Activity G

Planet X

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Introduction

Students investigate how similar a fictitious planet, Planet X, is to Earth. Tasks are arranged as a circus, each presenting evidence in text, pictorial or practical form. The plenary can be used to discuss the results and draw evidence together to form a more detailed picture of what Planet X may be like and whether conditions are similar enough to those on Earth to allow habitation.

Objectives

Pupils will learn:

- about mass and weight and the units of measurement;
- that gravity is not the same on different planets;
- how scientific data/observations can be used to support hypotheses and conclusions.

Outcomes

By the end of the lesson, pupils will be able to:

- record accurately and compare data for Planet X and Earth;
- give reasons why they think Planet X is or is not like Earth and might be habitable;
- evaluate the strength of evidence for Planet X being like Earth.

Notes for Teachers

The introduction should set a suitable (and believable) scenario, for example that a new planet has been discovered by a space probe. Scientists would like to establish how like Earth this new planet might be and whether there might be a chance that human beings could live there. The situation is not unlike that when NASA analysed data obtained from the Voyager space probe from Titan, the bright moon of Saturn, and established that it had a number of features in common with Earth. Additional materials (e.g. a slide show of pictures of planets and one of Titan) may be used to make Planet X more real. Pupils are asked to reflect on the characteristics that they would look for to establish whether the new planet is like Earth and whether it might sustain life. The subsequent sorting into groups of 3 or 4 to carry out the circus should be done quickly. Remind pupils of rules for this circus (i.e. you leave the station as you find it). An example of what to look for at each station and what should be recorded and discussed is provided as the first worked example on the pupils' recording sheet (pupil sheet 1). This can be shown to the class as an OHT before they start the circus. Help should be given at stations of the circus according to pupils' abilities and progress. The plenary can be made more exciting and productive by randomising the order for reporting back.

Notes for each station in the circus (including background science)

Station 1 (Mass)
Students read the text on the instruction card (see below) and consider the nature of mass; that it stays the same wherever you are, because mass only depends on the amount of matter/stuff that something is made from. They look at a can of food and say what its mass would be on Earth and on Planet X.

Same on Earth/Planet X, inconclusive (but correct piece of knowledge) and not helpful in deciding if X is habitable.

Station 2 (Oxygen content of the atmosphere)
A bell jar (heatproof glass) of a suitable size is placed over a lit candle (tealight). The time it takes for the candle to use up the oxygen (which should be about 12 seconds) is timed and compared with the time for Planet X provided on the instruction card (see below). Some pupils will inevitably fail to exchange the spent air from a previous experiment and may obtain shorter duration. Nevertheless, most pupils should see that the time is very different to Planet X. Further discussion could include the suitability of the experiment to determine the atmospheric composition of Planet X (tests only for oxygen, but atmosphere could have lower pressure or contain other toxic components etc.)

Shows that Planet X is different to Earth and quite conclusive (although debatable to some degree). It is not conclusive evidence that Planet X could sustain life as we would have to know more about other (toxic) components of the atmosphere. It is also possible that respiratory aids or artificial atmospheres in housing would be needed?

Station 3 (Falling)
A piece of plasticine on some nylon fishing line is dropped into a clear plastic tube filled with water. The time it takes the piece of plasticine to reach the bottom of the tube is timed. The card at the station gives a longer time for the drop in an identical experiment conducted on Planet X.

The result shows that Earth and Planet X are not alike. The more able students may work out that gravity must be less on Planet X. This could be used in conjunction with data from station 5 to determine that gravity is indeed less on Planet X. The result could also show that the density of the atmosphere is different to Planet X. The evidence does not tell us whether the planet is habitable.

Station 4 (Boiling point of surface liquid)
The instruction card shows a boiling kettle – alternatively pupils could boil a kettle containing a thermistor probe. The card tells them that the boiling point of liquid found on Planet X is lower than that of water on Earth.

The evidence shows difference to Earth and is conclusive at first sight.
The results, however, do not prove that the liquid on Planet X is not water as the atmospheric pressure on Planet X may be different. So the results are not conclusive as far as living on the planet is concerned. It might be possible to extract (distil) water from the liquid on Planet X. This would require evidence from further tests of the liquid.

Station 5 (Weight-Gravity)
Pupils examine three tins of baked beans that have been suspended from a forcemeter adjusted to show different weight. They appear to weigh a different number of Newtons (this is suspension of disbelief or a simulation, if you will). It is important that pupils grasp the difference between weight and mass for this purpose.

The weight is different and this is conclusive proof that the two planets are unlike. This result can be compared with data from station 3 and may be used in the discussion of results from station 6. Since there appears to be more gravity than on Earth's moon, and people can on the moon, it is not evidence that people could not live there – though the effects of low gravity on human physiology has to be taken into account.

Station 6 (Helium Balloon)
Pupils study two pictures of a helium balloon on Earth. The text on the instruction card tells them that this balloon would not fly, but would sink to the ground on Planet X.

This is different and conclusive evidence that Earth is different from Planet X. The discussion here could centre on whether this result is due to differences in atmospheric pressure (density) or to differences in gravitational force? Other experiments and observations show that the gravity is less on Planet X (e.g. falling weight in station 3). Therefore, it is likely that there is a difference in atmospheric pressure (also supported partially by results on oxygen content). As far as living on the planet is concerned, the effects of very high pressure would need to be explored in terms of their effects on human physiology, but it is likely that this would pose problems for humans (e.g. lungs could collapse).

Station 7 (Source of light)
Pupils are told that Planet X goes around one star, which is its source of light.

Of course, this is not conclusive as most planets go round a star (except in binary star systems). The evidence shows that Planet X and Earth are similar but we would need to know something about the nature of light (its spectrum) to establish whether the light source could support plant life (e.g. to grow food).

Station 8 (length of day)
The length of a day can be timed with a 1 hour timer on Earth by re-winding the timer 23 times (first time is not a re-wind – some pupils may point this out). On Planet X this is different.

This is conclusive evidence that the planet's spin around its axis must be different to Earth's. Discussion points could include the size of planet, rate of rotation (both unknown) and that the planet could be less dense and bigger than Earth. The evidence does not show that humans could not live there. You could talk about life at or near the poles on Earth where there can be 24-hour days and nights.

Teaching Sequence

- The teacher introduces the context - Planet X is a recently discovered planet. In order to see how like Earth it is and if it might be habitable a number of sources of evidence must be considered.

- The class is split into groups and each one assigned to a starting station. Pupils go around the circus collecting evidence (using pupils' sheet 1) deciding the extent to which evidence shows that Planet X is like Earth and is habitable.

- Each group reports back on findings from their starting station (randomise to maintain motivation). Afterwards, or during this, evidence can be discussed.

Pupil activity sheet 1: Planet X **Complete the table below. The first row is completed for you as an example of what to write.**

Evidence on	Result for Planet X	Result for Earth	How similar is Planet X to Earth?	Is evidence conclusive?	Is there evidence that we could live on Planet X?
Shape	Round viewed from space – a sphere	Round viewed from space – a sphere	Same	No. Most known planets are spheres	Cannot tell. Habitable and uninhabitable planets are spheres
(1) Mass					
(2) Oxygen					
(3) Free fall					
(4) Liquid					
(5) Weight					
(6) Helium balloon					
(7) Source of light					
(8) Length of day					

Station 1: Mass

The mass of an object is measured in grams or kilograms. The mass of an object remains the same wherever it is.

For example, an object with a mass of 100g on Earth will have a mass of 100g on Planet X or in space.

- What is the mass of the can of food at this station?
- What would its mass be on Planet X?
- Is this evidence that Planet X is like Earth?
- Is this evidence conclusive in deciding if Planet X is like Earth?
- Does this evidence tell you whether you could live on Planet X?

Station 2: Oxygen content of the atmosphere

You will find some matches, a candle, a jar and a timer/stopwatch. The aim of the experiment is to measure the time a candle can burn in a sample of air on Earth so that you can compare this with figures from a similar experiment conducted on Planet X.

Light the candle and let it burn for a little while (until you can see some liquid wax near the wick). Take the jar, fill it with air (by carefully wafting it around) and cover the candle with it. Start the stopwatch/timer as soon as the jar is over the candle. Stop the stopwatch/timer when the candle goes out. Record the time it burned for.

The result from a similar experiment on for Planet X was 7 seconds.

- What does the result show?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide if you could live on Planet X?

Station 3: Falling

You will find a perspex tube filled with water, a stopwatch and a plasticine ball attached to some nylon fishing line. The aim of the experiment is to measure the amount of time it takes for the plasticine ball to fall to the bottom of the tube. The experiment helps you see how long it might take something to fall to the surface of Planet X through its atmosphere.

Carefully pull at the cord and lift the plasticine ball up to the water surface (no need to take it out of the tube). Get ready to time the ball's decent.

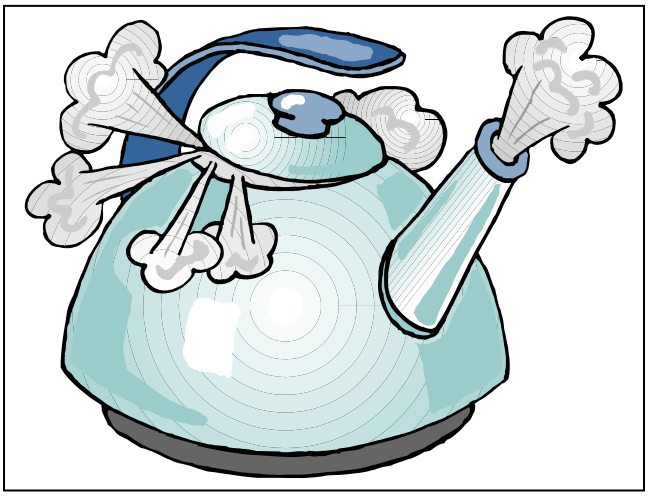
Let go of the yarn and measure the time it takes for the ball to sink to the bottom. If the yarn snags, ask for help or repeat the measurement.

Repeat this experiment at least once more. Are the times taken roughly the same? Take an average of the times.

The time taken on Planet X was 20 seconds.

- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide if you could live on Planet X?

Station 4: Boiling point of a liquid from Planet X



On Earth the liquid (water) in a kettle boils at 100 °C.

A liquid was boiled on Planet X. Its boiling point was found to be 85 °C.

- Does this prove conclusively that the liquid on Planet X is NOT water?
- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide if you could live on Planet X?

Station 5: Weight

You will find 3 identical cans of baked beans.

Each can is hanging on a force meter to show you what the force of gravity on each can would be like in three different places. Imagine that:

Can A is on Earth's moon.

Can B is on Earth.

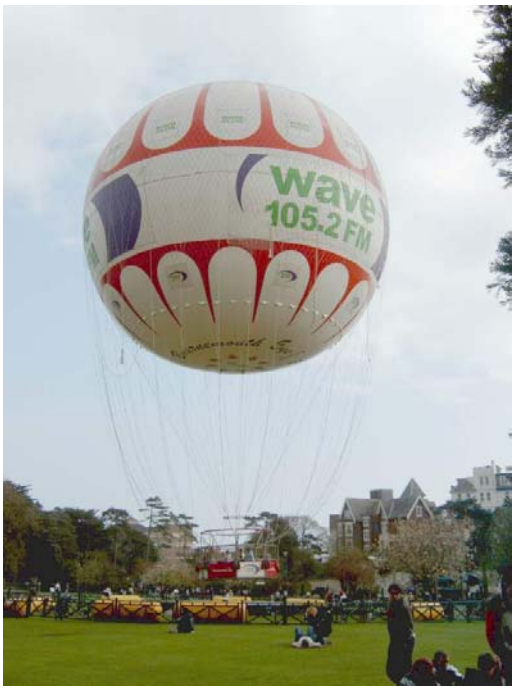
Can C is on Planet X.

- Given that the mass of the tin of baked beans is the same in all three places (because mass never changes), what does the difference in weight tell you about Planet X (compared with Earth)?
- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide if you could live on Planet X?

Station 6: Helium balloon

The pictures below show a helium-filled balloon on Earth. It is used as entertainment for tourists and reaches heights of 50 meters quite quickly. It is tethered down for safety in picture 1.

Picture 1



Picture 2

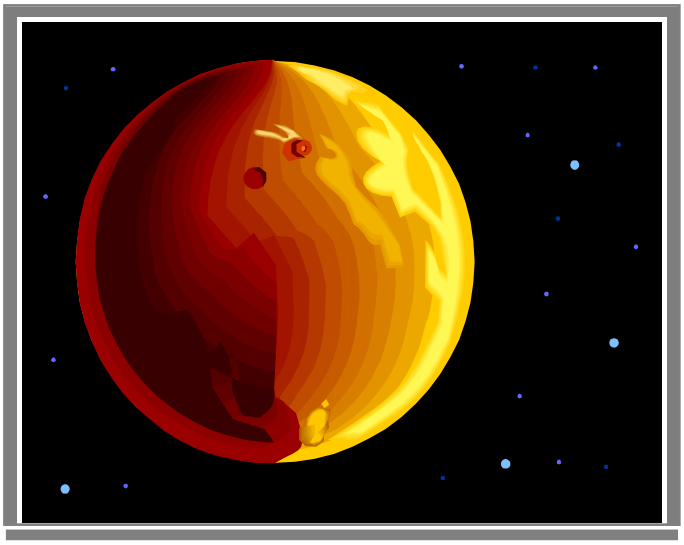
On Planet X, the same balloon would fall to the ground when released.

- What does this tell you about Planet X?
- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide if you could live on Planet X?

Station 7: Source of light

The Earth's source of light is the sun. Earth revolves around the sun in an orbit.

A sun also lights Planet X.



- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide of you could live on Planet X?

Station 8: Length of day

If you had one hour and you measured the time it took from dawn to dawn, how often would you expect to have to rewind the timer on Earth?

A visitor to Planet X would have to rewind the timer 20 times.

- How long is a day on Planet X?
- Does this show that Planet X is like Earth?
- Is this conclusive evidence that Planet X is like Earth?
- Does this result help you decide of you could live on Planet X?