

SCIENTIFIC METHOD

Scientific Method / what is science?

This is a discussion session that should last approximately 45 minutes to an hour.

The questions in this resource sheet have been developed to allow you and your students to discuss some of the social and philosophical elements of science. The notion of science has changed dramatically since ancient times. Of course in those days it was all classed as philosophy, whereas now a distinction is often made between science and philosophy.

Remember that a discussion is an opportunity for the students to express themselves. In your role as a facilitator it is important that you listen carefully and try to include everyone in the discussion. You, and your students, may find it useful to summarise the discussions at the end. How you do that very much depends on how the discussion has progressed: you may find a surprising amount of consensus or difference; or perhaps you've realised that your students need to do some research to be able to answer the questions. We'll leave the summarising up to you!

Discussion question 1 Who are the scientists?

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Instructions to the facilitator

- As a whole group, ask the students to identify the scientists either from the play or from the table above.
- Ask them why they call them scientists or not.
- Talk about the different techniques they used.
- This should lead onto discussion question 2.
- If the discussion is happening before the students have seen the play, you can go straight to question 2.

Discussion question 2 What is science?

Instructions to the facilitator

- On a scale ranging from 'not science' to 'science' students are asked to place various topics: astrophysics, psychology, economics, sociology, astrology, history, biophysics, genetics, etc.
- Ask them to explain why they have placed the different topics at the different places on the scale.
- You may find it useful to get students to hold the cards and move physically as the rest of the group discuss the question. We will return to the scale later to see if the discussion has changed their opinion.
- Remember there is no right answer to this question - philosophers still argue about it today! As a broad rule, science is about understanding the natural world and making predictions.

Discussion question 3 Ancient science today

How would you test some of the old ideas about how the human body worked, today?

Instructions to the facilitator

- Print out the scenarios and separate.
- Divide the students into small groups and give each group a scenario. You will find that there will be more than one group for each scenario.
- Allow the students time to discuss how they would test the ideas today. You may want to wander through the groups and listen in, or help individual groups.
- Taking each scenario in turn, go through the experimental techniques and ideas the students had.
- Encourage discussion and links between the different scenarios.

(Teacher's copy)

Scenario 1

In Ancient Greece, Aristotle thought that male sperm acted on the female menstrual blood to form the foetus. Aristotle had noticed that menstrual bleeding stopped during pregnancy but he would not have known what menstrual blood was. By this thinking, the sperm imparted all the shape and form of the baby. All that the woman contributed was the 'stuff'.

Around this time it was thought that life came from dead matter: they would see something dead, then maggots would spontaneously appear (or so it seemed).

What would you do to test Aristotle's ideas today?

(Consider: Remember, Aristotle was primarily a thinker, not much of a practical scientist. What evidence do you need? Why do babies look like a mixture of both parents if only the male shapes the baby? What instruments or techniques do you need to investigate?)

Scenario 2

William of Conches thought that women were cold and inferior to men who were hot and superior. He thought that it was this coldness that caused menstrual bleeding. The bleeding came, not from the womb lining, but from undigested food (women being unable to digest all the food because of their coldness). William's explanation for menstruation stopping during pregnancy was because the heat of the man's seed resulted in all the food being digested. This meant there was no excess food to expel. The full digestion of the food ensured the nourishment of the developing foetus.

What would you do to test William's ideas today?

(Consider: testing the menstrual blood to see if there is undigested food in it, or what it's made from. Does men's seed have the power to digest food outside the body? Are men and women hot and cold?)

Scenario 3

Aristotle believed all matter is made from four elements: Earth, Air, Fire and Water. These elements all have their place:

Fire is above

Air which is above

Water which is above

Earth

Aristotle used this hierarchy of the elements to explain how inanimate things moved. He suggested that everything had its natural order. For example earth moves downwards most strongly, water flows downwards too, but not so strongly, since a stone will fall through water. In contrast, air moves up (bubbles in water) and fire goes upwards most strongly of all, since it shoots upward through air. This general theory of how elements move has to be elaborated, of course, when applied to real materials, which are mixtures of elements. He would conclude that wood, say, has both earth and air in it, since it does not sink in water.

What would you do test for the four elements and to see if they really do have a natural order? You might find it easier to think about a specific example, for example heating water in a pan.

(Consider: how do you explain things not obviously made from only one of the four elements e.g. wood = earth + air because it floats. Is there ever a time where the four elements occur in a different order? Can these four elements be broken down into different things? What movement would you expect to see if you combined the elements?)

Scenario 4

Pliny the Elder wrote that “terrible things are told about the monstrous power of menses, whose magic I have already discussed, of which I can repeat the following without embarrassment: if the female force begins to flow in a solar or lunar eclipse the harm will be irremediable... But at other times during the menstrual period, if the women walk naked through a field, worms, beetles, and other pests fall down. Metrodorus of Scepsis says that this was discovered in Cappadocia during an infestation of cantharid beetles, so women walk through the fields with their dresses hiked up above their buttocks.”

Pliny the Elder also suggested that fruit would fall off trees, hives of bees will die and bronze immediately goes rusty should there be contact with a menstruating woman.

How would you test Pliny’s ideas today?

(Consider: repeat testing, ethics,)

Discussion question 4 What can you use the scientific approach for?

In this exercise the students are invited, as a group, to work out which of the situations would be appropriate for a ‘scientific’ study. By that we mean having a hypothesis, repeat testing, collecting observable results, controlling variables and making predictions from the results.

Instructions to the facilitator

There are three situations.

- Ask the students to work out if they can be tested using a scientific approach.
- If they are not sure, ask them to identify the hypothesis, the variables, what they’d be measuring and what they could predict from the results they collected.
- You could do this discussion as a whole or in small sub groups.

(Teacher's Copy)

Situation 1: Medical Trial

A new drug for breast cancer which has been through lab and non-human animal testing needs to be approved for license.

(Consider: hypothesis -the drug will reduce/eliminate the cancer. Testing - cancer is physically smaller, other blood tests. Variables - can you get a large number of identical people, some with identical cancer, some who are healthy? What are the variables, how do you accommodate for them? Variables could be: age at which cancer detected, stage of the cancer, health of the individual before cancer, gender, diet, other medicines, genetic makeup of the individual.)

Situation 2: Public Education campaign to get young people to use condoms

The government wants young people to use condoms to reduce the number of teenage pregnancies and the spread of diseases.

(Consider: hypothesis - that the campaign will make young people use condoms. Testing - how do you know if the success (assuming there is a reduction in teen pregnancies/disease) is down to increased condom use, or some other cultural change eg young people having less sex? Can you get observable results? Can you get two groups of identical people and give only one group the ad campaign? Is that ethical? What are the variables - age, health, wealth, social status, ad placement, cultural attitudes to sex and sexual health?)

Situation 3: a new widget for a car

Ferrari have developed a new widget which they hope will make their car reach higher speeds.

(Consider: hypothesis - the new widget makes the car go faster. Testing - can you measure the top speeds accurately enough? Can you control the variables (two cars - one with the widget, one without)? What about the driver, air temperature, time of day, humidity, wear and tear on the vehicles...)

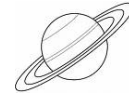
Discussion question 5 What is science?

- Return to the scale and review the positioning of the topics on the scale.
- Try to come up with a definition of what science is and decide if there is such a thing as 'the scientific method', or what the commonalities are between all the topics placed at the science end of the scale.

Discussion Questions 2 & 5



PSYCHOLOGY



ASTROPHYSICS



ECONOMICS



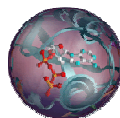
SOCIOLOGY



ASTROLOGY



HISTORY



BIOPHYSICS



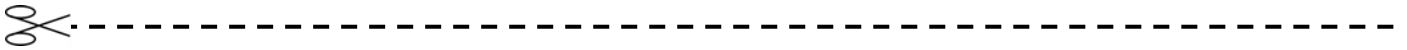
GENETICS

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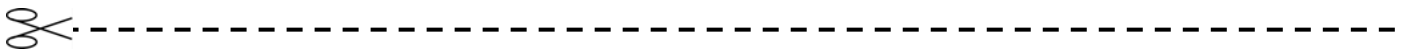
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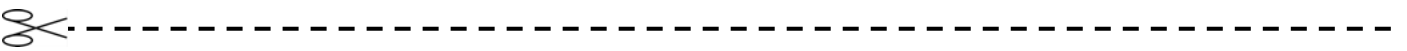


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