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The Nature of Science: Scurvy - the mystery disease

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Scurvy – The mystery disease

Teachers' notes

Objectives

- To understand the scientific method and how it has developed over the years.
- To learn about how scientists worked in the past.
- To understand that vitamins are essential for a healthy body.

Outline

This activity only requires a brief introduction and then the class can work thought it independently. It should be emphasised that early scientific theory depended on careful observation fitting in with the common theories. No experiments were carried out. Modern scientific thinking requires theories to be checked out by carefully designed experiments. In this piece of work it is possible to see how scientific method developed over 400 years.

Teaching topics

This activity is suitable for 14–16 year olds. The students will need the following pre-knowledge:

- Oranges and lemons are acidic
- Acids react with alkali to make neutral substances
- The meaning of a control experiment.

It could be included in a unit on acids and alkali or as an introduction to investigating which foods contain vitamin C.

Background information

Science, technology and medicine

Throughout history, the study of medicine has been considered to be very important. 5000 years ago many of the medicines were based on common sense ideas. However, people also used charms and spells to keep away evil spirits that were thought to cause disease and suffering. Slowly over time a more scientific approach was adopted. This is shown in Figure 6.

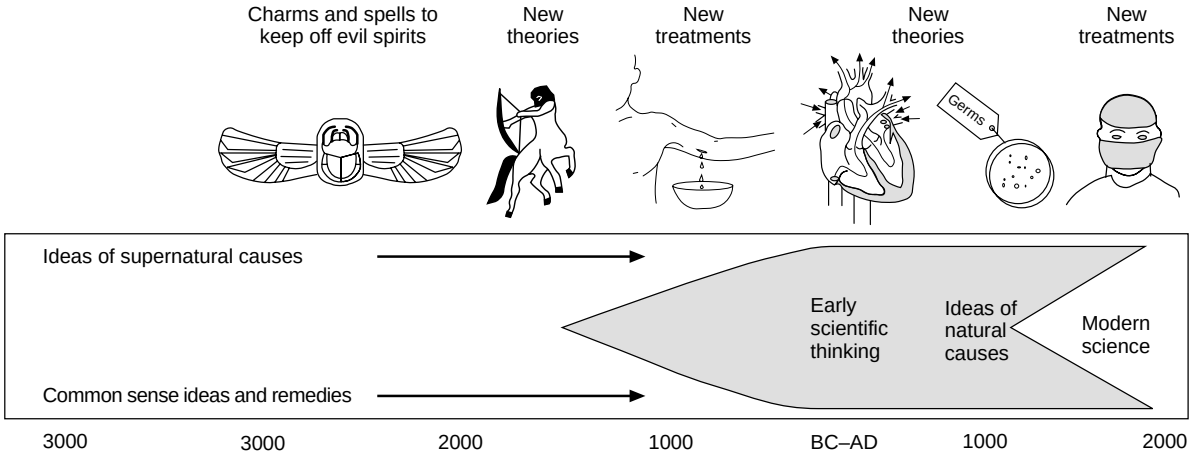

Figure 6 The development of scientific method
(Adapted and reproduced with permission from J. Scott, C. Culpin, *Medicine through time*, Collins Educational, 1996.)

In the 16th century, 'modern science' began. Since then scientists have used it to build up, for example, a detailed knowledge of the workings of the body. They carefully test and check each part of the knowledge so that they can apply the knowledge to problem solving. It is really important for doctors to understand scientific methods so that research can continue.

The diagrams in Figure 6 explain the main difference between early scientific thinking and modern scientific thinking. The change from one to another was quite slow. Some parts of scientific method had been used for a long time, whereas others were not fully understood until the 19th century.

Suggested question

What were the main differences between the two sorts of thinking?

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Figure 7 Scientific thinking
(Adapted and reproduced with permission from J. Scott, C. Culpin, Medicine through time, Collins Educational, 1996.)

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Teaching tips

Approach 1
The students work through the student worksheets, answering the questions.

Approach 2
The students carry out the James Lind role-play. This is an opportunity to include some aspects of the teaching of citizenship. The role-play can be treated as a stand-alone lesson without carrying out the other worksheets.

The James Lind role-play
This should be done before the class have seen the results of James Lind's experiment, otherwise it might influence what the sailors say and the decisions that are made.

Working in groups, the students are to play the role of James Lind and the sailors who are suffering from scurvy. James Lind should have an assistant or two to help him make the difficult decisions.

- Give a 5 minute introduction to the lesson explaining who James Lind was, what the scurvy problem was and how for about 200 years it had been known that eating fresh oranges, lemons and some other foods cured scurvy.
- Divide the class into groups of between 6 and 8.
- Sub-divide the group into sailors and James Lind + assistants.
- Give out the task sheets.
- Allow between 10 and 15 minutes for the sub-groups to read and discuss their task and start to think about possible strategies.
- Give the groups 15 minutes to carry out their role-play.
- One person from each group should report back to the rest of the class about how they decided which sailors would take part in the investigation and who got which treatment. You may find that some groups did not come to a conclusion.
- During the class discussion you need to get the groups to say how they tackled the problem, (*eg* looking for sailors with similar build *etc*. to make the test as fair as possible, consideration of the family background of individual sailors).
- Interviewing James Lind and the sailors is a useful technique for promoting discussion. For example, James Lind could be asked the following questions:
  – How did you decide which sailors to treat?
  – How did you decide which treatments to give to which sailors when you knew that some would work and others may not?
  – Were you worried about the effect some of the treatments could have on the sailors?

  The sailors could be asked the following questions:
  – How did you feel when you first heard about the experiment?
  – What do you think of James Lind?
  – How do you react to seeing other people getting better when you are not?
- The role-play should be followed up by revealing the results of Lind's experiment. This could be done either at the end of the lesson or during the next lesson.
- The class will now be in the position to answer the questions on student worksheet **Scurvy – the mystery disease**. This could prove to be a useful homework exercise.

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Resources

- Student worksheets
  - Scurvy – the mystery disease
  - Task sheet for the sailors suffering from scurvy
  - Task sheet for James Lind and his assistants.

Timing

Approach 1 A 60–70 minute lesson and homework.

Approach 2 A 60–70 minute lesson for the role-play, with a second lesson needed to complete the other sections.

Answers

1500s

1. Explanation 1 fits the theory 'bad air carries disease'. After 12 weeks they had got to a place with bad air. Explanation 2 fits the four humours medical theory.

2. Conditions at sea would have been cold, the sailors became gloomy, depressed and melancholy. It was suggested that they should get more exercise and so the hornpipe dancing was introduced.

3. The four humours theory did not encourage tests and experiments. Medicines were given on a trial and error basis.

4. Acidic medicines such as orange and lemon juice cured scurvy.

5. See if any non-acidic fruits or herbs cured scurvy.

1600s

1. By carrying out careful measurements Sanctorius discovered that people lose and gain weight all the time, regardless of the balance of the four humours.

Sanctorius knew that he caught the skin disease from a glove and not because the balance of the four humours was wrong.

1700s

1. Lind thought scurvy was an alkaline disease.

2. Yes, group 4 were not given an acid but seawater.

3. Yes, they all had the same menu. Only the treatment was varied, but he did run out of oranges after a week.

4. He needed more evidence to draw firm conclusions. There were only two people in each group and not all acids cured scurvy.

5. Have larger groups, run the experiment for a longer period of time.

6. Lind based his theory on the work of Sanctorius and the bad air disease.

7. Yes

8. Try out the experiment in warm, dry conditions.

9. The conditions were not the same, maybe the oranges and lemons were not very fresh.

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1900s

1. **(a)** Holst predicted that feeding guinea pigs on a diet of polished rice would give them beri-beri.
   (b) Holst observed the symptoms of scurvy rather than beri-beri.
   (c) Holst thought that giving the guinea pigs orange and lemon juice would cure the scurvy.
2. Guinea pigs are mammals and more like humans than birds.
3. Firstly they gave the guinea pigs scurvy by feeding them polished rice and then they fed them with one type of food such as cabbage or lemon juice to see if the scurvy was cured.
4. A deficiency disease is when you become ill because something is missing form your diet.
5. I would accept Holst's theory because all the experiments show that when certain foods are left out of the diet, the guinea pigs got scurvy and when they were replaced the guinea pigs got better. Boiled milk was the reason why the babies of the rich were getting scurvy in the 1800s. Holst's theory did not give any evidence that suggested a scurvy bacteria.
6. Vitamin C contains carbon, hydrogen and oxygen atoms.
7. Citrus fruits, green vegetables and potatoes all contain vitamin C.

Scurvy – the mystery disease

Understanding scurvy, a problem for over 400 years, saw many changes in scientific thinking and method.

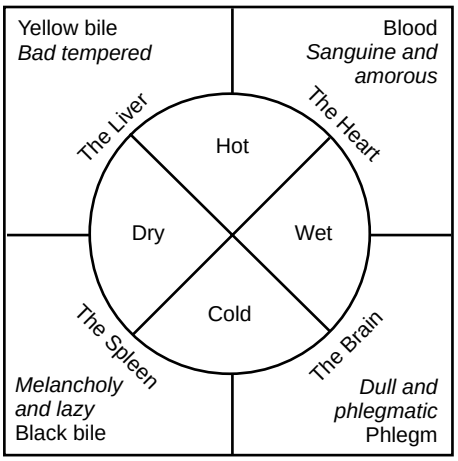
The story began in the 1500s

The Great Harry, one of Henry VIII's ships
(Reproduced with permission from the National Maritime Museum Picture Library.)

After 12 weeks at sea, many sailors got ill. Later the illness was called scurvy. Eating oranges, lemons and fresh food cured the sailors.

Common theories about disease

- Bad air carried disease
- You could get malaria by damp marshes
- You could get flu from being next to someone who had flu
- The four humours medical theory
- Healthy people had a good balance of the four humours.



The four humours theory

Possible explanations for the sailor's illness

- The air at that latitude was bad
- Too much black bile
- An alkaline disease.

The effect of scurvy on the mouth
(Picture: Science Photo Library.)

Questions – 1500s

1. Did the explanations fit the common disease theories?
2. What evidence led doctors to believe there was too much bile?
3. Do you think there was a problem with the four humours theory?
4. What evidence led some doctors to believe scurvy was an alkaline disease?
5. How could they test out the alkaline theory?

The 1600s – a new scientific approach

- Thermometers and balances had been invented and scientists were starting to carry out experiments by doing careful measurements.
- After careful weighing experiments Sanctorious concluded that 'People lose weight by invisible perspiration through the pores on the skin'.
- Sanctorious also caught a skin disease after picking up a glove from a lady who already had the skin disease.

Questions – 1600s

Give two reasons why you think that Sanctorious, along with some other scientists rejected the four humours theory.

1700s – Scotsman James Lind investigates Scurvy

While at sea, Lind gathered together 12 similar looking sailors, all suffering from scurvy. He then divided them into six pairs and gave them the following treatments.

Group No.	Treatment
1	2 pints of cider each day
2	A daily gargle with 25 drops of sulfuric acid in water
3	2 teaspoonfuls of vinegar three times a day
4	Half a pint of seawater a day
5	2 oranges and 1 lemon a day
6	A mixture of nutmeg, garlic, mustard, myrrh and radish root, plus barley water acidified with tamarinds.

Daily menu for a two week trial

Breakfast	Gruel (soaked bread) with sugar
Lunch	Mutton broth
Supper	Barley, raisins, rice and currants

Problem

After a week all the oranges had been eaten.

Results after 1 week

Group 5 were well.

Group 1 were getting better.

Groups 2,3,4,6 showed no improvement.

Results after 2 weeks

Group 1 were almost better.

Groups 2, 3, 4, 6 still showed no improvement.

Lind's interpretation of the results

Oranges and lemons contained a special substance. He called it 'Antiscorbutic'. He thought that the air in a cold wet climate might block up the important pores in the skin through which so much perspiration had to pass. Then the blocked perspiration went bad inside the body, causing scurvy. The oranges and lemons formed a kind of soap with the stale fat in the body which washed out the blocked pores and the scurvy was cured.

At home in Scotland, Lind tried to repeat his experiment, but did not get very good results.

Questions – 1700s

1. Which earlier theory do you think Lind based his experiments on? Explain your answer.
2. Do you think that Lind had a control experiment?
3. Did Lind carry out a fair test?
4. Do you think that he had enough evidence to draw firm conclusions?

5. How could he have got more evidence?
6. Which theories did Lind base his interpretation on?
7. Do you think Lind had a good imagination?
8. What experiment would you do to prove Lind's interpretation is correct?
9. Why do you think that Lind did not get very good results when he repeated the experiment at home?

1800s – Babies of the rich hit by disease

Symptoms

- Sore bodies
- Swollen and bleeding gums
- Swollen legs

Observations

Age: 10–15 months old

Diet: Bread, butter, boiled milk.

1897 American doctors investigate and link this disease with scurvy. They conclude 'they are the same'. A diet of raw cows milk, orange juice and raw beef juice cures the babies.

Meanwhile… Chemists investigated acids, analysed orange, lemon and lime juices and found that they all contained 'citric acid'. Further experiments showed that citric acid was not the 'antiscorbutic' which cured scurvy; neither was boiled juice or concentrated juice effective.

1900s – The scurvy disease still not understood

A new model of disease is needed.

Norwegian scientist, Axel Holst finds the answer to scurvy while trying to solve the problem of beri-beri.

Holst's experiment

Holst knew from work carried out by the Dutch that chickens and humans that did not eat a certain substance that is contained in normal rice but not in cooked or polished rice, became ill with beri-beri. Beri-beri was not an infection, it was not a poison and it did not come from infected air.

At first Holst experimented on pigeons but then he changed to experiment on guinea pigs. He fed the guinea pigs on a diet of polished rice. The guinea pigs began to show more signs of scurvy than beri-beri. After 30 days of polished rice, the guinea pigs were fed lemon and orange juice. The guinea pigs got better.

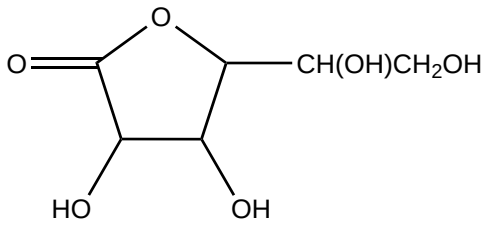
Holst joins up with scientists studying scurvy

Experiments during the next few years showed that the following foodstuffs all stopped guinea pigs from getting scurvy:

- fresh cabbage
- lemon juice
- apples
- milk unless it was heated to 100 °C
- sprouting grains and peas.

Conclusions about scurvy

- It was not an infection
- It was a deficiency disease
- Later, the missing substance was called vitamin C.



The vitamin C molecule

Response to 'The Holst Theory'

Some scientists were convinced and believed the 'deficiency' theory. Other scientists continued to look for 'scurvy bacteria'.

Questions

1. Which part of Holst's experiment would you describe as
(a) prediction
(b) observation
(c) clear thinking?

2. Why do you think Holst decided to use guinea pigs instead of pigeons?

3. How do you think the scurvy scientists carried out their experiments with cabbage etc?

4. What is meant by a deficiency disease?

5. From the evidence presented, how would you respond to the 'Holst Theory'? Give reasons for your answer.

6. What elements are in the vitamin C molecule?

7. Which foods contain vitamin C?

Task sheet for the sailors suffering from scurvy

1. You have heard that James Lind is looking for a cure for scurvy. Apparently he wants some of you to take part in the experiment. What is your first reaction? Do you want to be involved?

2. The rumours say that some treatments are a lot nicer than others. Everyone knows that fresh oranges and lemons cure scurvy. If he uses oranges and lemons in his experiment then you will be cured. How can you make sure that you get the oranges?

3. How do you feel about using other treatments? No one knows if they will work.

4. James Lind has arranged a meeting for all the scurvy sufferers at 2 p.m. on the deck. What are you going to say to him, when he tells you about the investigation? Will you help or is the risk not worth it?

Task sheet for James Lind and his assistants

- You must tell the sailors that you are going to investigate scurvy. You think that scurvy might be an alkaline disease and so you intend to try different acidic treatments. It is well known that oranges and lemons cure scurvy.
- You must tell the sailors about how you intend to carry out the investigation. Details are given below for the two week trial. Each group consists of two sailors.
- You must decide which sailors are to take part in the experiment.
- You must decide which sailors are to be given each treatment.

Group No.	Treatment
1	2 pints of cider each day
2	A daily gargle with 25 drops of sulfuric acid in water
3	2 teaspoonfuls of vinegar three times a day
4	Half a pint of seawater a day
5	2 oranges and 1 lemon a day
6	A mixture of nutmeg, garlic, mustard, myrrh and radish root, plus barley water acidified with tamarinds.

Daily menu for a two week trial

Breakfast
Gruel (soaked bread) with sugar

Lunch
Mutton broth

Supper
Barley, raisins, rice and currants