/stem

Resource 10

Pupil Stimulus Material



DANGERS *of* NANOTECHNOLOGY

There are two ways that scientists have shown how it will be possible to make nanoscale machines. One is by making molecules that copy themselves. The other is to use a scanning tunnelling electron microscope to move individual atoms to make new molecules designed to do work.

This is a bit like the way DNA works – the group of atoms that together make up the molecule are arranged on the surface of one that already exists, and so the structure 'grows'. Elements such as carbon can be manipulated to make molecules of this sort. Individual atoms of carbon are joined like Lego bricks to make larger shapes. Microscopic tubes, wheels and cogs can be made like this, which in turn can be made into nanorobots or nanobots for short. It would be possible to control the nanobots to work on individual cells in the human body.

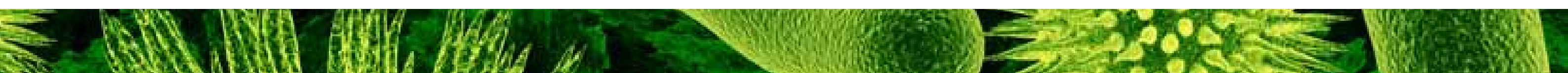
The possibilities of using nanobots to treat diseases include being able to target individual cells. In this way cancer cells could be destroyed and tiny doses of drugs delivered to exactly where it is needed in the body. It might even be possible to use such tiny machines to scrape away fatty deposits from inside arteries. This would be a revolutionary treatment for heart disease.

There are fears that this sort of technology could also be used with bad intention. If nanobots can be used to change human cells, they could be made to work like a new disease instead of the cure for a disease.

> **If terrorists got control of nanotechnology, they might be able to use it to cause harm.**

It might even be possible to change cells so that a person could be made to grow bigger or stronger – a bit like the use of performance-enhancing drugs in sport. Apart from cheating in sporting events, nanotechnology could be used to make changes to the body such as creating super soldiers. These inventions may seem far-fetched, but scientists know that they are theoretically possible. Governments and other organisations that regulate science are concerned about new developments in nanotechnology. Although there are many benefits promised by nanotechnology, there are also dangers.

Just as advances in science could lead to a situation where parents can choose whether their baby will be a boy or a girl, people are worried about whether this is right or wrong. Nanotechnology may be powerful enough for scientists to genetically modify humans. Because it is capable of achieving so much, scientists want the use of nanotechnology to be carefully controlled.



Dr Sarah Jones

Interview with Dr Sarah Jones, a researcher working on nanobots at Massachusetts Institute of Technology (MIT)

Q. What are you working on Dr Jones?

A. *My work is concerned with making tiny medical instruments that can be injected into the body.*

Q. Are we talking about nanotechnology here?

A. *That's right. We're working on making robots at a microscopic scale.*

Q. What will these nanobots be used for?

A. *At the moment we hope to develop a nanobot that can be used to break up cholesterol deposits in the arteries around the heart.*

Q. What are the difficulties in making a nanobot to do that?

A. *Well, first is the problem of making a robot small enough, and then making it move through the body.*

Q. How do you plan to do that?

A. *We are considering two ways of moving the nanobot about. One is to control it from outside the body using a device like a magnetic resonance imaging scanner (MRI scanner). Hospitals already have these, and we think they could be used to drive the nanobot very precisely towards the arteries close to the heart.*

Q. What is the other way you are considering?

A. *It is some way off yet, but we are experimenting with a version of a carbon nanotube to make a sort of propeller.*

Q. What is a carbon nanotube?

A. *A carbon nanotube is a group of carbon atoms joined in a ring, the ring can be built up to form a tube. The tube is only a few nanometres across.*

Q. How does it work as a propeller?

A. *It's like the spiral tail or flagellum which some bacteria have. You've heard of E. coli bacteria?*

Q. Yes, it's the one that is involved in some sorts of food poisoning?

A. *That's right. Some bacteria of that sort are able to move by wiggling a long tail. A bit like an eel swimming. We can create the effect of a propeller by making a carbon nanotube rotate. We build the tube with a twist. If we can attach the twisted tube as a tail to the base of the nanobot, then turn the tube, it will rotate – creating forward motion by displacing liquid. In this case the liquid is blood serum. It's really the same thing as kicking your legs when you swim.*

Q. How do you make the tube rotate?

A. *It needs two things, a wheel, and energy to make the wheel turn. Wheels can be constructed at the molecular level just like the carbon nano-tube. And the carbon nanotube is attached to the wheel.*

Q. What about the energy to turn the wheel? Where does that come from?

A. *We think that a small amount of chemical fuel can be built into the nanobot. This would react with liquid in the blood and release energy.*

Q. So the nanobot has a tiny motor?

A. *A sort of pump, yes. The challenge then becomes one of steering the nanobot to where we want it to go.*

Q. How long until we see this kind of technology used to treat heart disease?

A. *A few years. We've already solved most of the engineering problems – we can make a device at this scale. We have shown how we can get it into the body, and how to steer it to the site of the disease. There are still some safety concerns about how to get the nanobots back out of the patient after the treatment.*

Q. Are there any other safety concerns?

A. *Yes, a few. Very small particles can be toxic – think about how some kinds of dust affect the lungs.*

Q. And nanoparticles are even smaller than dust.

A. *That's right – many times smaller – dust can be seen by the naked eye. A nanoparticle can only be seen using a microscope. Most medical labs use very efficient air filtering to avoid bacterial contamination, but some nanoscale materials would be too small to be caught by filters.*

Q. So there is a danger if nanoparticles were to become airborne?

A. *Yes, we don't know exactly what would happen if nanoparticles were breathed in, but almost certainly they would be a serious health risk.*

Q. What are you doing to prevent the risk?

A. *All nanotechnology developments are very tightly controlled, and we follow the safety guidelines to the letter.*

REPORT

Report on the future development of nanotechnology in modern medicine

A nanometre is one billionth of a metre. A human hair is about 60 000 nanometres across. The prefix 'nano' means very small. The term nanotechnology refers to making objects as small as individual molecules. This technology is still being developed, although scientists have succeeded in making moving parts so small that they could be used to make microscopic machines. For example, a carbon nanotube can contain a chemical reaction capable of moving the tube forwards by producing thrust like a pump. In this way it is possible to make an engine small enough to travel inside a human cell.

Medicine

These inventions are of particular interest in medicine. Machines like this, so small that they could be injected into the bloodstream, could be used to treat diseases such as heart disease and cancer. A nanorobot or nanobot could be loaded with a drug and programmed to reach a cancer cell, deliver the drug and so destroy the cancer.

Side effects

Although it looks as if it will be possible to treat cancer and other illnesses using nanobots, this is still some way in the future. Even if scientists succeed in making medical nanobots, there are fears that the technology could have serious side effects. Apart from anything else, nanoparticles are so small that they may be toxic to humans in ways that are not clearly understood.

Treating a brain tumour

One form of cancer that is particularly difficult for doctors to treat is a brain tumour. Other tumours are often effectively treated using chemotherapy drugs. These drugs travel in the blood to reach the cancerous cells and destroy them. However, it is difficult to get drugs to work inside the brain because the brain is protected by the blood-brain barrier.

The blood-brain barrier

We have a blood-brain barrier because it is a protection against infection. The membranes of blood vessels in the brain don't allow larger molecules to pass through. This prevents things like bacteria from getting in and causing infection in the brain. Because of the blood-brain barrier, brain infections are rare. But when they do happen, like meningitis, they are very serious. The blood-brain barrier also means that drugs used to treat cancer are prevented from crossing from the blood vessels into the brain. This makes a brain tumour very hard to treat using anti-cancer drugs that work elsewhere in the body. Nanobots would be small enough that they could pass through the blood-brain barrier and deliver anti-cancer drug treatment inside the brain. Although this could be a life-saving treatment, it is not clear if there would be side effects that could cause other damage once the nanobots had done their job, but stayed in the brain of the patient.

Science and Technology Today
magazine

In this issue:

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Nanobots:
Healthcare workers of tomorrow?

New Treatments for Heart Disease and Cancer on the Horizon?

It is now a well-known fact that people in the Western industrialised nations are likely to be affected by the so-called 'diseases of civilisation' such as cancer and cardiovascular disease (heart problems). What if there was a single medical solution to these problems? That is what is promised by the development of revolutionary new technology. Using this technology, microscopic 'nano-scale' devices can deliver medicines so precisely that individual human cells can be treated.

Nanobots

The idea of the nanorobot or nanobot is an offshoot of nanotechnology. A nanobot is a miniature machine capable of being programmed to carry a dose of medicine to exactly where it is needed in the body. Nanobots are made in a similar way to building the wafers of silicon used in the manufacture of computer chips. Individual molecules are combined in a controlled environment to construct a tiny machine. The machines might also be capable of replicating. In other words, the machines may be able to build copies of themselves and carry out specific actions. In this way nanobots could be designed specifically to be injected into the bloodstream of a cancer patient, to carry a dose of anti-cancer drug directly to the cancer cell.

Trial Cancer Treatments

Some trials have already taken place that show how this kind of cancer therapy might work. Doctors have inserted carbon nanotubes inside cancer cells and then heated the tubes using infrared radiation, killing the cell. If a nanorobot could do this inside the body of a patient it would be many times more effective than ordinary chemotherapy treatments. It might also have fewer side effects. Nanobots could be the way forward for the treatment of many of the commonest and most life-threatening diseases.

Heart Disease

Another candidate for Nanobot treatment is heart disease. Here, microscopic machines could be sent into the arteries to scrape away the accumulations of fatty deposits. It is the build-up of fatty plaques in the arteries that limits blood flow and can cause heart attacks. Around the world many groups of scientists are close to making the breakthroughs that will lead to nanorobot medical treatments. They could become a standard means of treatment rather than surgery or expensive drugs. Nanotechnology could see big advances in the treatment of many conditions as well as heart disease and cancer.

Other Medical Conditions

Nanobots could be used to investigate the causes of various diseases by obtaining information from inside the body – like using x-rays or other forms of medical scanning. They could also be used to treat all kinds of conditions such as haemophilia where the blood does not clot properly, asthma, and allergies. Nanobots could be used to clean wounds, break up blood clots or use a small laser to break up kidney stones. They could also be an effective treatment to destroy parasites that cause diseases like malaria, sleeping sickness and Lyme disease.

Scratch Safety Guidance
(Teacher's Briefing Sheet)

NOTE: Includes some pointers that teachers may decide to share with pupils.

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- from many different countries and cultures
- from many different schools in Northern Ireland
- of all ages (from young children to adults)
- with all levels of experience with ICT

We need your help to make this community a safe, enjoyable and supportive place for every member. Here's how you can help:

- **Be respectful.** When sharing projects or posting comments, remember that many people of different ages and backgrounds will see your contributions.
- **Offer constructive comments.** It is good to comment on Scratch projects you see. Always say positive things and offer suggestions on how to make it better.
- **Give credit.** Feel free to make modified versions of other people's Scratch projects that you like - just make sure to give them credit. One place to give credit is in your Project Notes.
- **Be honest.** Don't pretend to be someone else within the Scratch community.
- **Keep personal information private.** Don't share your full name, home address, email address, phone number, or other personal contact information. Never upload a photograph of yourself.
- **Help keep the site friendly.** If you feel others would find a project or comment mean, insulting, too violent, or otherwise inappropriate, click the link that says "flag as inappropriate."

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- You will not be asked for your name, phone number, or home address. Do not put any personal details into Scratch. Follow these THINK guidelines:
- **T**ell your Teacher, Mum or Dad if you see something online that upsets you, or if someone makes you feel unhappy.
- **H**ide your password. Never share it with your friends. Someone else could go online pretending to be you and do something that could get you into trouble.
- **I**nteresting websites can be fun. Check with your teacher if a site is okay to use before you visit. Sometimes they can set up a good list of sites just for you.
- Be **N**ice to people you talk to on the internet or phone. Name calling or being mean is not cool. Look out for yourself and for others.
- **K**eep your special personal information safe. Never give your real name, address or phone number to anyone online. Use a nickname in Scratch forums or when you play games on the computer and never put your photograph online..

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Research

Some of the information and data collected on the Scratch website may be used in research studies intended to understand and improve people's experiences by Scratch. The results of this research are shared with educators and researchers through conferences, journals, and other publications.

Useful Websites

These links were active at the time of publishing.

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Nanobots and Nanotechnology

http://electronics.howstuffworks.com/nanorobot.htm/printable
www.explainthatstuff.com/nanotechnologyforkids.html

Exploring Movement

Robofish
http://news.bbc.co.uk/1/hi/wales/north_west/8690083.stm
www.technologyreview.com/computing/23659/?a=f

How Personal Watercraft Work (How does a jet ski work?)

http://adventure.howstuffworks.com/outdoor-activities/water-sports/personal-watercraft1.htm

How Cruise Ships Work (What does a ship's propeller do? What are azimuth thrusters?)

http://adventure.howstuffworks.com/cruise-ship3.htm

Nanotechnology and Health

US National Cancer Institute
http://nano.cancer.gov

Nanotechnology Kills Cancer Cells

http://news.bbc.co.uk/1/hi/health/4734507.stm

Benefits of Nanotechnology in Cardiovascular Surgery

www.touchcardiology.com/articles/benefits-nanotechnology-cardiovascular-surgery-a-review-potential-applications

Nanotechnology Shows Early Promise to Treat Cardiovascular Disease

www.sciencedaily.com/releases/2006/05/060510232337.htm

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