

Research in the Classroom

PONDERING POND LIFE

Use this microbiology toolkit to explore the use of the scientific method and microorganisms



Teaching Guide

Curriculum links: Cells,
Microorganisms, Biodiversity
& Topical Science

Ages: 8 - 14

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ABOUT PONDERING POND LIFE



Pondering Pond Life is a microbiology toolkit designed for teachers (upper primary and lower secondary) to support and encourage scientific inquiry in their own classrooms and to reveal real-world science happening at the University of Edinburgh's Roslin Institute.

The toolkit was designed by Dr Laura Glendinning, a scientist from the University of Edinburgh's Roslin Institute with support from the Roslin Institute's Public Engagement team at the Easter Bush Science Outreach Centre. Dr Glendinning is a winner of the Microbiology Society's 2020 Microbiology in Society Award, which funds education, outreach or public engagement work that promotes the art and science of microbiology and has made this project possible.



We hope you enjoy using the toolkit, please share your scientific investigations with us by tweeting @EBSOClab @MicrobioSoc #PonderingPondLife

Acknowledgements

We would like to thank the following people and organisations for their part in development of this toolkit.



Deepali Vasoya, a bioinformatician who works at the Roslin Institute, for her role in helping to develop this toolkit.



Becky Smith, a bioinformatician who works at the Roslin Institute, for producing artwork for the pupils workbook.



Kate Andrews (Head of Professional Learning) and colleagues at the Scottish Schools Education Research Centre (SSERC) for providing guidance in the development of this toolkit.



Gayle Duffus (National Education Officer) and the Scottish Primary Science Development Officers for supporting the delivery of this project in Scottish schools via the RAiSE initiative.

Who is this toolkit for?

Learners are engaged and motivated when they are involved in planning their own science investigations. This toolkit will support you in using and teaching the scientific method in a multitude of different ways, via its wide range of possible investigations. Through using this toolkit in your classroom, you can help support your upper primary and early secondary school learners to create and carry out their own unique investigations.

The activities in this toolkit have been linked with:

Scotland's Curriculum for Excellence:

Second level (8-11 years old):

- I can identify and classify examples of living things, past and present, to help me appreciate their diversity (SCN 2-01a)
- I have contributed to investigations into the role of microorganisms in producing and breaking down some materials (SCN 2-13a)
- Through research and discussion I have an appreciation of the contribution that individuals are making to scientific discovery and invention and the impact this has made on society (SCN 2-20a)

Third level (11-14 years old):

- I can sample and identify living things from different habitats to compare their biodiversity and can suggest reasons for their distribution (SCN 3-01a)
- Using a microscope, I have developed my understanding of the structure and variety of cells and of their functions (SCN 3-13a)
- I have contributed to investigations into the different types of microorganisms and can explain how their growth can be controlled (SCN 3-13b)

England's National Curriculum:

Upper Key Stage 2 (9-11 years old):

- **Working Scientifically**
- **Living things and their habitats**

Key Stage 3 (11-14 years old):

- **Working Scientifically**- experimental skills and investigations, analysis and evaluation
- **Biology** - structure and function of living organisms, material cycles and energy, interactions and interdependencies

What are the aims of this toolkit?

The aims of this toolkit are to:

- give young learners the opportunity to get hands-on with real-life science
- give them a positive and realistic experience of science
- show how science is done
- reveal that anyone can do science
- provide access to current scientific research
- promote inspiration around STEM subjects and careers in STEM

What are the intended learning outcomes of this toolkit?

Through bringing this toolkit into your classroom, your learners will have the opportunity to practice the same scientific skills as professional scientists:

- using the scientific method through developing their own investigation
- developing their practical skills through handling equipment
- being creative when designing their investigation and predicting its outcome
- exercising their critical thinking skills through observing, analysing data, evaluating results, making decisions and problem solving
- strengthening their communication skills through working with their peers and sharing their science with others

What does the toolkit include?

The *Pondering Pond Life* Toolkit includes the following:

Educational materials:

- Learner Experiment Booklet for each learner to document their investigation
- Teaching Guide to provide support and information for teachers using the toolkit
- Class Presentation for teachers to use with their learners in the classroom
- Real-Life Research Non-Fiction Reading Text to be used to talk about the real-world science that is happening at The University of Edinburgh's Roslin Institute, included in the learner investigation booklet.

All of these materials are available to download for free from www.ebsoc.ed.ac.uk in our Teacher Zone

Experimental materials:

To carry out the full range of investigations listed on pages 14 - 19 the following equipment and reagents are required.

Equipment

- A microscope (with 10X lens)
- Microscope slides
- Blu Tac
- Droppers
- Clear plastic tubes with screw-cap lids
- Coloured cellophane



Reagents

- Universal Indicator paper (to measure acidity/alkalinity)
- Lemon juice (supermarket bought concentrate or freshly squeezed from a lemon)
- Bicarbonate of soda (supermarket bought)
- Salt (table salt)
- Pond microorganisms: two different samples of pond water microorganisms purchased from an educational supplier. You can use a mixed population of microorganisms (more complex investigations) or purchase a few single types (simpler/starter investigations).

Suggested

Protozoan Pellets - food to keep pond microorganisms growing for a few weeks in your school.

Alcohol wipes - to clean microscope eye pieces between uses.

MICROORGANISM FACT FILE



Your young science explorers are sure to have lots of questions for you about microorganisms! We have made a microorganism fact file to help you answer their WONDER-filled questions.

What are microorganisms? Microorganisms are living things that are small enough that we (usually) can't see them with the naked eye. They include bacteria, viruses, fungi, algae, protozoa, and Archaea.

Can we see microorganisms? Many of these microorganisms can be observed using ordinary microscopes, although some are so small (like viruses) that they can only be viewed using very powerful electron microscopes. When using this toolkit your learners are most likely to observe protozoa and algae, as these are some of the largest microorganisms that can be found in pond water.

Where do microorganisms live? Basically everywhere! As well as living in hospitable places such as ponds, soil or the guts of animals, they can also live in pretty extreme environments including deep sea hydrothermal vents, hot springs and glaciers!

Are all microorganisms dangerous? No. While some microorganisms can cause disease, the vast majority of them are harmless or are actually beneficial.

Are microorganisms important? Yes! Without microorganisms it would be almost impossible for any other life to exist for very long on Earth. They are also thought to be some of the earliest forms of life on Earth and at the moment the Mars rover is looking for traces of microorganisms on Mars!

How do microorganisms get energy? In a huge variety of ways! For example, some microorganisms produce food from sunlight, while others consume decaying plants or other microorganisms. Some microorganisms are even able to consume nuclear waste and plastic!

Do microorganisms use oxygen? Like humans, some microorganisms need oxygen to survive. However, oxygen is toxic to other microorganisms and they need to live in an oxygen-free or anaerobic environment.

Do scientists study microorganisms? Yes, scientists are interested in how microorganisms influence a huge number of areas including human and animal nutrition, climate change and health.

Do scientists at the Roslin Institute study microorganism? Yes! Scientists at Roslin research the microorganisms that live inside farm animals and pets. By understanding how these microorganisms interact with the animals, we can use our knowledge to improve animal health and nutrition.

INVESTIGATING POND LIFE



Introduction

Microorganisms are living things that are too small to be seen with our eyes. There are lots of different types of microorganisms including bacteria, viruses, fungi, algae and protozoa. They have vitally important roles in nearly every ecosystem on the planet. Some play key environmental roles, such as absorbing carbon dioxide from the atmosphere. Others live in animal guts and help the animal get nutrients from its food and protect it from being infected by disease-causing microorganisms. Many of the scientists at the University of Edinburgh's Roslin Institute study the microorganisms that live in farm animals so that they can understand the role microorganisms have in keeping animals healthy, well-nourished and happy.

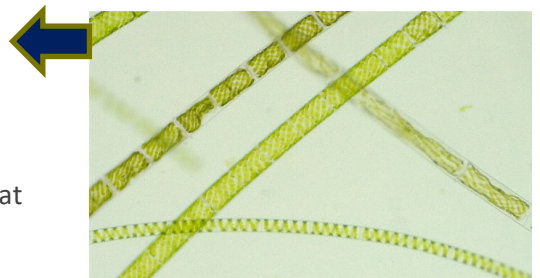
The study of microorganisms in the classroom provides opportunities for teaching learners about doing science using the scientific method. In *Pondering Pond Life* your young learners will investigate protozoa and/or algae.



➔ **Protozoa** are single-celled organisms that are found in wet habitats such as pond water, rivers, seas and soils. They are wonderful for your learners to look at under the microscope as they come in all shapes and sizes, some can move with tiny hairs (cilia) or tails (flagella), some are plant-like and make food using sunlight, others are animal-like and eat food to survive...and some do both!

Algae are usually green, and like plants they make their own food from sunlight using photosynthesis.

Together, protozoa & algae really do reveal the diversity of pond life that can be revealed using a microscope.



Encouraging your learners to wonder

It is important to give your learners the opportunity to ask their own questions and wonder about the microscopic life in pond water themselves.

To elicit ideas and questions from them, why not give each group a tube of pond water and a [question frame](#) to place around the tube? You can also demonstrate how to make a hanging drop slide and use the microscope and have a question frame around the microscope too.

In groups, or as a class, they can begin to share their questions with each other, these can be documented in their investigation booklet (p.2). If you wish to help them focus their investigation why not give them some of the materials that you want them to use, and place them in the frame too.

What do I need to remember about carrying out a scientific investigation?

The first thing is to help your pupils create a SMART question! Depending on the level of experience and/or age of your learners you may wish to work as a class to answer one question together, have small groups work on the same question, or different groups work on different questions. Carrying out scientific investigations takes practice, so it is important to differentiate this toolkit for your learners and their needs.

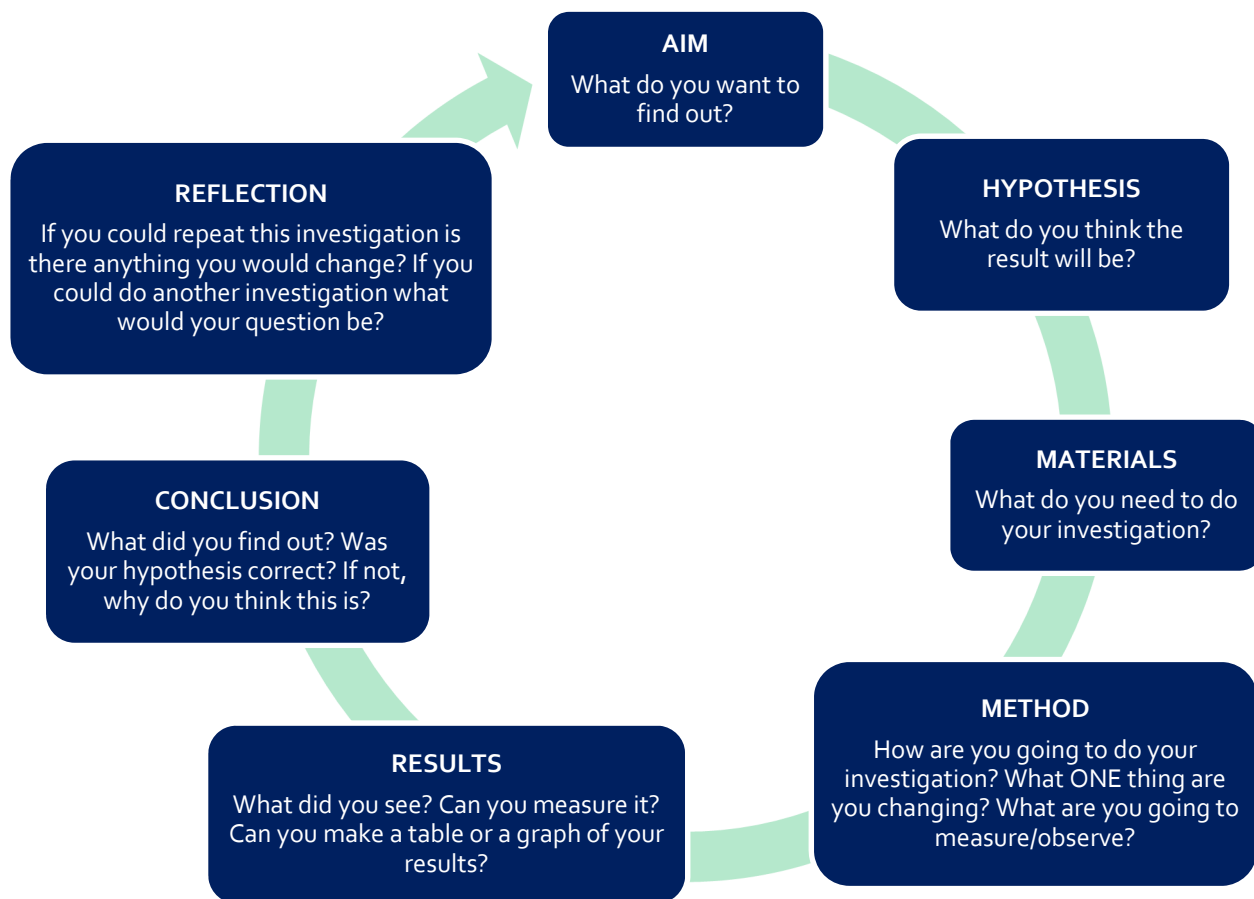
A SMART question is:

- **Specific** - Good investigations are about changing one thing to see what the effect is on another thing.
- **Measurable** - **Can you measure it?** *e.g. how far something grows/moves, the time it takes for an animal/person to react/cross a line, how many times it moves/divides; or **Can you observe it?** *e.g. defining a pattern, comparing and contrasting**
- **Achievable** - Can it be done in a reasonable time period? Do you have the materials to hand? Are they cheap enough to buy?
- **Relevant** - Is the question subject age/curriculum relevant?
- **Testable** - Is the investigation safe? Is the investigation ethical?

We have suggested some SMART questions below.

The second thing you need to remember is the scientific method! The key to all good scientific investigations is the structure. We have supplied an investigation booklet for your learners that includes sections for each stage of the scientific method and introduces some of the vocabulary. You may wish to create a classroom display with these words so that your learners can refer to them at a glance and become comfortable with using them.

The stages of the scientific method are:



What health and safety measures do I need to consider?

Before carrying out any practical activity, please ensure that this investigation is compatible with your school's risk assessment procedure. You must carry out a full risk assessment before starting any work.

What is the purpose of a risk assessment?

Risk assessments should include assessment of hazards and any control measures required, and should also take into account the age and stage of students and their ability to follow the control measures. The risk assessment should also take account your own local situation (age of pupils, ability of pupils, classroom set-up etc.) and guidelines.

Where do I go for advice?

For schools in Scotland, Scottish Schools Education Research Centre (SSERC) provides a health and safety advisory service for all Local Authority Schools in Scotland and for independent SSERC member schools.

SSERC provides several documents to aid you in carrying out safe experiments with your class, including *Materials of Living Origin - Educational Uses* (SSERC, 2018) and *Safety in Microbiology for Scottish Schools and Colleges* (SSERC, 2018). To access these documents you can request login details from <https://www.sserc.org.uk/login/>

For schools in England, Wales and Northern Ireland, please refer to guidance from CLEAPPS on safe working with microorganisms.

What risks should I consider and how can I reduce them?

1) To reduce risk of infection from pond water samples.

a. Purchase level 1 microorganisms from approved suppliers:

In accordance with *Safety in Microbiology for Scottish Schools and Colleges* (SSERC, 2018) the pond microorganisms must be purchased from an approved specialist supplier or culture collection (p7. 2.15).

Microorganisms which can be used for this project include:

- Blue-green algae
- Green algae
- Free-living protozoa

The above are classified as organisms that can be used for work at level 1 of SSERC's Microbiology Code of Practice. *These microorganisms carry little, if any, known risk and may be used in experiments by teachers with no specialist training* (p.7, SSERC, 2018).

b. Keep work surfaces clean

Work surfaces should be cleaned using hot water and detergent or disinfectant before and after working with the microorganisms.

c. Maintain good hygiene

- i. Learners and staff should wash their hands thoroughly, using soap and water, at an appropriate hand washing facility as soon as possible after coming into contact with the samples.
- ii. Cuts should be covered with waterproof dressings.
- iii. Learners should be reminded that they should not touch their faces (eyes/nose/mouth) with their hands until they have been washed thoroughly.

d. No eating or drinking

Food/drink should not be consumed until after hands have been washed. No food or drink should be consumed when working with samples.

e. Spills

- i. Spills should be cleaned up immediately by an adult using a suitable disinfectant.
- ii. Only give learners small volumes of pond water/microorganism samples to handle.

f. Disposal of samples



- i. Learners must not be allowed to take samples home.
- ii. Samples should be disposed of by an adult by pouring down the sink and washing away with plenty of water.
- iii. Clean tubes immediately after use and ensure they are dry before storage.

2) To reduce the risk of growing dangerous microorganisms

a. Investigations must be carried out at room temperature

The samples must never be heated above 30°C.

b. Do not add protein sources or iron to the pond water samples

For example, do not add egg powder or meat.

For Scottish schools, complete guidance can be found in the following documents:

- *Materials of Living Origin - Educational Uses* (SSERC, 2018)
- *Safety in Microbiology for Scottish Schools and Colleges* (SSERC, 2018)

Both can be accessed via once you have a SSERC login via <https://www.sserc.org.uk/health-safety/biology-health-safety/codes-of-practice/>.

For schools in England, Wales and Northern Ireland, please refer to the relevant guidance from CLEAPPS on safe working with microorganisms.

3) To reduce general risks:

a. Cuts from broken glass

Microscope slides are made of glass and can be hazardous if broken.

- i. **Highlight to learners the need for care when using the glass slides**
- ii. Broken glass should be cleaned up by an adult and disposed of in an appropriate bin in accordance with your school's policy.

b. Electrical hazards

Samples will be wet and therefore care should be taken to avoid handling them near electrical equipment, such as the microscope.

- i. Hands must be dry before using electrical equipment e.g. microscope
- ii. **Adults should be responsible for turning the microscope on and off**

More about "pond water" samples

Throughout this teaching guide we will refer to "pond water samples" on which learners can carry out their investigations. In order to make this toolkit as **safe and easy** to use as possible, and to ensure that the investigations are in accordance with the guidance outlined in *Materials of Living Origin - Educational Uses* (SSERC, 2018), we suggest using specific pond microorganisms (blue-green algae, green algae, free-living protozoa) purchased from a specialist supplier, individual protozoa and algae can be purchased. To more closely simulate a real pond water

sample, mixed populations of algae or protozoa can be purchased- this may be suited to older learners and/or a more advanced investigation.

Using samples from ponds that the learners have collected under the supervision of a teacher can add to the fun of the project, but this teaching guide does not cover the risks associated with pond water collection and sampling. In order to carry out such activity you must carry out a full risk assessment and refer to SSERC or CLEAPSS for guidance.

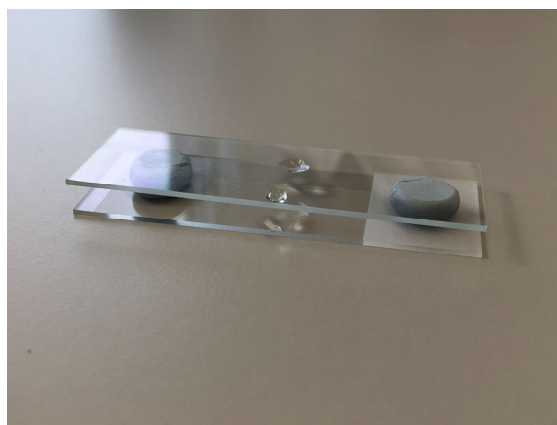
It is important that when storing pond water for 4-5 days it should NOT be stored in a tightly sealed container. If samples are stored in sealed containers then the microorganisms this can be avoided by keeping the lids of tubes and pots screwed on loosely. Most pond microorganisms also need sunlight, so do not store in a box or cupboard unless this is part of an investigation!

Preparing a hanging drop slide

To watch Deepali prepare a hanging drop slide [click here](#).

Instructions

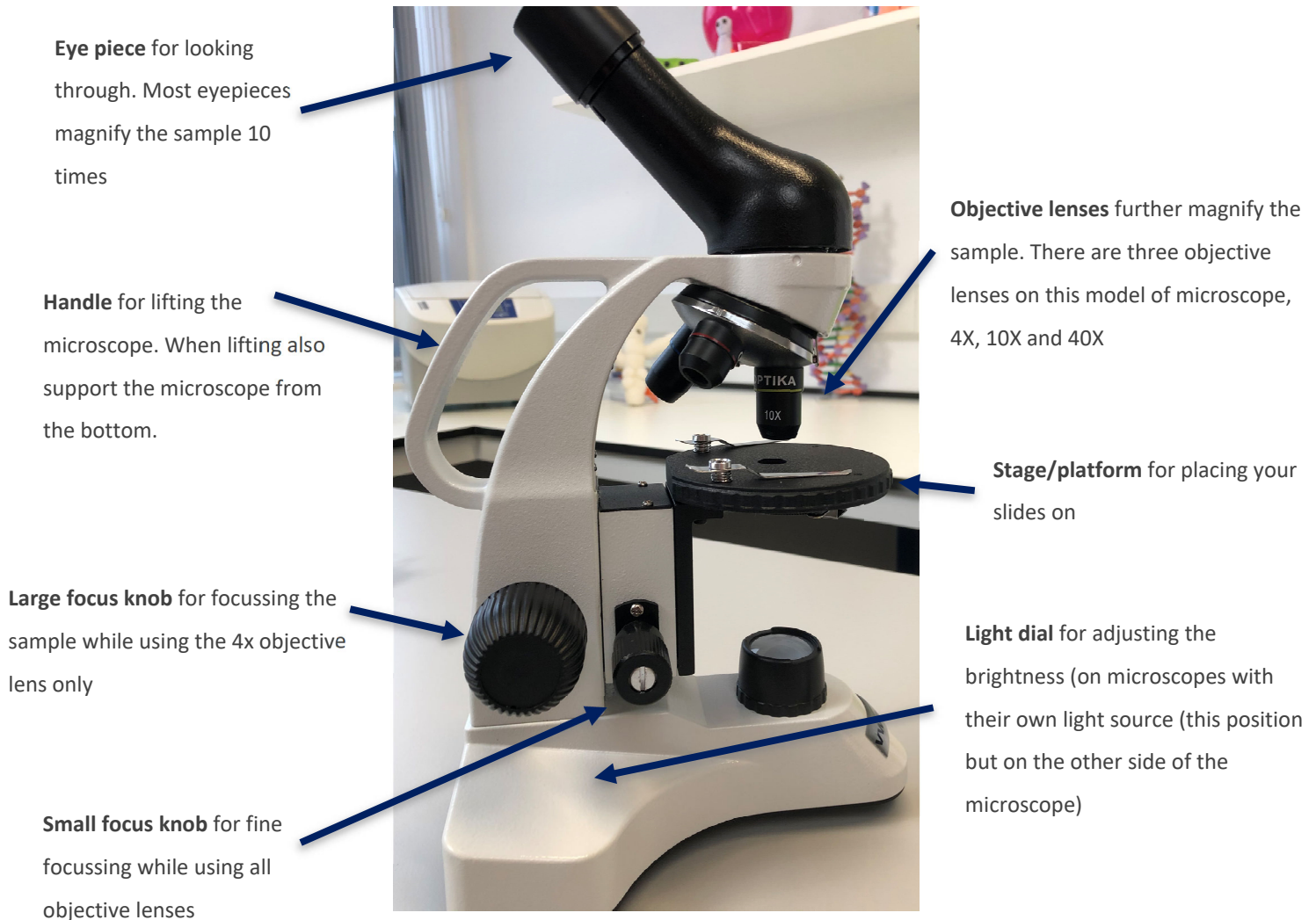
1. Take two clean microscope slides.
2. Attach two pieces of blu tack to one of the slides, about 3cm apart.
3. Gently shake/swirl your pond water sample (the lids are loosely attached so screw them on tightly before shaking) to re-suspend the microorganisms which may have settled to the bottom.
4. Using a plastic dropper, suck up a small amount of the sample (no more than 1ml).
5. Take the microscope slide that does not have blu tack attached and position the tip of the dropper over its centre. Place a drop of sample onto the centre of the slide.
6. Place the slide with the blu tack on top of the slide with the pond water sample, blu tack side down, and **gently** push it down to sandwich the two slides together, leaving a gap between them. Take care as the slides are made of glass and too much pressure will make them break!
7. Quickly turn the slides over so that the drop of sample is hanging from the top slide into the gap between the slides.
8. Your slides are now ready to view under the microscope.



Cleaning & storing slides

After viewing the slides, they should be dismantled, thoroughly cleaned and left in a safe place to air dry. We suggest you inspect the slides before returning them to the box and to discard any that have cracks in your usual glass disposal.

How to use a microscope



To watch Laura showing you how to set-up and use the microscope* [click here](#).

To see how to set-up the microscope* for the first time use the microscope instructions (included in the box) and for some advice from Laura [click here](#).

*Please note that our video has been made for a specific model of microscope, but the general principles are the same for all microscopes.

Instructions

1. **Turn on the microscope** and check that the light source is turned up using the light dial.
2. The microscope comes with several different **objective lenses**. Your microscope will likely have 4X, 10X and 40X lenses. Turn the lenses so that the **4X lens is positioned** above the viewing platform.
3. **Place the slide** on the centre of the viewing platform of the microscope.
4. While looking down the microscope, **turn the large focus knob** on the side of the microscope until pond water comes into focus. At this magnification you are unlikely to see many microorganisms in detail, but you may be able to see larger microorganisms moving around.
5. Now that you have focused your microscope using the low magnification lens, you will find it easier to focus it at higher magnifications. **Turn the objective lens labelled 10X** so that it is above the sample.
6. Look down the eye piece, you will probably see that the sample is no longer exactly in focus. Using the **small focus knob** (not the large focus knob- large movements at this point could cause the lens to crash into the slide!) slowly adjust the knob until the sample comes more clearly into focus. At this magnification (10X from eyepiece and 10X from objective lens = 100X) you should be able to clearly see pond water microorganisms such as protozoa and algae.

Important: Do not use the 40X lens with a hanging-drop slide as the height of the slide means that the objective is likely to touch the slide, damaging the lens.

What questions could my learners ask with this toolkit?

This investigation is an ideal opportunity for creative thinking and there are many questions that your learners could ask and investigate safely. We've come up with some examples below, but please don't be limited by them.

1) Do my pond microorganisms need light to grow?

[Watch this video](#) to see how to set up this investigation.

<p>How to set up and run the investigation</p>	<p>Day 1</p> <ul style="list-style-type: none"> Learners take two clean tubes and add approximately 1ml of pond water to each. Loosely screw on the lids and put one tube in a safe place in the light, and the other tube in a safe place in the dark e.g. under a cardboard box, for 4-5 days. <p>Day 4/5</p> <ul style="list-style-type: none"> Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record these observations on p6 of their investigation booklet, for both the light and dark tubes. 	
<p>You will need (per group)</p>	<p>2 screw cap tubes 2 droppers 2ml pond water Cardboard box</p>	<p>4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)</p>
<p>Questions to ask your learners</p>	<ul style="list-style-type: none"> Why do you think your microorganisms will grow/not grow in the light/dark? How can you measure whether there are more microorganisms after 4-5 days in the light compared to the dark? 	
<p>What your learners are likely to see and why</p>	<p>Learners are likely to see higher numbers of green microorganisms in the light exposed sample after the 4-5 days, because these microorganisms can produce food from sunlight via photosynthesis and can grow and divide.</p> <p>In the dark, many of the green microorganisms seen at day 1 are likely to have died after 4-5 days as they can't make their own food without sunlight. Learners may instead see higher numbers of other, non-green microorganisms after 4-5 days.</p>	
<p>Notes</p>		

2) Can my pond microorganisms grow with red/yellow/blue/green/purple light?

How to set up and run the investigation	<p>Day 1</p> <ul style="list-style-type: none"> Learners put in around 1ml of pond water it into two clean tubes. Loosely attach the lids and cover one tube with coloured cellophane of one colour. Put both tubes in a safe place in the light for 4-5 days <p>Day 4/5</p> <ul style="list-style-type: none"> Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record these observations on p6 of their investigation booklet for both the white light and coloured light tubes. 	
You will need (per group)	2 screw cap tubes 2 droppers 2ml Pond water Coloured cellophane (one colour)	4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)
Questions to ask your learners	<ul style="list-style-type: none"> Why do you think your microorganisms will grow/not grow in the red/yellow/blue light? How will you measure whether there are more microorganisms after 4-5 days in the white or coloured light? 	
What your learners are likely to see and why	<p>Learners are likely to see more green microorganisms in the blue and purple light-exposed sample after the 4-5 days, because these microorganisms can produce more food from blue and purple light via photosynthesis than they can from white light.</p> <p>Learners are likely to see fewer green microorganisms in the tubes covered with green cellophanes because this light will be reflected by the green pigment in the green microorganisms, rather than absorbed by them and used to make energy for growth.</p>	
Notes		

3) Do my pond microorganisms grow better in fresh or salty water?

How to set up and run the investigation	<p>Day 1</p> <ul style="list-style-type: none"> Learners take two clean tubes and add approximately 1ml pond water into each. Learners add ¼ tsp of salt to one tube. Loosely screw on the lids and put both tubes in a safe place in the light. <p>Day 4/5</p> <ul style="list-style-type: none"> Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record their observations on p6 of their investigation booklet for both the fresh water tube and salt water tube. 	
You will need	2 screw cap tubes 2 droppers 2ml Pond water	4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)

	¼ teaspoon of salt Teaspoon	
Questions to ask your learners	<ul style="list-style-type: none"> • Why do you think microorganisms will grow/not grow in the salt/fresh water? • How can you measure whether there are more microorganisms in the water after 4-5 days in the salt/fresh water? • How much salt will you add? Could you extend the investigation by adding different amounts of salt to several tubes? 	
What your learners are likely to see and why	<p>In the salt water, many of the microorganisms seen at day 1 are likely to have died after 4-5 days as they cannot live in salt water.</p> <p>Any microorganisms that they do see in the salt water tube are likely to be less in number compared to the fresh water tube and there will probably be fewer different types of microorganism.</p>	
Notes	<p>This investigation could be extended by using a range of salt concentrations. Pupils could make a salt solution and then add different volumes of that to the pond water sample tube.</p> <p>Important: Do not do this experiment adding substances that might be used as food by microorganisms e.g. sugar.</p> <p>Providing a food source for microorganisms is dangerous as it could encourage the growth of disease-causing microorganisms (see health and safety guidance above).</p>	

4) Can my pond microorganisms grow in the cold?

How to set up and run the investigation	<p>Day 1</p> <ul style="list-style-type: none"> • Learners take two clean tubes and add approximately 1ml pond water into each. • Loosely screw on the lids and put one tube at room temperature in a safe place for a 4-5 days, and the other in suitable cold place (not a fridge that is used for food/drink) for the same period of time. <p>Day 4/5</p> <ul style="list-style-type: none"> • Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record their observations on p6 of their investigation booklet) for both the room temperature tube and the cold tube. 	
You will need	2 screw cap tubes 2 droppers 2ml Pond water Cold place i.e. outside, suitable fridge Thermometer (optional)	4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)
Questions to ask your learners	<ul style="list-style-type: none"> • Why do you think microorganisms will grow/not grow in the cold? • Is it important to think about where we are putting the tubes and how much light they will get? • How could you tell if the microorganisms are growing? • What will you measure? 	

What your learners are likely to see and why	Learners are likely to see fewer microorganisms and less movement in the cold sample after 4-5 days compared to the room temperature sample. This is because most microorganisms do not grow well at low temperatures.
Notes	Important: Do not do the reverse of this experiment i.e. “Do microorganisms grow better in warm/hot temperatures?” Growing microorganisms above 30°C is dangerous as it can result in the growth of disease-causing microorganisms (see health and safety guidance above).

5) Do my pond microorganisms grow in acidic water?

How to set up and run the investigation	<p>Day 1</p> <ul style="list-style-type: none"> Learners take two clean tubes and add approximately 1ml pond water into each. They record how acid or alkali the pond water is using the universal indicator paper. If the paper turns red then the sample is acidic, if it turns green it is neutral, if it turns purple then it is alkaline. Using the guide provided, make a note of the pH number, this tells us how acid or alkali the sample is at the start of the investigation. To one tube, learners add a small amount of lemon juice (5-6 drops). Use the pH paper to check that the water sample is now acidic or at least more acidic than before (i.e. lower pH number). Loosely screw on the lids and put the tubes in a safe place in the light for 4-5 days. <p>Day 4/5</p> <ul style="list-style-type: none"> Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record their observations on p6 of their investigation booklet for both the acid water tube and unchanged tube. 	
You will need	2 screw cap tubes 2 droppers 2ml Pond water Universal indicator paper 5-6 drops of lemon juice	4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)
Questions to ask your learners	<ul style="list-style-type: none"> Why do you think the microorganisms will grow/not grow in acidic pond water? How can you measure whether there are more or fewer microorganisms? Will you look at all the different types of microorganisms or just one type? (If you are using a mixture of microorganisms) 	
What your learners are likely to see and why	If the sample is very acidic it is likely to kill all of the microorganisms. They may still be visible but they will not be moving. Some microorganisms may survive in the acidic condition, but learners should observe that there are fewer microorganisms in total and there are likely to be fewer different types in a mixed culture.	

	Some microorganisms may flourish in these conditions and this would indicate that this is their preferred type of water. Pond microorganisms can be used as bio-indicators , which allow us to measure the status of the water they are living in based on the types of microorganisms present.
Additional curriculum links	I have collaborated in activities which safely demonstrate simple chemical reactions using everyday chemicals. I can show an appreciation of a chemical reaction as being a change in which different materials are made. SCN 2-19a
Notes	The pH of water is neutral, pH7 pH 1-6 is acidic

6) Do my pond microorganisms grow in alkaline water?

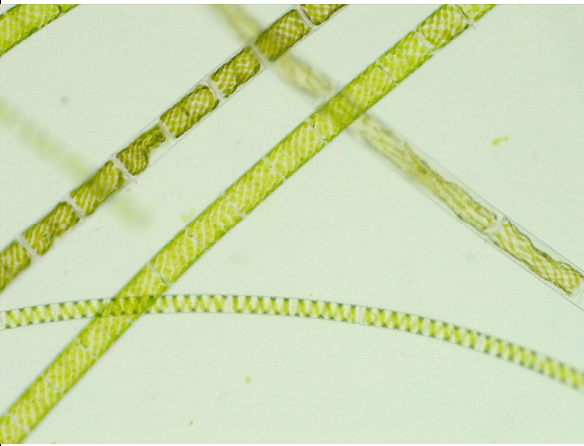
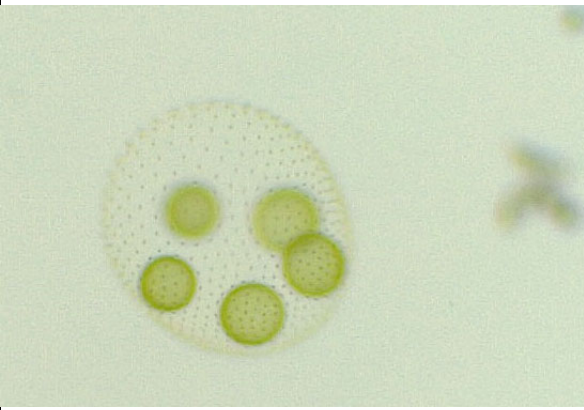
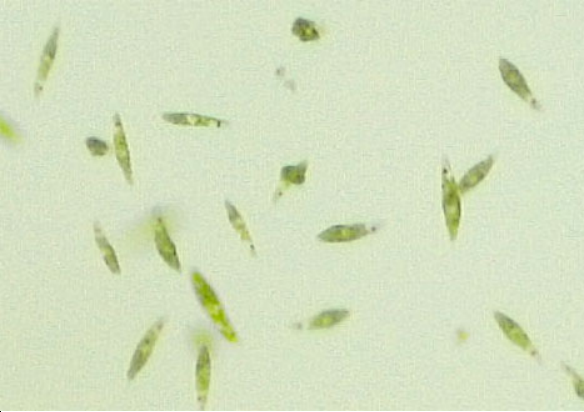
How to set up the investigation	<p>Day 1</p> <ul style="list-style-type: none"> Learners take two clean tubes and add approximately 1ml pond water into each.. Learners measure how acid or alkali the pond water is using the Universal Indicator paper. If the paper turns red then the sample is acidic, if it turns green it is neutral, if it turns purple it is alkaline. Make a note of the pH number and colour - this tells us how acid or alkaline the sample is at the start of the investigation. To one tube, learners add a small amount of bicarbonate of soda (1/4 teaspoon). Use the pH paper to check that the water sample is now alkaline or at least more alkaline than before (higher pH number). Loosely screw on the lids and put both the tubes in a safe place in the light for a 4-5 days. <p>Day 4/5</p> <ul style="list-style-type: none"> Learners collect their tubes and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide for each tube). They should record their observations on p6 of their investigation booklet for both the alkaline water tube and unchanged/control tube. 	
You will need	2 screw cap tubes 2 droppers 2ml Pond water Universal Indicator paper ¼ teaspoon of bicarbonate of soda Teaspoon	4 slides 4 small pieces of blu tack 1 microscope (can be shared by class)
Questions to ask your learners	<ul style="list-style-type: none"> Why do you think the microorganisms will grow/not grow in alkaline pond water? How can you measure whether there are more or fewer microorganisms after 4-5days in alkaline water? Will you look at all the different types of microorganisms or just one type? (if using a mixed sample of microorganisms) 	


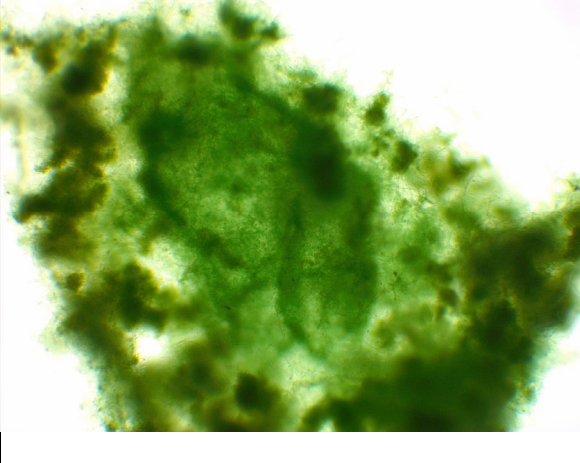
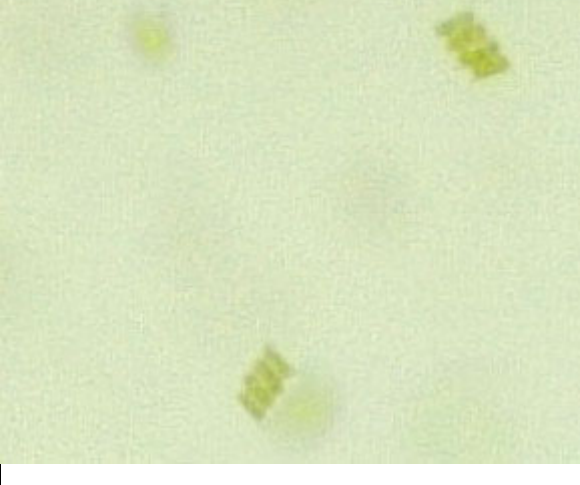

What your learners are likely to see and why	<p>If the sample is very alkaline it is likely to kill all of the microorganisms.</p> <p>Some microorganisms may survive in the alkaline conditions, but learners are likely to observe that there will be fewer microorganisms in total and fewer different types (if they are using a mixed sample).</p> <p>Some microorganisms may flourish in these alkaline conditions and this would indicate that this is their preferred type of water. Pond microorganisms can be used as bio-indicators, which allow us to measure the status of the water they are living in based on the types of microorganisms present.</p>
Additional curriculum links	I have collaborated in activities which safely demonstrate simple chemical reactions using everyday chemicals. I can show an appreciation of a chemical reaction as being a change in which different materials are made. SCN 2-19a
Notes	The pH of water is neutral, pH7 pH 8-14 is alkaline


7) Do the microorganisms in my pond water change over time?

How to set up and run the investigation	<p>Day 1</p> <ul style="list-style-type: none"> Learners add approximately 1ml pond water (needs to be a mix of at least two species of microorganism) into a clean tube. Loosely screw on the lid and then put the tube in a safe place in the light for 1-6 days. <p>Days 2-7</p> <ul style="list-style-type: none"> Learners collect their tube and observe what the contents look like in the tube and under the microscope (they will set up a hanging drop slide). They should record their observations on p6 of their investigation booklet. They repeat this several times up to a maximum of 7 days, adding extra pieces of paper to their investigation booklet as necessary. Learners should record the different numbers, colours, types and sizes of microorganisms that they see each time. 	
You will need	1 screw cap tube 1 dropper 1ml Pond water (mixture of microorganisms)	2 slides 2 small pieces of blu tack 1 microscope (can be shared by class)
Questions to ask your learners	<ul style="list-style-type: none"> Why you think the types of microorganisms in the pond water will change over time? How can you measure whether there are more or fewer microorganisms? Will you look at all of the different types of microorganisms or just one type? Will you estimate their size? If so, how? 	
What your learners are likely to see and why	<p>It is likely that at earlier times your learners will observe smaller microorganisms that are further down the food chain and can live on the nutrients in the pond water. Over time these will be eaten by other larger microorganisms that are further up the food chain, so the relative numbers of different types of microorganisms should change over time.</p> <p>This experiment will work more clearly using a pond water sample with a larger variety of microorganism species.</p>	

Common microorganisms that your learners might observe:

<p>Spirogyra (10X lens)</p>	<p>Also called water silk. Long green strands of rectangle-shaped cells. These rectangular cells contain spirals of green, hence their name. Like plants, they make their food from sunlight using photosynthesis.</p>	
<p>Volvox (10X lens)</p>	<p>Large translucent/see-through spheres with small and large green circles dotted all over the outside. These green circles will eventually break off and form their own spheres. These organisms move slowly, and often rotate as they move (video available online). They make their food from sunlight.</p>	
<p>Euglena (10X lens)</p>	<p>Moving, thin, green cells with a red dot at one end which is able to detect light. Euglena swim towards the light and they are able to convert sunlight into food. A video of their movement can be found in the class presentation.</p>	

<p>Anabena (4X lens)</p>	<p>Chains of small, round, green cells. Often there will be several smaller cells, followed by a larger cell with a thicker line around it. The bigger cells are able to produce food from sunlight (photosynthesis) and they share this energy with the smaller cells in the chain.</p>	
<p>Chlorella (4X lens)</p>	<p>These microorganisms are very small, round, green cells. However, they like to gather together, so you are most likely to see them appear under the microscope as large, green clumps. Chlorella are very efficient at producing food from sunlight. Some people eat them as a health food - you might see them dried and added to smoothies!</p>	
<p>Scenedesmus (10X lens)</p>	<p>Green, rectangle-shaped cells. They can be found on their own, but often join together to make chains. They produce food from sunlight. Scenedesmus are more likely to form chains when in dim light rather than bright light. They are also more likely to form chains when predators (such as Paramecium) are present, as a form of protection.</p>	
<p>Colpidium (10X lens)</p>	<p>Quickly moving, translucent/see-through, oval cells. A video of their movement can be found online. Colpidium feed on bacteria and thrive in environments where bacterial contamination is high, such as wastewater treatment plants.</p>	

<p>Paramecium (10X lens)</p>	<p>Very fast moving, large, translucent/see-through, oval-shaped cells. The cells have a large groove in them, and they are often described as looking like slippers! Due to this odd shape they often move in a spiral pattern (video can be found online). These microorganisms are pond life predators and eat a wide range of other microbes.</p>	
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What are the links to numeracy and literacy?

Numeracy in science	Literacy in science
<p>Encourage your learners to carry out quantitative analysis (measuring in units)</p> <ul style="list-style-type: none"> ➤ Count how many microorganisms they can see ➤ Calculate group or class averages e.g. Learner A counts 17 green microorganisms, Learner B counts 19, so the average is 18 microorganisms. ➤ Compare size of microorganisms ➤ Measure differences in pH ➤ Use tally marks ➤ Create tables and charts to represent results ➤ Use and managing units i.e. ml, l, cm, m ➤ Estimate ➤ Round numbers up and down 	<p>Encourage your learner to carry out qualitative analysis (description of what they observe in words, oral or written, and/or pictures)</p> <ul style="list-style-type: none"> ➤ Make a word wall with scientific vocabulary <p>Learners could:</p> <ul style="list-style-type: none"> ➤ Create scientific posters (based on the sections of their investigation book) that can be displayed in the classroom or hall ➤ Write a blog post/news report for the school newsletter about their findings ➤ Prepare an oral presentation or vlog for the class, school or for their families. ➤ Make a video diary of their investigation ➤ Think and write about why microorganisms are important for a school magazine article. ➤ Write a creative story about pond life to illustrate their findings. ➤ Create an infographic to show their results ➤ Make a stop motion video of what happened in their tubes in the 4-5 days the pond microorganisms were put in the test conditions

REAL-LIFE RESEARCH



How do my learners' investigations relate to real-life science?

We have prepared an example of how the scientific method has been used at the Roslin Institute to study the microorganisms that live in farm animals. This can be downloaded and can be found on the final page of the pupil experiment booklet.

Real-Life Research: What kind of microorganisms live in chicken guts?

Scientists ask questions and answer them using the scientific method just like you have. Read about Laura's research and then look at the questions:

Aim

Chickens need to eat protein to grow. But if they eat too much protein, **harmful microorganisms** can grow in their guts.

Laura wanted to know **what kinds of microorganisms live in chickens when they are fed fish protein.**

Materials

- 24 chickens
- Chicken food:
 - Type A - with fish protein
 - Type B - without fish protein
- Tools to measure what kinds of microorganisms were in chicken gut samples

Method

Laura took 24 chickens and separated them into two groups:

- o 12 chickens fed type A food
- o 12 chickens fed type B food

When they were 5 weeks old, Laura compared the types of microorganisms that were living in their guts.



Results

The two groups had different kinds of microorganisms growing in their guts.

Laura also made a **new discovery** - hundreds of these microorganisms had never been seen before!



This is Dr Laura

Conclusions

Feeding chickens fish protein causes changes in their gut microorganisms.



Answer key:

- 1) **How do you think microorganisms get into the chicken gut?** –
Students own answers

Additional information

They eat them when they are pecking at their food and pen. When they are kept in the same pen as their mum they eat her poo and therefore end up with the same gut microorganisms that she has.

- 2) **Why do you think the chickens were kept in groups?**

Students own answers

Additional information

Keeping the two groups separate meant that chickens from one group weren't able to eat the poo of chickens from the other group. This stopped the gut microorganisms from being passed between groups.

- 3) **What part of the scientific method is missing? Can you write it?**

The hypothesis: Chickens fed a high protein diet have different gut microorganisms than those fed a low protein diet.

- 4) **How many chickens were given more protein?**

12 chickens.

- 5) **Why were only some chickens given the high protein food?**

So that they could be compared to a group chickens who had not eaten high protein food.

- 6) **Why do you think it important to understand what types of microorganisms live in animals?**

Students own answers

Additional information

Microorganisms in animals can:

- Help the animal break down their food.
- Make the animal sick.
- Protect the animal from other microorganisms that would make the animal sick.
- Produce greenhouse gasses, such as methane.
- Improve the mood of the animal.

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Share your science!

We'd love to see what your class gets up to with this toolkit! You can tweet us @EBSOClab @MicrobioSoc #PonderingPondLife to share your science beyond the classroom! Alternatively, send an email to ebsoc@ed.ac.uk along with some photos that we can share via our website and Twitter account.



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