CHAPTER 3

Understanding of present-day organisms and their environments

Further developments in our knowledge of present-day organisms and the discovery of new organisms allows for better understanding of the origins of life and the processes involved in the evolution of living things

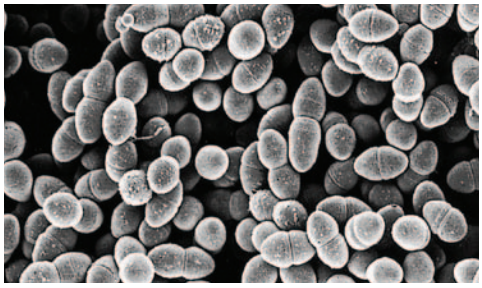
Technology and increased knowledge of procaryotic organisms

3.1

- ***describe technological advances that have increased knowledge of procaryotic organisms***

Structural methods of classifying **procaryotic organisms** in the past have been very valuable (see Fig. 3.1); however, these methods did not always reflect the organisms' possible evolution. New technological advances have changed the way procaryotic organisms are now classified, and increased our understanding and knowledge of biological structures, chemical composition and biochemical (genetic) characteristics of procaryotic organisms, as summarised below in Table 3.1.

(a)



(b)

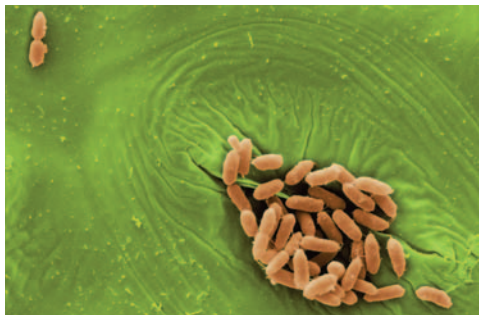


Figure 3.1 Electron micrographs of procaryotic cells: (a) *Streptococcus thermophilus*; (b) *Escherichia coli*

Table 3.1 Technological advances that have increased knowledge of procaryotic organisms

Technological advances	Increased knowledge of procaryotic organisms
Light microscope	■ Ability to identify cells as being unicellular and small (up to 1 micrometre) with a cell membrane and cell wall
Electron microscope	■ Ability to see fine details such as the lack of a nuclear membrane and membrane-bound organelles, the presence of a single strand of DNA and small ribosomes, and that cell division is not by mitosis
Chemical analysis	■ Ability to determine the chemical composition of cytoplasm and membranes ■ Enzymes and photosynthetic pigments are attached to cell membrane ■ Respiratory coenzymes are unique ■ Metabolism of some carbon compounds is different in Archaea than other organisms
Genetic sequencing	■ Determine number of chromosomes
Amino acid sequence	■ Amino acid sequence in proteins and DNA/RNA nucleotides vary ■ Nucleotide sequences of the Archaea RNA are different to bacteria and eucaryotic organisms.

3.2 Environment and the role of organisms in Archaea and Bacteria groups

- ***describe the main features of the environment of an organism from one of the following groups and identify its role in that environment:***
  —Archaea
  —Bacteria

Bacteria have evolved along two main evolutionary lines, classified as super kingdoms—Bacteria and Archaea.

Bacteria

Bacteria are an enormously diverse group that share many environments with, or live on and in humans and other animals and plants. These are habitats of moderate temperature with water freely available, low in salt or other solutes, and where sunlight or organic compounds are plentiful. Oxygen is not so important since many of the Bacteria have powerful fermentation capabilities, producing ATP (adenosine triphosphate) under anaerobic conditions. In fact, the group Bacteria contains almost every variety and combination of biochemical energy extraction and carbon-fixation that is thought to be feasible on the basis of the molecular composition of the biosphere. However, this group also contains some of the most specialised and sensitive cellular organisms known. These are often pathogens that have become highly adapted to particular environments within animal or plant hosts.

Cyanobacteria

Cyanobacteria resemble algae and plants in that they contain chlorophyll and generate oxygen during photosynthesis. They occur as individual cells or as filamentous aggregates of many individual cells joined end to end (see Fig. 3.2). Cyanobacteria contains pigments called phycobilins which give them a blue-green appearance (see Fig. 3.3). Cyanobacteria often form dense mats of growth in shallow marine or estuarine environments.

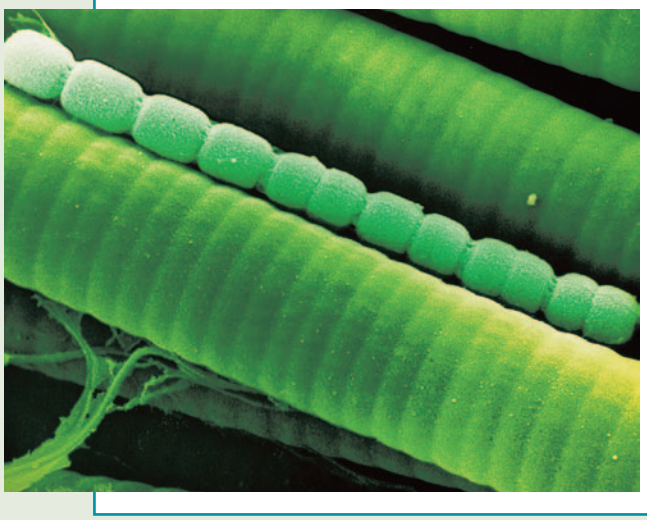


Figure 3.2 Two types of cyanobacteria common in lakes and rivers—*Microcoleus* (large cylindrical form) and *Anabaena* (smaller bead-like filament of cells)

Figure 3.3 Cyanobacterial bloom in Lake Burley Griffin, Canberra

Endospore-forming bacteria

These are bacteria that produce endospores, the most resistant form of life known (see Fig. 3.4). Endospores form inside the mother cell rather than by budding from it. They form under conditions of nutrient depletion or as a result of other environmental signals forewarning difficult times ahead for the bacterium. Endospores appear to have evolved as a resistant, virtually metabolically inactive cell type, increasing the probability of survival under conditions of excessive cold, heat or desiccation. Bacterial endospores are remarkably resistant to high temperature, high radiation and many chemicals (e.g. disinfectants and detergents) which would rapidly destroy all other living cells.

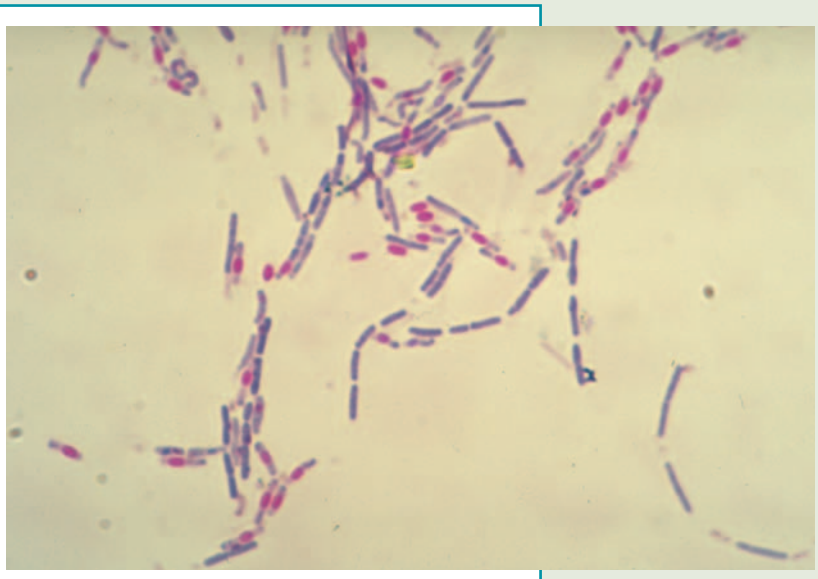


Figure 3.4 Spores of the *Bacillus* species stained red

Archaea

Archaea are still commonly referred to as archaebacteria in scientific literature; however, this term has now been discarded as they are not bacteria. Archaea is a more specialised group than Bacteria and its members are therefore more restricted to the environments they inhabit. Archaea are single-celled, microscopic organisms which do not contain any membrane-bound organelles. They do not require sunlight for photosynthesis, nor do they require oxygen. Most live in extreme environments and are called **extremophiles**; however, some still live in ordinary temperatures, salinities and acid levels. Types of extremophiles are described in Table 3.2.

Figure 3.5 Thermophiles grow in thermal reserves near Rotorua in New Zealand

Table 3.2 Environments of different types of extremophiles

Type of Archaea extremophile	Environment prefers to live in
Thermophiles	Water temperatures greater than 50°C (up to 110°C) or in volcanoes because they prefer the high temperature environments (see Fig. 3.5)
Halophiles	High saline (hypersaline) environments greater than 9% salt concentration (up to 32% salt concentration)
Acidophiles	Acidic environments lower than pH 2 (as low as pH 0.9)
Thermoacidophiles	Hot, acidic environments

Methanogens

Methanogens produce methane as a metabolic end product. They do not necessarily occupy extreme environments and are strictly anaerobic.

Examples of an organism from each of the two super kingdoms above are described in Table 3.3 below, focusing on the main features of their environment and their role within that specific environment.

Table 3.3 Environmental features and roles for organisms from the Archaea and Bacteria super kingdoms

Super kingdom	Organism	Main features of environment	Role in that environment
Archaea	*Methanobrevibacter* (methanogen)	■ Anaerobic environments such as deep soils or bogs, the digestive system of herbivores, and in sediments of marine and freshwater ecosystems	■ Converts carbon dioxide and hydrogen produced from the fermentation into methane ■ Releases methane into the atmosphere contributing to the carbon cycle ■ Plays an essential role in the final steps in the decomposition of organic matter and recycling of carbon in anaerobic environments ■ Those in the digestive system of cattle assist the breakdown of cellulose and aid in digestion
Bacteria	*Oscillatoria brevis* (cyanobacterium)	■ Warm temperature ■ Water freely available (e.g. ponds, streams and soil) ■ Low in salt or other solutes ■ Sunlight or organic compounds are plentiful ■ Oxygen is not so important.	■ Evolve oxygen into the atmosphere ■ Primary producers in the food chain (photosynthetic) ■ Powerful fermentation capabilities, producing ATP under anaerobic conditions ■ Some replace oxygen with nitrate and sulfate ■ Some are also capable of substituting, as a source of energy, reducing inorganic compounds in place of organic carbon.

Similarities in environments past and present

SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P13
P14

TR

Assessment task

■ ***use the available evidence to outline similarities in the environments past and present for a group of organisms within one of the following:***
—Archaea
—Bacteria

Aim

To outline similarities in past and present environments for a group of organisms within Archaea or Bacteria.

Method

Read the information provided in Section 3.2 describing the main features of the environment of organisms from the super kingdoms Archaea and Bacteria. Select your category of Archaea or Bacteria and choose a group of organisms within this category. You may choose the same as presented in Section 3.2. If not, you may select one of your own. A Google search on the Internet of examples of Archaea and Bacteria groups will assist in making your decision. Expand your search of secondary sources by looking at available evidence regarding the *environment* of your chosen group of organisms. Search in particular for information outlining features of both the *past* and *present environments*.

Results

Address the following tasks:

1. Select the group: Archaea or Bacteria.
2. Name of the group of organisms.
3. Indicate the main features that are similar between past and present environments for your chosen group of organisms by completing Table 3.4.

Discussion/conclusion

1. List the main features similar in both past and present environments for your chosen group of organisms.
2. Describe the possible characteristics of the group of organisms that make them suited to these same features of their environment.

Table 3.4 Similarities in past and present environments

Kingdom	Group of organisms	Main features of past environment	Main features of present environment	Similarities between past and present environments

Alternative environments in which life may have originated

SECONDARY SOURCE INVESTIGATION

BIOLOGY SKILLS

P14

■ ***analyse information from secondary sources to discuss the diverse environments that living things occupy today and use available evidence to describe possible alternative environments in which life may have originated***

Aim

1. To analyse information from secondary sources.
2. To discuss the diverse environments that living things occupy today.
3. To use available evidence to describe possible alternative environments in which life may have originated.

Background information

So far we have looked at the extreme and diverse environments that Archaea and Bacteria live in today and also looked at the similarities in their past and present environments. This may provide support in suggesting possible alternative environments in which life may have originated. The large diversity in present-day environments provides varying habitats for a significant proportion of the Earth's advanced multicellular organisms. However, present-day environments are not as extreme as those proposed to exist on early Earth in which life may have originated, and so would not promote the beginnings of early life forms. This suggests a possible reason why we do not see any new primitive life spontaneously forming on Earth today. The diversity of environments may be only available to complex organisms that are suited to them, as opposed to simple organisms that may only really have a small variety of environments to exist in.

However, extreme environments do still remain on Earth to the present day. Archaea still exist in these extreme environments (e.g. hydrothermal vents or volcanoes) and Bacteria in diverse environments (e.g. environments with extreme temperatures or estuarine environments). With this in mind we can describe possible alternative environments in which life may have originated. Some of these extreme environments are thought to have existed on early Earth and so may be alternative places where life may have originated and primitive life forms began.

Method

Analyse information from secondary sources

Revise information you have already covered in this chapter and read the above 'Background information' before sourcing a variety of other secondary sources. Gather and analyse information to address Parts 1 and 2.

Part 1 Discuss the diverse environments that living things occupy today

Use Table 3.5 as a guide in attempting to *discuss* or *give points for and/or against* the diversity of environments that present-day organisms live in. Once you have analysed information gathered for the task, you must decide the appropriate method of approaching the verb discuss, that is whether you provide *both points for and against*, or you just provide *one or the other*. Modify your final table accordingly.

Part 2 Describe possible alternative environments in which life may have originated

Name and give a brief description (provide any specific conditions) of three alternative environments in which life may have originated. Start by listing the possible alternative environments for the origin of life using your understanding of the conditions of early Earth and your knowledge of environments that simple organisms can live and survive in. Once you have your list, expand on this by describing each environment. Use Table 3.6 as a guide.

Results

Ensure that your findings are presented in a clear and succinct manner for each of the two parts. You may choose to summarise and simplify your tables by using point form, making it easier to remember throughout the course.

Discussion/conclusion

1. Discuss the difference in diversity of available environments for organisms between the present day and early, primitive Earth.
2. Describe the characteristics of two possible alternative environments in which life may have originated.

Table 3.5 Diverse environments that living things occupy today

Diverse environments that living things occupy today	
For	**Against**

Table 3.6 Possible alternative environments in which life may have originated

Alternative environment in which life may have originated	Description of alternative environment
Hydrothermal vent	Water temperatures sometimes above 350°C, high pressure, no sunlight, high amounts of dissolved minerals (toxic to animals on land) such as hydrogen sulfide

REVISION QUESTIONS

1. Describe three examples of different types of technological advances that have increased our understanding of procaryotic organisms.
2. Describe the main features of the environment of a named organism from either the Archaea or Bacteria group and identify the role of your named organism in that environment.
3. List three types of extremophiles from the Archaea group and identify the environment they prefer to live in.
4. Discuss the diverse environments that living things occupy today and the possibility of alternative environments in which life may have originated.

Answers to revision questions