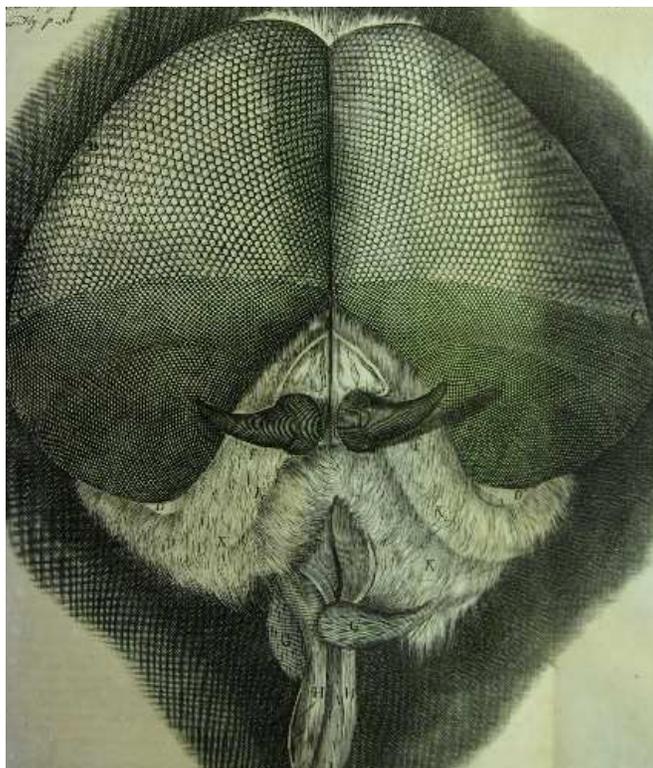




Museum of the History of Science

The world through a Microscope



Introduction

Welcome to the Museum of the History of Science in Oxford. These education resources are intended to make the Museum an accessible and useful resource for pupils studying science or history in schools. They draw on the extensive and valuable collections of the Museum and the expertise of the Museum staff. Ideally, the resources should be used in conjunction with a visit to the Museum, but they can also be adapted for use in the classroom providing background historical material on microscopy.

The Museum of the History of Science



The building that the Museum occupies was the original home of the Ashmolean Museum when it was established in 1683. It was designed to house the objects presented to the University of Oxford by Elias Ashmole, a man with a wide range of interests including antiquaries. As well as being the first purpose built Museum it was also a centre for teaching and research of “natural and experimental knowledge” during the seventeenth and eighteenth centuries.

Today the Museum houses one of the finest collections of historical scientific objects in the world. Through its collections the Museum aims to be a national and international centre of excellence for research and education and a source of understanding and inspiration to visitors. The Museum is a department of the University of Oxford.

The World Through a Microscope

The microscope is one of the most important modern scientific instruments. This resource makes use of the fine collection of microscopes possessed by the Museum of the History of Science. The resource is aimed at pupils in Key Stage 3 (ages 11 – 14) but can be used by older age groups.

Curriculum Links

The resource has links with the QCA scheme of work, as follows:

Unit 7A Cells: How can using a microscope give us information about structure?

Unit 8C Microbes and Disease: What are micro-organisms and how do we grow them?

Guide to the resource

In this resource pupils will learn about the development of microscopes, some of the people who made them and some of the people who used them.

The resource is in five parts.

Part 1 - Mr Hooke and his microscope page 5

The first compound microscopes; Robert Hooke and *Micrographia*

Part 2 - Simpler is better? page 9

Antoni van Leeuwenhoek; simple microscopes and the discovery of animalcules.

Part 3 - Family entertainment page 12

The microscope as entertainment; Henry Baker and John Cuff and their microscopes.

Part 4 - The microscope in science page 15

J J Lister and the achromatic lens; the germ theory of disease and the role of the microscope in scientific discovery.

Part 5 – Visiting the collection page 19

An active guide to discovering the microscopes on show in the Museum.

Evaluation form page 21

Parts 1 to 4 follow a chronological pattern but may also be used independently. Each of these parts contains some passages of text illustrated by pictures from the Museum's archive. At the Museum these sections will be given in an audio-visual presentation. Each part also includes a practical activity. These activities can only be carried out if you are using the resource at the Museum although it may be possible to set up similar experiences in the school laboratory. The activities use artefacts from the Museum to illustrate the changing designs and uses of microscopes. There are also questions and extension tasks which can be done while at the Museum, or in school.

MHS Education Resources
The World Through a Microscope

Part 5 is a guide for a visit to the Museum's galleries exploring the collection of microscopes. This can be done at any time in the programme depending on the number of pupils involved. The tour does not depend on knowledge of the other four parts.

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Visiting the Museum

For further details of the Museum's Education Programme, contact details for the Education Officers and details about arranging a visit please consult the Museum's website.

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Website: www.mhs.ox.ac.uk

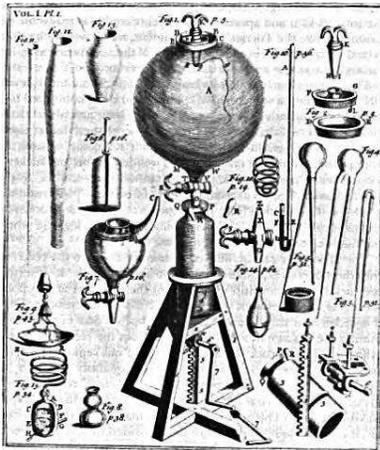
Part 1 - Mr Hooke and his microscope

Robert Hooke

In 1665 The Royal Society published a wonderful book by Mr Robert Hooke. It was called *Micrographia*. It was full of carefully drawn pictures and descriptions of objects that cannot be seen clearly with the eye. Robert had seen these things through his microscope.

Robert Hooke was born on the Isle of Wight in 1635. His father was a clergyman. Robert was a sick child but loved to make wooden toys. The family was not rich but Robert was sent to Oxford University. He had very little money for food or books so he had to serve the richer students.

In Oxford, Robert became friendly with Robert Boyle. Boyle was a rich man who spent his life studying science. Boyle gave Robert a job as his assistant. Boyle soon discovered that Robert could make any bit of scientific apparatus that he wanted.



Hooke's air pump built for Robert Boyle

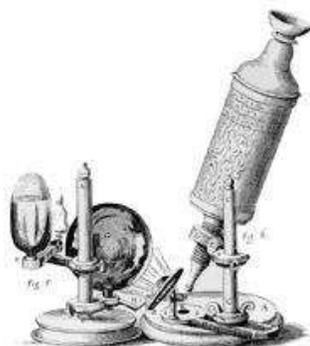
Boyle was in a group of men that met to discuss scientific ideas. In 1660 the group formed the Royal Society in London. Boyle suggested that Robert Hooke should work for the Royal Society as its Curator of Experiments. In 1662, Robert moved to London. He lived in Gresham College where the Royal Society met. Every week he demonstrated two or three new experiments to the members. It was a lot of work but he was soon making discoveries in many areas of science.

Robert carried on working for the Royal Society until he died in 1703. He became quite wealthy, especially after the Great Fire of London in 1666. He was an architect as well as a scientist. He designed many of the new buildings that were built after the fire.

Robert Hooke's microscope

Microscopes appeared in the early seventeenth century. Spectacles had been used for centuries. Then someone put one lens in front of another. Things looked bigger. By arranging the lenses in different ways they made telescopes and microscopes. Galileo heard about the inventions. In 1610 he made his own telescope. He used it to look into the sky at night. Some of Galileo's friends made microscopes and looked at the world around them.

Robert Hooke knew about microscopes and was always improving instruments. He worked with instrument makers to improve the design of microscopes. Robert practised using the microscope and became expert at making observations. He also practised drawing what he saw.



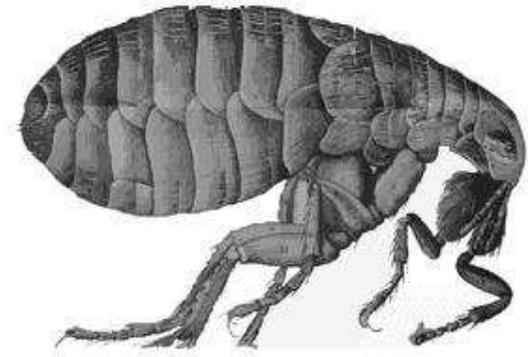
Activity: Looking at an early microscope

Look at the microscope but take care not to touch it. The microscope is over three hundred years old and can easily be damaged.
Answer the following questions.

MHS Education Resources
The World Through a Microscope

What is the microscope made of?

Where can you see the lenses are fitted?



What source of light does the microscope use?

How did Robert Hooke make sure that the object being studied was well lit?

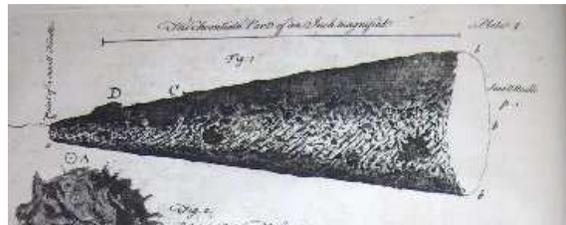
Where does light enter the microscope?

What can you see through the microscope? Lower your head carefully and look through the eyepiece with one eye. Close or cover your other eye. Describe what you can see and draw a diagram.

Micrographia

Micrographia was Robert Hooke's collection of his observations. He drew careful diagrams of the things he saw through his microscope and described them as well. He looked at lots of different objects.

You can look at a copy of the book from the Museum's library.



Why do you think that Robert Hooke was surprised when he first looked at the point of a pin through the microscope?

When some people saw Hooke's diagrams they didn't believe them. They thought Hooke was imagining what he saw. Why do you think they thought this? Do you think Hooke's diagrams are accurate?

This is what Robert Hooke wrote when he looked at a piece of cork through his microscope.

“ I...perceived it to be perforated and porous much like a honeycomb but that the pores were not regular.

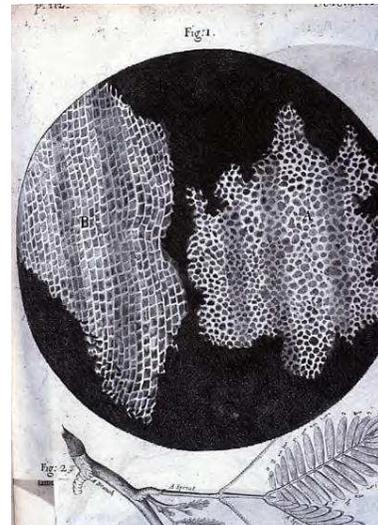
... the walls of the pores were not as thin as those of a honeycomb which enclose hexagonal cells.

...these pores or cells consisted of a great many boxes.

...I found there were about threescore of these small Cells in an eighteenth part of an inch, (less than 2 millimetres) about 12 hundred million in a cubic inch. (about 80 million per cubic centimetre)”

Why does Hooke compare the cork to a honeycomb?

In what ways does Hooke say that the “cells” in the cork differ from a honeycomb?



This was the first use of the word “cell” to describe parts of an organism. What does “cell” mean to you?

How is Hooke's use of the word “cell” different to your own?

Further questions and tasks

1 Why did Robert Hooke become Robert Boyle's assistant?

2 What special skills did Robert Hooke have?

3 Imagine that you have attended a meeting at the Royal Society. Robert Hooke has just demonstrated his microscope. He has described the things that he has seen and shown some of his diagrams. Write a letter to a friend saying what you saw and what you thought of it all.

Part 2 - Simpler is better?

Mr Oldenburg receives a letter

It is 1673. Mr Oldenburg is secretary to the Royal Society of London. A packet has arrived from a Dutch gentleman who is a member of the Royal Society. The packet contains two letters. The gentleman's letter tells Mr Oldenburg that the other papers are from Antoni van Leeuwenhoek. The gentleman says that Leeuwenhoek has made amazing discoveries using a simple microscope.

Mr Oldenburg read Leeuwenhoek's letter. He thought that it was so important it should be published in the Royal Society's journal. Over the next fifty years another 164 of Leeuwenhoek's letters are delivered to the Royal Society. They describe a microscopic world more wonderful than people imagined.

Antoni van Leeuwenhoek

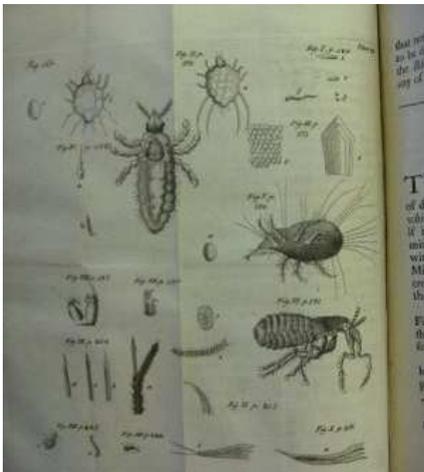
Antoni van Leeuwenhoek was born in Delft in Holland in 1632. His father was a basket maker. The family was not well off and could not afford to send Antoni to school. When he was 16 years old he started work as a linen draper. Linen was cloth made from fibres of the flax plant. A draper buys and sells cloth. By 1654 Antoni had his own shop. He became an important merchant in the town of Delft. Although his business took up a lot of his time, it was his microscopes that really interested him. During his lifetime he built over two hundred microscopes.



Late in life Antoni became famous for his observations. Kings and queens travelled to Delft to see him and look through his microscopes. But he was still just little Mr Leeuwenhoek, the draper. He died in 1723.

The amazing world of animalcules

When Antoni van Leeuwenhoek looked through his microscope he saw things that could not be seen with eyes alone. He saw things that were so small they could not be seen by the microscopes built by Robert Hooke and others. In a tiny drop of water he saw lots and lots of tiny creatures. He guessed there were over a million of these animals in a single drop. He called them "animalcules". Later Antoni saw sperm in semen and red blood cells in blood.



Leeuwenhoek's world on 'animalcules'

Activity – single lens microscopes

Look at a Leeuwenhoek type microscope. It has just one lens held between two sheets of metal. There is a pin for holding specimens and a screw to adjust their position.

What do you notice about the size of Leeuwenhoek’s lens?

The smaller the lens, the bigger things look. Leeuwenhoek made his lenses in this way. First he heated a glass rod. Then he drew it out until it made a fine glass fibre. He snipped the fibre in half and heated the end again. A tiny droplet of glass would form. He broke the bead off the fibre and when it was cool he polished it.

What are the problems of using such a small lens?

Look through the Leeuwenhoek microscope. Describe or draw what you can see.



Edmund Culpeper (1660-1738) made small microscopes which he sold to ladies and gentlemen.

Look at a Culpeper microscope.

In what ways is the Culpeper microscope different to Leeuwenhoek’s microscope?

Look at the prepared slide through the Culpeper microscope. The slide is made of ivory with small sheets of a transparent material over the specimen. Describe or draw what you see.

Photo: Whipple
Museum, Cambridge

Further questions and tasks

1. Why do you think that Leeuwenhoek did not write to the Royal Society himself?

2. Why do you think people were surprised by Leeuwenhoek's discovery of "animalcules"?

3. What names do we use for "animalcules" today?

4. Imagine you are a lady or gentleman from the early eighteenth century. You have bought one of Mr Culpeper's microscopes. What would you use it for?

Part 3 - Family entertainment

The Microscope Show



Cuff's Microscope
(circa mid 1700s)



Hooke and Leeuwenhoek found a new world under their microscopes. People in the eighteenth century were excited by the discoveries. They wanted to see the amazing giant flea or the strange animalcules for themselves. Some rich men bought their own microscope. They showed their families and friends what they found. Other families had to wait for a visit by a travelling showman.

The showman would arrive in a town. He would call on homes until someone offered to pay his fee. Then he would set up his microscope and specimens. He would talk about the wonderful things that could be seen through the eyepiece of his microscope. Gentlemen, ladies and children would crowd around to take their turn for a look.

Baker and Cuff – the microscope men



Henry Baker was born in 1698. At the age of fifteen he was apprenticed to a bookseller. He did many things in his life. He taught deaf people how to speak and did scientific experiments with crystals and electricity. He was a member of the Royal Society Henry designed a better microscope to help his observations.

John Cuff was a microscope maker in London. His brochure says he had his workshop in Fleet Street next to Sergeant Inn's gate. John Cuff worked with Henry Baker to make the improved microscope. He advertised the microscopes in his brochure and sold them from his workshop.

By the end of the eighteenth century there were a lot of microscopes to choose from. The cheapest was about 2 shillings and 6 pence (that is 12½ p). The most expensive was over £35 – that was a very large sum of money at that time.

Henry Baker designed what he called a “solar microscope”. This used the Sun's light to project an image from the microscope on to a wall. A group of people could look at a specimen at the same time. He also wrote a book called “The Microscope made easy”. The book described how microscopes work. There were pictures and descriptions of the microscopes that Baker and Cuff had designed and it also showed things that could be seen under the microscope.



MHS Education Resources
The World Through a Microscope

It gave readers lots of tips on how to use a microscope.

Activity: Visiting a new world

Imagine that you were a child in the 1700s. This is your first opportunity to look through a microscope. You have heard that monsters can be seen that are almost invisible to us normally.

What feelings do you have?

Look through the microscope at the prepared slides. Describe what you see and draw a diagram.

What is the microscope made from?

Is it a **simple microscope** (1 lens) or a **compound microscope** (2 or more lenses)?

How does light get into the microscope?

How could the microscope be adjusted?

Further questions and tasks

1. Why do you think the visit of the showman and his microscope was popular in the eighteenth century?

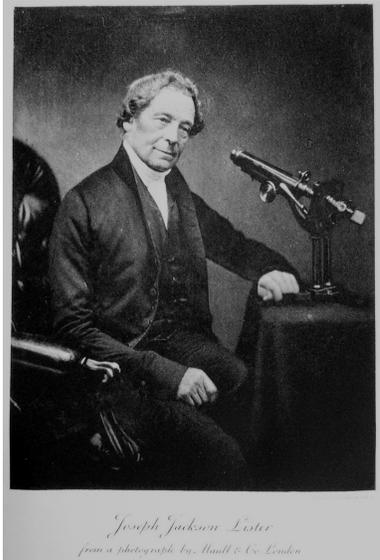
2. Describe what it may have been like to visit John Cuff's shop in eighteenth century London.

3. Why do you think Henry Baker's book, "The Microscope Made Easy" was a best seller?

4. If you have done Part 1: Mr Hooke and his microscope, you can answer this question. What differences are there between Robert Hooke's microscope and the microscope made by John Cuff?

Part 4 - The microscope in science

J J Lister and the even better microscope



Joseph Jackson Lister was born in London in 1786. His family were Quakers and so he went to a Quaker school until he was 14 years old. The Quakers were a Christian group but they were not allowed to go to the universities or to train as doctors or lawyers. J J Lister became a wine merchant and became wealthy. He married the daughter of a widow who worked in one of the Quaker schools. Their son, Joseph, was born in 1827.

Quakers did not approve of music, sport, games or going to the theatre. When he had spare time J J Lister studied science. He became interested in microscopes. There were lots of problems with microscopes that had been used since the time of Robert Hooke. The images were always slightly blurred. There were always coloured fringes around the objects. These faults were caused by the glass lenses that were used. People wondered if microscopists such as Hooke and Leeuwenhoek had really seen what they said they had seen.

Other people had tried to solve the problem. They joined together lenses made of different types of glass. Sometimes they were successful. In the 1820s J J Lister began experiments on the properties of the types of glass. Then he worked out how to make a lens that would give an image without all the blurring and coloured fringes. James Smith built a microscope for Lister in 1826 using the new lenses. In 1830 Lister wrote a paper for the Royal Society.

Other people did not take much notice of J J Lister's work. It was another seven years before Andrew Ross began selling a microscope to Lister's design. Then people began to realise how good it was. Ross began to sell lots of the new microscopes. Other microscope builders copied the design.

J J Lister became a Fellow of the Royal Society and friends with many, well known, scientists.



The microbe revolution

The Microscopical Society was formed in London in 1839. Members shared their observations. They suggested ways of improving microscopes.

In 1855 there was a competition to design a microscope for schools. One rule was that the microscope must cost less than 50p. The new interest in microscopes was just in time for a big change in science.

Leeuwenhoek's "animalcules" had amused eighteenth century ladies and gentlemen. Scientists had taken little interest in what the animalcules did. In the 1860s all that changed. The animalcules were now called germs or microbes. The Frenchman, Louis Pasteur discovered that microbes in the air made milk turn sour. He collected samples of air on cotton wool and examined the microbes. Similar microbes also made beer ferment and food turn bad. J J Lister's son, Joseph Lister, was a doctor. He realised that germs were the cause of diseases.

MHS Education Resources

The World Through a Microscope

Now the microscope was useful. Hospitals and universities needed a room with a microscope on every bench. Scientists looked for germs everywhere. They saw that there were lots of types of bacteria and other microbes. Some microbes are useful to us but others cause diseases.

People had often looked at the microbes in river water. Now they realised that rivers such as the Thames were full of dangerous microbes. People had to drink the water. There was a big fight to clean up the water and stop diseases like cholera from killing the people in cities.



Activity Science through the microscope

For this activity you will be using a nineteenth century microscope. By this time, scientists realised that all living things were made up of cells. Look at the slides of cells. Write down where the cells come from. Describe what you see and draw a diagram.

Further questions and tasks

1 Why was Lister's microscope with the new lenses an improvement on older microscopes?

2 How do you think a microscope was useful to Louis Pasteur?

3 How do you think people felt when they realised that there were dangerous microbes in their drinking water?

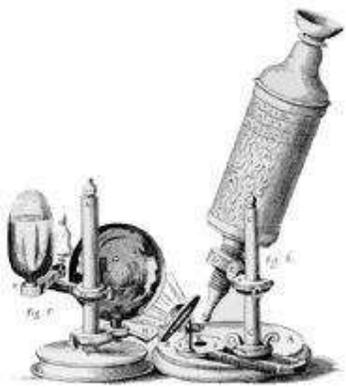
4 If you have covered the other three parts of this pack, answer this question.
How have microscopes changed from the time of Robert Hooke to Joseph Lister?

Part 5 – Visiting the collection

Follow this guide and answer the questions at each stop.

STOP 1 : Go to the Basement of the Museum. Enter the small room at the bottom of the stairs. On the wall opposite there is a glass cabinet. Look at the bottom left shelf. You will see a number of microscopes.

Look at the microscope labelled No.2 English Microscope from c.1700. This is similar to the microscopes that Robert Hooke used in the second half of the seventeenth century.



Robert Hooke's microscope from a diagram in his book Micrographia.

Q1: What materials is the microscope made out of?

Now look at the screwbarrel microscopes on the same shelf?

Q2: How do you think these screwbarrel microscopes were used?

STOP 2: Now go in to the main basement gallery. Find the glass cabinet on the left furthest from the door you have just come through. You will see lots of microscopes at the far end of the cabinet.

Look for the microscope sold by Edmund Culpeper in 1725.

Q3: How does light get into this microscope?

Now go to the other side of the cabinet. Look for the replicas of Leeuwenhoek's microscopes. Antoni van Leeuwenhoek saw microbes through microscopes like these.

Q4: In what ways is Leeuwenhoek's microscope different to the others you have seen?

Also look at the John Cuff microscope of 1745

Q5: How could Cuff's microscope be adjusted?

MHS Education Resources
The World Through a Microscope

STOP 3: Now leave the basement and take the stairs to the ground floor. Enter the main gallery and go to the left of the main doorway. Here you will find the collection of the Royal Microscopical Society. Look at the cabinet between the windows. On the top shelf you will see various microscopes built by Culpeper.

Q6: What types of microscope did Culpeper make and sell?

Now look in the large cabinet against the end wall. Look at the top shelf. On the right you will find a microscope built by Ross (no.3). This was one of the first microscopes to use the special lenses designed by J J Lister. These lenses gave a clearer image.

Q7: What materials are used in Ross' microscope?

Q8: What year was the Ross microscope built?

Look at the other microscopes in the same cabinet.

Q9: Write down some the names of some of the other microscope builders of the 1800s.

Q10: What changes took place in the building of microscopes from 1700 to 1841?

That is the end of this short guided tour of the microscope collection. Before you return to the Education Room, you may like to look at some of the other instruments and objects in the Museum's collection.

Evaluation: The World through a Microscope

Please let us know what you think:

Circle the appropriate response to each statement. Add a comment if you wish.

- 1 The information provided before the visit was
sufficient/adequate/insufficient

comment:

- 2 The accommodation in the Education Room was
suitable/adequate/unsuitable

comment:

- 3 The presentations were
excellent/good/satisfactory/poor

comment

- 4 The activities were
excellent/good/satisfactory/poor

comment:

- 5 The guided visit to the displays was
excellent/good/satisfactory/poor

comment:

- 6 The printed pack was
excellent/good/satisfactory/poor

comment

- 7 Please consider the four sections of the pack
Part 1: Mr Hooke and his microscope
interesting/uninteresting

relevant/irrelevant

- Part 2: Simpler is better
interesting/uninteresting

relevant/irrelevant

- Part 3: Family Entertainment
interesting/uninteresting

relevant/irrelevant

- Part 4: The Microscope in Science
interesting/uninteresting

relevant/irrelevant

Thank you.