Unit 18 · Life and Its Origin

ANSWER KEY · FOR TEACHERS

Full marks 35

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

K · 4

1. nebula
2. reducing
3. panspermia
4. abiogenesis
5. chemogeny
6. coacervates
7. eobionts
8. stromatolites

Each carries 0.5 mark.

2 Label the diagram

K · 3

1. steam rises
2. boiling water ("ocean")
3. sparks (lightning)
4. condenser
5. methane, ammonia, hydrogen, water vapor
6. trap, with a tap

Each carries 0.5 mark.

3 Multiple choice

i. **b.** iron and nickel — K · 1

The core is **iron and nickel**, the densest elements, which sank to the center. Some books give "iron, nickel, zinc and sodium": zinc and sodium are not in the core (sodium is a light element, found in the crust and in sea salt).

ii. **c.** pre-existing life — K · 1

Biogenesis: life comes only from life. (A supernatural power is special creation; non-living matter, spontaneous generation; another planet, the cosmozoic theory.)

iii. **b.** biogeny — U · 1

Biogeny begins with nucleotides joining into nucleic acids, molecules that can be copied. (Chemogeny made the nucleotides.)

iv. **c.** cyanobacteria — U · 1

Cyanobacteria were the first to split water in photosynthesis, giving out oxygen. Sulphur bacteria give out sulphur instead; land plants came over two billion years later.

v. **c.** dust carrying microbes settled in the bend of the neck and never reached the broth — A · 1

The air passed freely, but the dust and the microbes on it settled in the low **bend**. Broth that touched the bend, or a flask whose neck was broken off, soon grew microbes: the broth could still feed them, and the air was there all along.

4 Very short answers

a. MARKING SCHEME — K · 1

✓ About 4.54 billion years.

b. MARKING SCHEME — K · 1

✓ Any two of glycine, alanine, aspartic acid.

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c. MARKING SCHEME U · 1

✓ Oxygen would break the molecules down and microbes would eat them.

5 Short answers

a. MARKING SCHEME U · 2

✓ All living things were created by a supernatural power or God, in the forms they have now.

✓ It is a belief that can't be tested by observation or experiment, so it is not a scientific theory.

b. MARKING SCHEME U · 2

✓ No free oxygen (reducing), its oxygen locked in water and carbon dioxide.

✓ No ozone layer, since there was no oxygen to form it, so ultraviolet reached the surface.

c. MARKING SCHEME A · 2

✓ No: it needs light, so it is photosynthesis (of sulphur bacteria, H_2S in place of water, giving sulphur).

✓ Chemosynthesis uses energy from a chemical reaction without light (e.g. nitrifying bacteria).

d. MARKING SCHEME U · 3

✓ Meat in open, sealed and gauze-covered jars (gauze lets in air but not flies).

✓ Maggots only on the meat in the open jars, where flies laid eggs.

✓ Maggots come from flies' eggs, not meat: against spontaneous generation.

6 Long answers

a. ANSWER U · 4

Chemogeny is the making of complex organic molecules from simple inorganic ones, in the primitive seas and air.

i. As the surface cooled, carbon, hydrogen, nitrogen and oxygen combined into **water, ammonia, methane** and **cyanamide**.

ii. Free radicals such as CH and CH_2 joined into **hydrocarbons** (acetylene, ethylene, methane), and hydrocarbons reacted with steam to give **aldehydes and ketones**.

iii. By condensation, polymerization, oxidation and reduction these gave **simple sugars, amino acids and fatty acids**, and then **purines, pyrimidines and nucleotides**.

iv. With no free oxygen and nothing alive to eat them, they built up in the warm sea, Haldane's **"hot dilute soup"**.

Energy came from the Sun's **ultraviolet** light (no ozone layer), **lightning**, the **heat** of volcanoes and **radioactivity**; ultraviolet gave by far the most.

MARKING SCHEME

✓ Chemogeny: organic molecules from inorganic ones; water, ammonia, methane and cyanamide first.

✓ Hydrocarbons, then aldehydes and ketones.

✓ Sugars, amino acids, fatty acids, purines, pyrimidines and nucleotides, collecting as the hot dilute soup.

✓ Energy from ultraviolet light, lightning, heat of volcanoes (radioactivity).

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b. ANSWER A · 4

Spontaneous generation held that living things arise again and again from **non-living matter**: frogs and snakes from mud, maggots from rotting meat, aphids from plant juice, mice from sweaty rags and grain (van Helmont). Aristotle believed it, and so did most people until the 1800s.

Pasteur's swan-neck flask experiment (about 1859–1862):

a. He boiled meat broth in flasks with long necks bent into an S, and **left them open** to the air.
b. Air reached the broth, but dust and microbes settled in the bend of the neck.
c. The broth stayed clear for months.
d. When the neck was broken off, or the broth tilted into the bend, microbes grew within days.

Conclusion: the microbes came from the air's dust, not from the broth: life comes only from life.
(Redi's meat-and-gauze experiment of 1668 is also a correct answer, for maggots.)

MARKING SCHEME

- ✓ Spontaneous generation: living things arise again and again from non-living matter, with an example (maggots from meat, frogs from mud).
- ✓ Pasteur boiled broth in flasks with necks bent into an S and left them open to the air.
- ✓ Dust and microbes settled in the bend; the broth stayed clear for months.
- ✓ When the neck was broken or the broth tilted into the bend, microbes grew: they came from the air's dust, so life comes only from life.

7 Think

ANSWER HA · 3

No. It shows that **one step**, chemogeny, is possible: the building blocks of proteins form easily from simple gases with energy. It doesn't show how amino acids and nucleotides joined into proteins and nucleic acids, how a molecule came to copy itself, or how the first cell got its membrane. It also depends on the gases chosen: if the first air was mostly carbon dioxide and nitrogen, as many geologists now think, fewer amino acids form.

MARKING SCHEME

- ✓ No: it shows only one step (chemogeny) is possible.
- ✓ It doesn't show how proteins, self-copying nucleic acids or cells formed.
- ✓ The result depends on the gases chosen; the first air may have been mostly CO_2 and nitrogen.

8 Activity: Redi's jars at home

(not marked)

WHAT STUDENTS SHOULD FIND

Maggots appear only in the **open** jar, where flies landed and laid eggs; on the cloth-covered jar flies may lay eggs **on the cloth**, but none reach the meat; the closed jar has none. The cloth lets **air** in, so nobody can say the meat had no maggots because air was shut out (as Needham argued against Spallanzani): the maggots come from flies' eggs, not from the meat, as Redi showed in 1668.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	14	7	3	**35**

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