

1 Life on Mars

Reading, Speaking, Writing

Work in groups of six.

Here is an essay written by a high school student. It is in six numbered sections.

In your groups, look at one section each. Read your section carefully twice, then, working alone, write a short summary. Use the notes on summary writing to help you.

Read your summaries in sequence (1 to 6) to the whole group. Work together to write a short summary of the whole essay. When it is complete, everyone can read all of the essay. How complete was your summary?

IS IT POSSIBLE THAT LIFE EVOLVED ON MARS?

- 1 Mars has always raised much more interest than any other planet, both from astronomers and from the general public. When we think of intelligent life in another world we immediately think of Martians. But is it just science fiction?

Before we can answer the question of whether life could have evolved on Mars, we must first define what we mean by "life". In a paper about the search for extraterrestrial life in *Scientific American* in October 1994, Carl Sagan said that "life is any system capable of reproduction, mutation, and reproduction of its mutations". This definition allows us to decide whether something we find in the universe counts as a fully evolved life form.

Before anything can become capable of reproducing and mutating, however, it must first develop a complex structure: in our experience this always means an organic (carbon-based) molecular structure. For the purposes of this essay I would therefore like to broaden Sagan's definition to include the kind of complex organic compounds and amino acids which are not yet biological entities but which, in the early period of the Earth, led to real life.

- 2 Chemically speaking, three main conditions are viewed as having led to the growth of life on Earth: water, temperature and atmosphere.

The necessity of water for life is quite an intuitive concept. Water is a fundamental solvent which is required for many kinds of chemical reactions to take place. Then there is temperature. On the Earth, there are some living organisms (bacteria and archaea) which adapt to survive in all kinds of extreme climates. There is, though, something which all organisms fail to do when the temperature is too low: reproduce. This is why freezers can protect food from bacteria. So if the temperature never rises above zero

degrees, life is very unlikely to emerge. The atmosphere, too, has played a fundamental role in the path to life. The atmospheric composition on Earth, before the growth of life, was mainly nitrogen, carbon dioxide, ammonia and methane; there was no oxygen.

Without a layer of atmosphere as there is now, too many cosmic rays would have reached the Earth's surface, thus making it too hot and hostile to most kinds of life. This layer has been created by autotrophic living organisms, capable of synthesising organic matter from simple inorganic matter like carbon dioxide and water vapour through the process of photosynthesis, which exploits solar energy and produces oxygen. The appearance of these living organisms was preceded by the formation, through non-biological processes, of a complex chemical environment composed of a solution of organic matter such as carbohydrates and nucleotides. Proteins, amino acids and nucleic acids are formed from various combinations of these organic molecules. These structures are already very complicated compared to the inorganic compounds which are present throughout the universe.

- 3 But what was the Earth like before it reached the stage when autotrophic organisms emerged and became capable of photosynthesis?

Two major answers to this question are supported by experimental evidence. The first one was an experiment carried out in 1953 by Miller and Urey, who put a mixture of hydrogen, ammonia, methane and water vapour in a bulb and bombarded it with electrical discharges (thereby simulating the ultraviolet rays of the sun, before these are filtered by the ozone layer). After a few days they found that some organic compounds and some amino acids had appeared in the solution. This was an astonishing discovery, even though now we think the Earth's environment was not as simple and hospitable as Urey and Miller imagined.

The second theory is derived from comets. In 1986 the Giotto spacecraft detected the composition of Haley's comet, which contained mostly ice and organic matter. From this observation we could theorise that the bombardment of the Earth by many cosmic particles (a process which ended about 3.8 billion years ago) included comets as well. They could have brought ice, and hence water, to the Earth's surface. Whether organic matter would have survived such a strong collision is still being debated, but it looks as though some of it could have. This could represent the first stage leading to and permitting the development of life.

- 4 Coming back to Mars, scientists have worked on two main elements in trying to study the planet; one was provided by the Viking landers in 1976 and the other by the observation of some meteorites found in Antarctica, particularly ALH84001, which are thought to have come from Mars.

How do we know these are Martian meteorites? First of all, it is very unlikely that they came from planets like Jupiter and Saturn, because their gravitational attraction is too strong. Moreover, the oxygen isotopic composition and the small quantities of atmospheric gases found on these

meteorites are very similar to Martian ones and different from those on Earth. In the meteorites, which were well preserved, scientists have detected traces of carbonate globules, magnetite and iron sulphide particles which are the result of oxidation and reduction processes.

As far as we know, Mars has an atmosphere with a density of 1% of that on Earth, which is composed mainly of carbon dioxide, nitrogen, oxygen, argon and water vapour. Information sent back by the Viking landers suggests that Mars has probably contained water or ice (probably under the ground in the Northern plains), since its surface is furrowed by ancient rivers, valleys and canyons. Now it is too cold and hostile an environment to allow water to remain in a liquid state. As Matthew Golombek (project scientist for the Pathfinder research program) said: "It just seems that everywhere you look on Mars, you see water. At least the evidence of it."

- 5 Moreover, although the Viking seismographs do not indicate any seismic activity now, the planet has volcanoes and craters which were probably once very lively. The Viking landers carried out some experiments to test the soil of Mars and the atmosphere to see if it reacted well, but those experiments, which at first were considered positive, have turned out to be quite disappointing. The experiments measured the gases exchanged between the surface and atmosphere and the organic nutrients of the Earth, to detect whether there are life forms which could eat food and oxidise it, and to detect whether any microbe could absorb radioactive carbon dioxide and carbon monoxide (brought from Earth). The positive results of these experiments were deceptive because these activities could also have been carried out by chemicals and not only by primitive life forms.

At this point of the account it is interesting, I think, to dedicate a few words to the 1997 Pathfinder expedition to Mars. Its 'Sojourner' lander analysed a surface area of Mars which had evidently suffered a catastrophic ancient flood, thereby permitting the study of a variety of different rocks. The analysis revealed mixed rocks called conglomerates, silicon (through the help of alpha-proton x-ray spectrometers), and some iron particles (by means of magnets placed on the spacecraft).

- 6 So, is it possible that life evolved to a certain point on Mars? The short answer is that yes, it is possible. If we accept the broad definition of life, which includes organic compounds, then it is not unlikely. It is even possible that something similar to bacteria or archaea may have evolved. The main problem arises when we come to think of intelligent life. It seems that the conditions that have prevailed on Earth, and particularly the interactions needed at specific times in the history of evolution for life to emerge as it has done here, are very uncommon in the universe. As a result, the probability of finding the same rare event that happened on Earth on a neighbouring planet like Mars is extremely low. Moreover, even if this unlikely event were to have happened, the growth of a technological society like ours would be even more improbable. Even on our own planet, where many different forms of sophisticated and intelligent life have evolved, only one species – humanity – has developed anything recognisable as civilization.

Summarizing

When you need to summarize a text follow these steps:

1. Read the text once to get a general idea of its meaning.
2. Read the text a second time and underline two or three key words in each paragraph that convey the general idea of that specific paragraph. Do not underline whole sentences.
3. Copy the words that you have underlined onto another sheet of paper. Without looking at the text, use the key words to write short sentences to represent each of the paragraphs.
4. Read the text again, to make sure that your understanding of it is accurate.
5. Write your sentences into a proper short summary paragraph. Make sure they don't reproduce the exact words of the original text.

2 Alien life

Speaking

Work in new groups. One group will support the case in the 'Life on Mars' essay (that simple life may have evolved on Mars), another group will argue against it (that life cannot have evolved on Mars). A third group will make the case that more sophisticated alien life may still be hiding on Mars or elsewhere in the solar system.

Prepare your arguments (using additional research if possible), and then use the language in the Useful Language box to keep the debate going.

Useful Language

Giving your opinion

In our opinion...
We strongly believe that...

Disagreeing with an opinion

We don't agree with...
We cannot accept that...
There is no basis for...

Offering evidence

Evidence/research shows that...

Giving an opposing opinion

It has to be considered, though, that...

Nonetheless/Nevertheless,...

Partly accepting an opinion in order to counter it

While it could be said that..., let's not forget...

While it is certainly true that..., this does not mean that...

Even though there is evidence of ..., it would be unwise to suggest this means...

Completely rejecting an opinion

It is foolish to think that...

It would be ridiculous to suggest that...

3 Moon landings**Writing**

Using the help in the box, research and then write an essay about the following question:

Did men really land on the moon in 1969?*Constructing a paragraph*

When writing a scientific essay you should remember to write in a logical and sequential way. Begin each paragraph with a topic sentence that states the basic idea of that paragraph. Then support your statement with evidence and examples. Finish each paragraph with a sentence that leads on to the next paragraph.

First paragraph should not be too long and it should introduce what you are about to write.

Second/third/fourth/etc paragraphs should talk about the issue you are writing about. Make one main point per paragraph, with evidence.

Last paragraph shouldn't be too long and it should sum up what you have written about.

This worksheet is designed for two lessons plus a major homework project assignment, and will take two hours of class time plus several hours outside of class to complete. It is suitable for upper secondary school students who are ready to engage with lengthy writing about popular debates in astronomy.

It will help if you photocopy each part of the text onto several cards and distribute them to the groups.

1 Life on Mars

Reading, Speaking, Writing

Aims

- To learn about the debate regarding the possibility of life on Mars
- To work together to assimilate a long and complex text
- To read and summarize a short passage for others
- To write a summary
- To engage with a model essay

This activity allows students to engage with a long and complex piece of writing in an engaging and interactive way. Divide the class into groups of six. Distribute any extra students around the groups to make groups of seven or eight. In these groups, two students will both work on the same passage and will summarize it independently for the group.

Before students start reading, make quite sure that everyone knows exactly which part they are supposed to be reading, and that they are clear that they need to write a one or two sentence summary of it for the benefit of the group.

Give them plenty of time to read the passage several times and think about the content. You will need to answer questions. It is better to restrict your answers to individuals, even if that means answering the same question several times. Those who can arrive at the meaning without asking will benefit more by deducing the information themselves and then confirming later.

Before anyone starts writing, direct everyone's attention to the help box at the end of the text. As students start to try to write summaries, make sure you are circulating to help them. Most students will probably want reassurance that their attempts are what is required, as well as help with the language.

When all the students have made a good attempt at a summary, get the students to read their summaries out to their groups (so all groups do this at

the same time, without listening to one another), in the order of the original text. Encourage them to ask each other questions to clarify the meaning.

Before returning to the text, get the groups to write their full summaries together. This will basically just involve writing out the six short summaries in sequence, but they will then need to check together that the whole thing makes sense and that the text flows properly. Ask each group in turn to read out their complete summary to the whole class. Point out any differences.

When all the summaries have been read, allow all the students to read the whole essay. This activity is designed to encourage them to read the whole thing quickly in order to clarify the things they didn't understand. There should be no need to set a time limit, as by now the students will be very familiar with the content and will probably not want to take a long time.

2 Alien life

Speaking

Aims

- To discuss the possibility of extraterrestrial life
- To have a lively and stimulating class debate

It will be ideal if the reading exercise takes one whole class, and students can be given an opportunity to research outside of class before the debate begins. Establish the groups before they start the research. It is best to mix up the groups so that each of the three new groups contains some members of each of the reading groups.

Make sure that each of the groups is clear about the position they have to defend: they should not be given a choice, as that leads to complications that can compromise the whole activity. Regardless of their own views, group 1 must argue that limited life may have evolved on Mars, group 2 that no life can have evolved on Mars, and group 3 that more sophisticated life may still be hidden on Mars or elsewhere in the solar system.

Give each group class time in addition to their research time to prepare their case. Remind them not to write out speeches, but to make notes from which they can speak. The group should agree about the order in which to present the points they have to make. Direct everyone to the Useful Language box before you begin.

The debate needs to be well structured. Each group can elect one or two speakers. There is then one short speech by each group, during which nobody may interrupt. After the three speeches, everyone is allowed to ask questions to the other groups. The teacher needs to chair this part of the debate, deciding

who is allowed to speak when and recasting questions and replies in order to maintain the flow and structure of the discussion. When all the questions have been asked and answered, each group may briefly sum up their case.

At the end of the debate, take a class vote. Nobody is allowed to vote for their own team.

3 Moon landings

Writing

Aims

- To learn about the Apollo missions to the moon
- To consider the nature of evidence, and of critical thinking
- To write a thorough essay in imitation of a model

This is project work to be completed outside of class. Students can start by simply putting the words 'moon landings' into a search engine.