Key Stage 5 – Microscopy matters

Pupil worksheet

Professor Sherrington

Sir Charles Sherrington (1857 – 1952) was Professor of Physiology at the University of Oxford. He described many of the basic reflex arcs, named the small gap between neurons 'synapses' and in 1932 he was jointly awarded the Nobel Prize in Physiology or Medicine for his discoveries regarding the functions of neurons.

His box of wonders

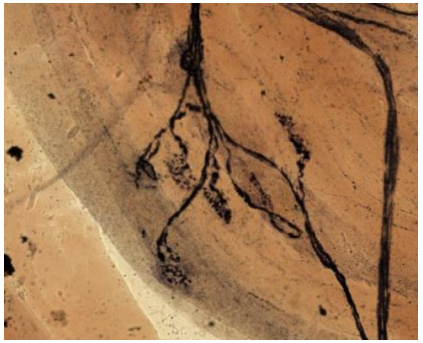
This wooden box was recently found hidden away in Physiology Department at the University of Oxford. It contains 21 drawers of expertly made specimens mounted on glass microscope slides. They are of various tissues, including nerves and other parts of the nervous system. Some of the slides are Sherrington's own work, and some are from colleagues, students or from collaborators.

These are the very slides that Sherrington used in his research in order to make his important discoveries.

http://www.oxfordsparks.net/video/youve-got-nerve

Why microscopes matter

Without the light microscope Sherrington would not have been able to make the majority of his discoveries.



One of Sherrington's slides showing neuromuscular junctions in cat muscle

Microscopes are useful biological tools. Most living organisms are too small to be seen by the naked eye and individual cells and their organelles can only be studied by using a microscope. Electron microscopes allow us to study viruses and even individual atoms.

A microscope is only useful if it allows us to increase the level of detail that can be seen. Microscopes have the ability to magnify and also to increase resolution - but what do these terms actually mean?

Your task

You are going to be doing some activities looking at resolution and magnification. By the end you will be able to explain the difference between these terms.

What to do

1. Work in a small group of 2-3.
2. Visit your first station, your teacher will tell you which one. Follow the instructions on the briefing sheet there.
3. When you have completed the task, turn over the answer sheet and check your understanding of what you have just done. If you made any mistakes, correct them.

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Activity 1 - Using a light microscope

Briefing sheet

1. Use the microscope to view the specimen slide at two different magnifications.

2. Draw what you can see and write down the total magnification.

3. Discuss in your group how your observation of the specimen changes as you increase the magnification.

Activity 1 - Using a light microscope

Answer sheet

The total magnification used can be calculated by multiplying the magnification of the eyepiece lens (normally 10x) by the magnification of the objective lens used.

So, if an objective lens of 50x is used the total magnification used is 500x. This means that the specimen appears to be 500 times bigger than its actual size - increasing the magnification increases the apparent size of the specimen.

It also increases the amount you can see. For example, if you look at a sample of cells under a microscope at low magnification you can just see the shape of the cells but at a higher magnification you can see the nucleus.

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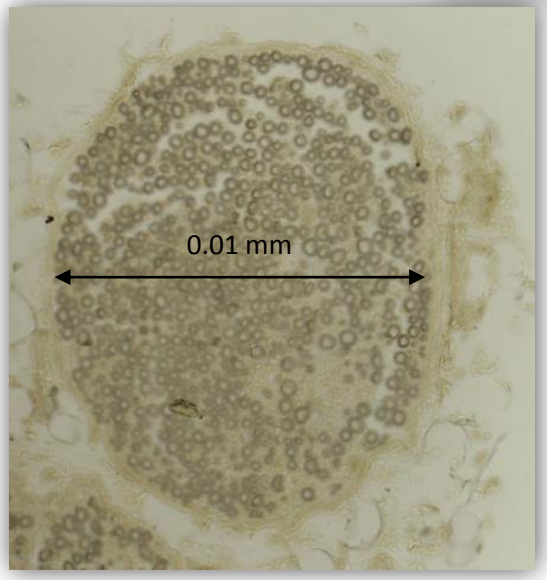
Activity 2 - How wide is a neuron?

Briefing sheet

In the 'You've got a nerve' video you saw one of Sherrington's slides of nerve cross-sections.



If the width of a nerve is 0.01 mm use the magnified image below to work out:

1. The magnification of the image
2. The diameter of the axon of an individual neuron.

Activity 2 - How wide is a neuron?

Answer sheet

The work these calculations out you will need to use the formula:

Image size = actual size x magnification

1. In the image the width of the nerve is 5 cm = 50 mm.
   The actual width is 0.01 mm
   Therefore, the magnification = 50/0.01 = **5000x**

2. In the image the diameter of one neuron axon is approximately 1 mm.
   So, the actual diameter = 1/5000 = **0.002 mm or 0.2 µm**
   (1000 µm = 1 mm)

Note: you can see from the image that the diameter of all neuron axons are not the same.

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Activity 3 - Time for your close-up

Briefing sheet

Charles Sherrington's box contains slides of different tissues including the blood.

Blood can be studied under the microscope by creating a blood smear slide.

1. Go to http://upload.wikimedia.org/wikipedia/commons/1/10/Blood_smear_unstained.jpg to see an example of a blood smear slide.
   Quick link: goo.gl/6FJ1mS

2. Magnify this image by zooming in on it (press Ctrl and + on the keyboard)

3. Now, view one of Sherrington's blood smear slides by going to https://cslide.medsci.ox.ac.uk/items/view/92
   Quick link: goo.gl/gwehhN

4. Use the 'zoomify' function to magnify this image.

5. In your group discuss the differences between the two zooming functions. Can you explain why this is?

Activity 3 - Time for your close-up

Answer sheet

When you zoomed into the blood smear image all your were doing was **magnifying** the image. Rather than see more detail, such as the individual blood cells, the image got more and more blurry. It would be pointless if this is all a microscope did!

However, when you zoomed into the Sherrington slide you will have noticed that the detail of the image increased as well as the magnification. This is because the slide was scanned by a machine called a Nanozoomer which takes high **resolution** images like a microscope.

Microscopes are able to increase resolution so we can see more detail. However, they have a limit. If you were to magnify Sherrington's slide any further you wouldn't be able to see any more detail and the image would appear blurry.

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Activity 4 - Tricking your eyes

Briefing sheet

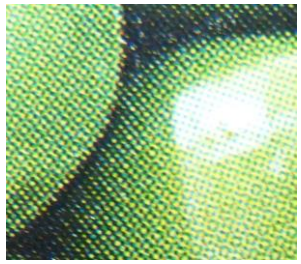
1. Take a look at the image on the magazine page using just your eyes.

2. Now, use a hand lens to magnify the image. What makes up the image?

3. Discuss what you see. How are our eyes tricked into seeing a solid image?

Activity 4 - Tricking your eyes

Answer sheet



Printed images are made up of lots of tiny dots of ink. When we view them we cannot see the individual dots and the image looks like solid colour.

This is because if two small objects are less than 0.1 mm apart our eyes see them as one - we can't tell them apart or **resolve** them. We say that the **resolving power** of our eyes is 0.1 mm.

A hand lens has a larger resolving power so when you view the image using one you can see that the dots are actually separate objects.

Magnifying devices increase the amount of detail that we can see. Another word for the level of detail we can see is **resolution**.

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Activity 5 - An idea of scale

Briefing sheet

When talking about microscopic objects it can be very difficult to visualise just how small they are.

The Scale of the Universe (htwins.net/scale2/) is an online animation which allows you to zoom in and out and study objects of different sizes. If you click on an object it will give you more information including its size.

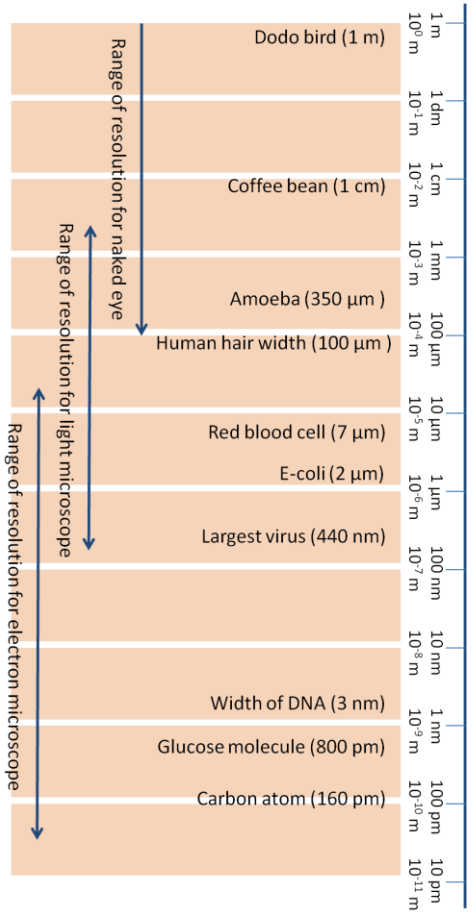
1. Use the animation to help you to add the following to the 'an ideal of scale' number line:

Dodo bird	E-coli (this has been done for you)
Coffee bean	Largest virus
Amoeba	Width of DNA
Width of human hair	Glucose molecule
Red blood cell	Carbon atom

2. The largest sized object a light (optical) microscope can resolve is around 5 mm. The largest sized object an electron microscope can resolve is around 40 µm. Use this information and that from the animation to add ranges of resolution for the naked eye, light microscope and electron microscope.

Activity 5 - An idea of scale

Answer sheet



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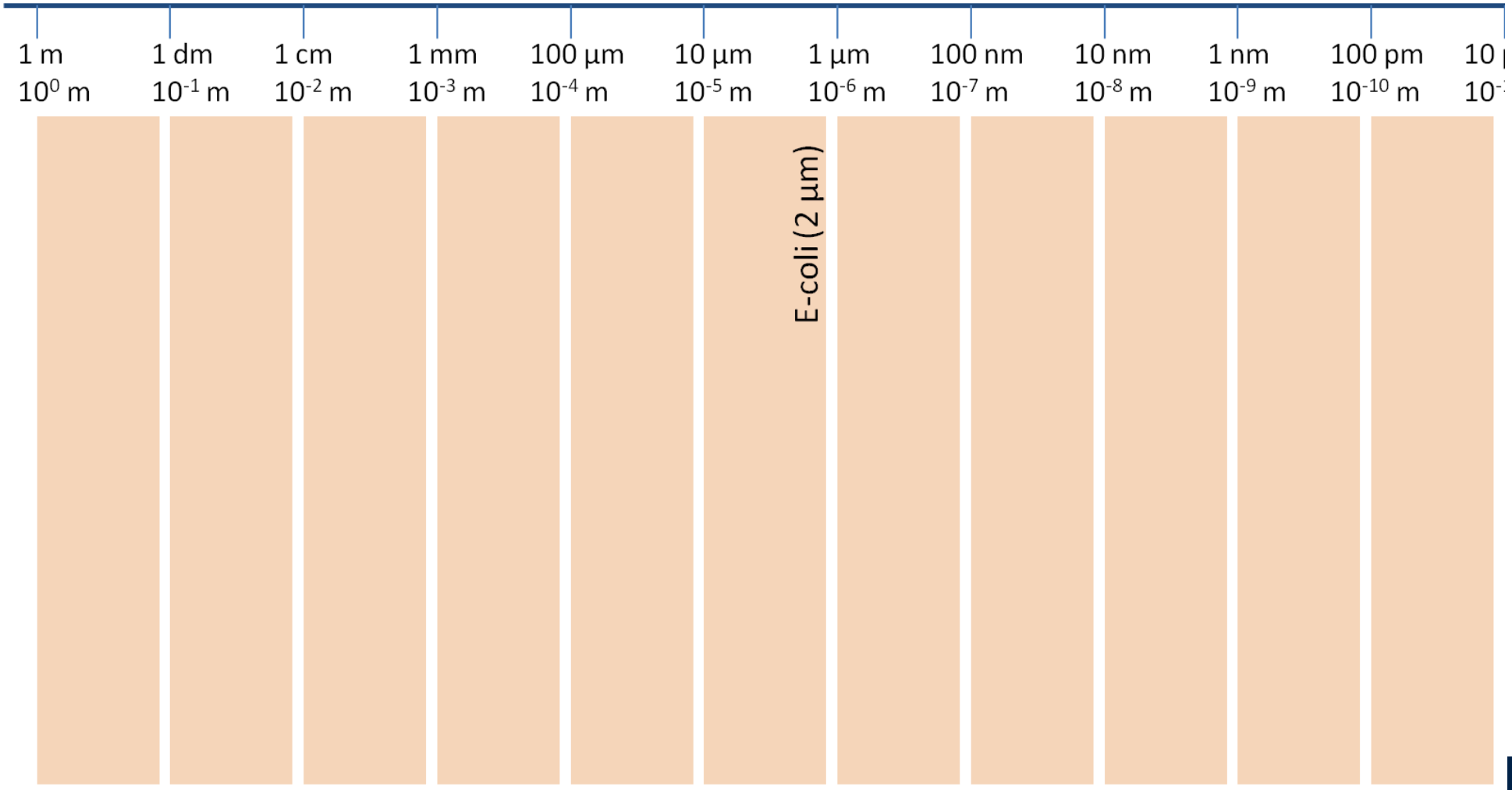
An idea of scale number line



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Activity 6 - Satellite resolution

Briefing sheet

Google Earth allows you to zoom in and explore areas of the Earth. The images used to compile it were taken by a range of different satellites from their orbit around 700 km above the ground.

1. Go to Google maps (www.google.co.uk/maps) and click on 'Earth' (bottom left corner). Into the search bar type in the coordinates 36.949253, -122.065389.

2. Zoom in as far as you can. What do you see?

3. Now, travel to 77 Water Steet, New York. What's on the roof?

4. In your groups discuss what you think would happen to the image if you could keep zooming in. Why would this happen?

Activity 6 - Satellite resolution

Answer sheet

If you could keep on zooming in, at a certain point the image would become blurry and lose detail.

This is because the satellite has reached its maximum **resolving power.** Current satellites used by Google Earth are technically capable of a resolving power of 41 cm, although they have been banned from going below 50 cm for privacy issues.

Resolution is the ability to tell two points apart as separate points. If the resolving power is 41 cm it means two points that are 41 cm apart can be seen as separate points. If they are closer together than that, they will blend together into one point.

Some spy satellites have a resolving power of 10 cm which means they can see more detail on the Earth's surface.