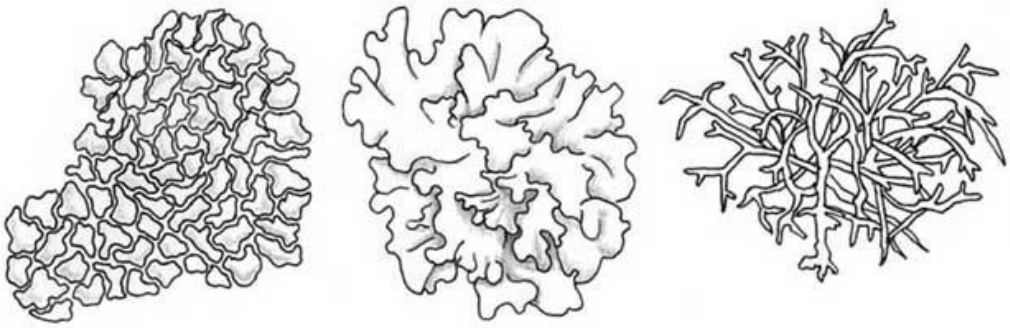
PISA Style Scientific Literacy Question

Lichens

Lichens are unusual organisms. They are actually two organisms living very closely together. The main body of the lichen is made up of a fungus, and cells of an alga are found living within the fungus. This partnership benefits both the fungus and alga.

There are three main types of lichen :



Lichens can be found growing on tree bark, rocks and stones, and other objects made of stone such as buildings and gravestones.

Lichens obtain the minerals and water they need from the atmosphere and from rain. These substances are absorbed directly into the lichen through its surface. This makes lichens very sensitive to air pollution, in particular sulphur dioxide.

This sensitivity makes lichens very good biological indicators of air pollution. Different types of lichens are sensitive to different amounts of pollution. Fruticose or shrubby lichens are extremely sensitive and will only grow in very clean air. Foliose or leafy lichens can tolerate a small amount of air pollution, and crustose (crusty) lichens can survive in quite polluted air. If the air is very polluted no lichens may be present.

Studies have observed patterns of lichen growth in zones around towns and cities and industrial areas which usually have the highest levels of air pollution.

Question 1 : LICHENS

Shrubby and leafy lichens are not usually seen in areas where there are high levels of air pollution. Which is the most scientific explanation for this according to the information given in the passage?

A Shrubby lichens are bigger so they stand out against the grey colours in industrial areas and can be eaten by predators
B There are fewer trees for lichens to grow on in industrial areas
C Shrubby lichens have a larger surface area so they absorb more sulphur dioxide pollution from the air which prevents them from growing
D People clean the lichens off their stonework in towns and cities

Question 2 : LICHENS

Students from Ysgol Gyfun Cwm Gwyrdd have been asked to investigate the link between lichen growth and air pollution. They decide to survey the types of lichens growing in their town. Which method will give them the best results?

A Survey the types of lichens found in the town centre, and in the countryside 5km outside the town
B Survey the types of lichens found in the town centre, and 1km, 2km, 3km, 4km and 5km from the town centre.
C Survey the types of lichens in the town centre only
D Survey the types of lichens found in the countryside only

Question 3 : LICHENS

The town centre of Cwm Gwyrdd experiences very high levels of sulphur dioxide pollution from vehicles during the rush hours.

Circle 'yes' or 'no' to the statements in the table below.

Types of lichens that will be found in the town centre of Cwm Gwyrdd	**Yes or No ?**
Crustose (crusty) lichens	Yes / No
Foliose (leafy) lichens	Yes / No
Fruticose (shrubby) lichens	Yes / No
No lichens present at all	Yes / No

Question 4 : LICHENS

There is a large industrial estate on the edge of the town of Cwm Gwyrdd. What pattern do you think the students will see in the results of their survey ?

Pattern _____
_____
_____

Explanation _____
_____
_____

Question 5 : LICHENS

Studies have shown that pollution levels in towns and cities have reduced over the last 30 years.

Give two possible explanations for this.

Explanation 1 _____
_____

Explanation 2 _____
_____

SCORING : LICHENS

Question 1 : Lichens

Full credit :

C Shrubby lichens have a larger surface area so they absorb more sulphur dioxide pollution which prevents them from growing

No credit :

Other responses

Missing

Narrative

This question asks students to base their choice on information from the passage, so statements that cannot be supported by information in the passage will not be correct.

Shrubby lichens are bigger than other types of lichens and so they may be more visible, but the passage does not mention anything about predators, so this statement is not correct.

There may be fewer trees which might affect the numbers of lichens, but there is no reference to numbers of trees in the passage, and there is a better, more scientific explanation in the list.

The larger surface area of the shrubby lichen is the most scientific explanation for its distribution. The larger the surface area, the greater the amount of sulphur dioxide will be absorbed. Sulphur dioxide is known to damage the lichen and stop it from growing. As a result, shrubby lichens with a large surface area are unlikely to be found in areas which have high levels of sulphur dioxide pollution.

People may well clean lichens from buildings and other stonework in urban areas, but the question asks for a scientific explanation. Explanation C is the most scientific of the explanations. There is no reference in the passage to people cleaning stonework either.

Framework Categories	2015 Framework
Knowledge Type	Knowledge of the content of science
Competency	Explain phenomena scientifically
Context	Environmental quality - global
Cognitive demand	Low / medium

Question 2 : Lichens

Full credit :

B Survey the types of lichens found in the town centre and 1km, 2km, 3km, 4km, and 5km from the town centre

No credit :

Other responses

Missing

Narrative

This question focusses on the most scientific method for collecting results in a survey.
Suggestion A is a suitable method, but will only provide 2 sets of results. Students will be able to make a comparison between the two sets of results to draw conclusions, but they will not really be able to find a pattern in the distribution.
B is the best method as it collects a number of sets of results along a transect and will allow the students to make comparisons between the different areas that are sampled and to see any patterns in the distribution.
Methods C and D are not suitable for the survey as they do not allow for any comparison. These methods may allow students to see whether there are lots of lichens or few lichens in a particular area, but it will not tell them whether this is more or less than is found elsewhere. They will not be able to look for patterns either.

Framework Categories	2015 Framework
Knowledge Type	Procedural
Competency	Evaluate and design scientific enquiry
Context	Environmental quality - global
Cognitive demand	Medium

Question 3 : Lichens

Full credit :

No, No, No, Yes in that order

No credit :

Other responses

Missing

Narrative

There will be no crustose lichens in the town centre. Even though they are the most tolerant type of lichen to air pollution, even these lichens are not able to survive in very heavily polluted areas.

There will not be any foliose lichens. These are even less tolerant to sulphur dioxide pollution than crusiose lichens. They can tolerate a small amount of air pollution, but not the amount that would be present in an area with very heavy traffic.

Fruticose lichens are the most sensitive / least tolerant to air pollution. They cannot survive in even a small amount of air pollution. These lichens would not be able to survive in an area which would be heavily polluted by traffic.

Studies have shown that none of the types of lichens are able to survive in areas with high levels of pollution. The most likely answer is that no lichens would be present in a heavily polluted town centre.

Framework Categories	2015 Framework
Knowledge Type	Knowledge of the content of science
Competency	Explain phenomena scientifically
Context	Environmental quality - global
Cognitive demand	Low / medium

Question 4 : Lichens

Pattern

Full credit:

Few or no lichens in town centre, then numbers increase as you go out from the town centre but decrease again as you approach the industrial area.

Few or no lichens in town centre, then see crusty lichens, then leafy lichens and then shrubby lichens as you go out from the town centre, see crusty lichens only, or no lichens again around the industrial area.

Partial credit :

No lichens in the town centre, more lichens as you go further out of the town centre

Not very many lichens in the town centre or around the industrial area

Only crusty lichens in the town centre and around the industrial area

Shrubby lichens only found outside the town centre and away from the industrial area

No credit:

Other responses

Missing

Explanation

Full credit :

Levels of Sulphur dioxide are higher in the town and decrease as you go further outside the town. Levels increase again around the industrial area.

Sulphur dioxide levels decrease as you get further out of town but increase again near to the industrial area.

There are lots of cars in the city centre which are giving out sulphur dioxide. There are less cars as you go further out of town. The factories in the industrial area give out sulphur dioxide.

Partial credit :

There are lots of cars in the city centre.

The industrial area gives out pollution.

No credit :

Other responses

Missing

Narrative

The levels of pollution are likely to be high in the town centre where there is lots of traffic. This is because the combustion of fuel in the engines of vehicles releases sulphur dioxide into the air. This will mean that few or no lichens will be able to survive and grow in the town centre, so only small numbers may be observed and recorded. As you move out from the town centre the traffic should get less and so the levels of pollution will decrease. As a result the students should see the numbers of lichens increasing the further they go from the town centre. This pattern will start with numbers of the least sensitive crustose type increasing, followed by foliose and then fruticose lichens. The question says that there is an industrial area on the outskirts of town however, so the students will expect the numbers of

lichens to start to decrease as they approach the industrial area, due to the pollution from the factories and the increased traffic. The fruticose lichens will disappear first followed by the foliose and then crutose lichens. There may be very few or no lichens present very close to the industrial area depending on how high the pollution levels are. The numbers of lichens will increase again as the students get further away from the industrial area, as the pollution levels will decrease.

Framework Categories	2015 Framework
Knowledge Type	Knowledge of the content of science
Competency	Explain phenomena scientifically
Context	Environmental quality - global
Cognitive demand	High

Question 5 : Lichens

Full credit :

Two different explanations from :

Cars have been designed to give out less pollution

Industrial areas and businesses have moved further out of towns

Public transport systems in the towns and cities have improved

Fossil fuels are being used less for energy production

Alternative energy sources e.g solar, wind power, are being used for energy production

Technology means that factories emit less pollution

Manufacturing industry that creates pollution has declined in the UK

Partial credit :

One explanation from the above list

No credit :

Other responses

Missing

Narrative

The reduced levels of sulphur dioxide pollution are largely due to advances in technology which have reduced the emissions from vehicles (such as catalytic converters, more efficient engines, and the development of cleaner fuels such as unleaded petrol and LPG). These advances in technology have helped to reduce the impact of the increasing numbers of vehicles on the environment. Technology has also helped to reduce the emissions from factories (e.g. cleaner fuels, filters in chimneys etc…). Manufacturing industry has also declined in the UK over the past 30 years and has been replaced by service industries which do not create pollution like heavy industry does. The reduction in levels of pollution observed in towns and cities may also be due to industry, and the traffic associated with it, moving away from town centres to the outskirts.

Framework Categories	2015 Framework
Knowledge Type	Knowledge of the content of science
Competency	Explain phenomena scientifically
Context	Environmental quality - global
Cognitive demand	Medium