SURFING

NATIONAL BIOLOGY

Unit 1 Biodiversity and the Interconnectedness of Life

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Contents

Use the table of contents to record your progress through this book. As you complete each unit, write the date completed, then tick one of the three remaining columns to guide your revision for later. The column headers use the following codes:

?? = Don't understand this very well at all. RR = Need to revise this. OK = Know this.

Introduction

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory sections of the syllabus, along with questions and answers.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions, including multiple choice and free response questions. These cover every aspect of the topic, and are useful for revision and exam practice. Marking guidelines are supplied where appropriate.

Words To Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

conctruct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

1 Assumed Knowledge

1. Define biodiversity.
2. List three reasons why scientists classify organisms into groups.
3. Define a species.
4. Define ecosystem.
5. Distinguish between biotic and abiotic features of the environment.
6. Describe the importance of cycles of materials in ecosystems.
7. Describe some impacts of human activities on ecosystems.
8. Discuss one strategy used to balance human activities and needs in ecosystems with conserving, protecting and maintaining the quality of the environment.
9. Figure 1.1 shows the relationships between the environment and organisms.

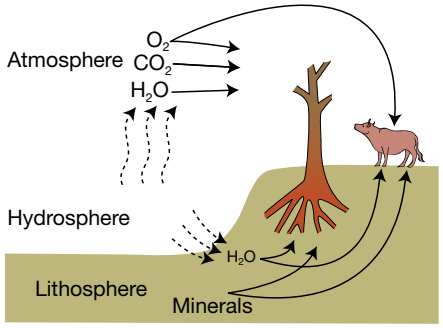


Figure 1.1 Organisms and the environment.

   (a) Define environment.
   (b) What are the biosphere, hydrosphere and lithosphere?
10. Define adaptation.
11. Use an example to show how a named adaptation assists in a specific environment.
12. Figure 1.2 shows plankton.
   (a) What is plankton?
   (b) What is the difference between phytoplankton and zooplankton?

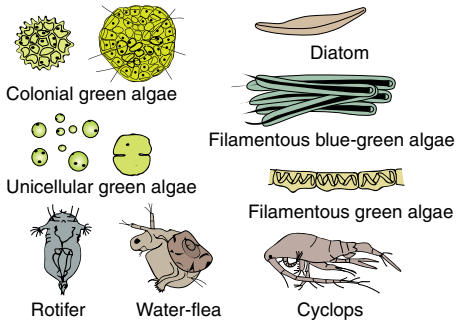


Figure 1.2 Plankton.

13. Define producer, consumer and decomposer.
14. Use a food chain to show how producers, consumers and decomposers are related.
15. (a) What is a food chain?
   (b) Draw a food chain containing four organisms.
16. Define food web.
17. How does a food web differ from a food chain?
18. What is meant by a feral species? Give an Australian example.
19. Define population.
20. Figure 1.3 shows the red kangaroo, *Macropus rufus*.

Figure 1.3 Red kangaroo, *Macropus rufus.*

   (a) How does the binomial system help identify this kangaroo?
   (b) Describe one adaptation of the red kangaroo to its environment.
21. Define predation.
22. Figure 1.4 shows how habitats vary from the pole to the equator as well as from sea level to the top of tall mountains.
   (a) Use this diagram to list the changes in habitat from the pole to the equator.
   (b) Compare the change in habitat as you move from the equator to the poles with the change in habitat as you move from sea level to the top of a high mountain.

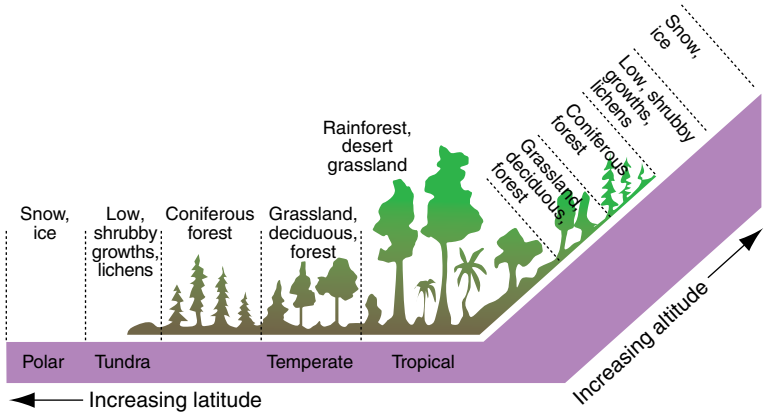


Figure 1.4 Changes in habitat with altitude and latitude.

2 The Biosphere

The **biosphere** is the total of all areas where living things are found, i.e. the sum of all ecosystems. The biosphere extends from the equator to the polar caps. Since the discovery of microbes deep in the Earth's crust, in the upper layers of the atmosphere and deep in oceanic trenches, it is hard to estimate the thickness of the Earth's biosphere.

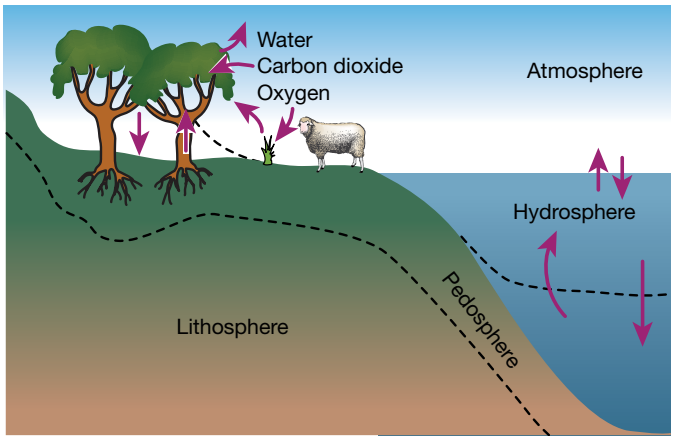


Figure 2.1 Interaction of biosphere, lithosphere, hydrosphere and atmosphere at pedosphere.

Processes and interactions occur between the biosphere, hydrosphere lithosphere and atmosphere. Living things interact with the non-living things in their environment – they use air, water, soils and sediments in their daily struggle for survival. The **lithosphere** is the outer, rigid solid shell of rock on Earth consisting of the crust and part of the upper mantle. The **hydrosphere** is the combined mass of water found on, under and over the surface of the Earth. It includes the water in oceans, rivers and lakes and the water in the air.

The **atmosphere** is the body of air surrounding the planet. The **pedosphere** is the outermost layer of the Earth where the lithosphere, hydrosphere, atmosphere and biosphere interact to form soil. It is the sum total of all organisms, rock, air and water interacting in a dynamic way to form soil.

The **biosphere** has three important functions:

- It converts energy from either the Sun or chemical sources to organic material.
- It harvests essential elements and minerals from the atmosphere, hydrosphere and lithosphere to maintain life.
- It responds to changes by altering food webs when geological, cosmic or dynamic Earth movements occur.

A **biome** is a large geographical area that has a specific climate and sustains distinctive communities of plants and animals and can be any of the world's major ecosystems, e.g. tundra, desert, grassland, desert and tropical rainforest.

QUESTIONS

1. Define biosphere.
2. What is the difference between the lithosphere, the hydrosphere and the atmosphere?
3. Define pedosphere.
4. Outline the three important functions of the biosphere.
5. Define biome.
6. Name three biomes found in Australia.
7. Which biomes would you expect to have the following conditions?
   (a) Dry and cold.
   (b) Wet and hot.
   (c) Dry and hot.
   (d) Fairly dry and warm.

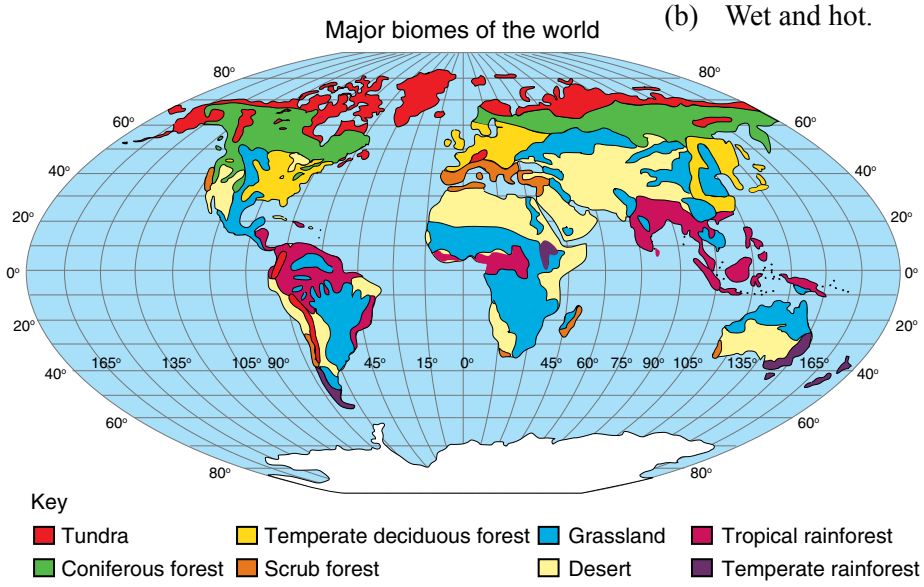


Figure 2.2 Major biomes of the world.

3 18th and 19th Century Naturalists

Our understanding of the biosphere and how different ecosystems interact is based on the work of several 18th and 19th century naturalists who gathered information about different organisms and their distribution around the world.

Carolus Linnaeus (1707-1778)

Linnaeus was a Swedish botanist and zoologist who established the binomial system of nomenclature to refer to organisms by their genus, species name. He founded the branch of science for naming and classifying organisms – **taxonomy**. He collected many specimens in Sweden and on other journeys in the region, e.g. on a trip to Lapland he described about 100 previously unidentified plants. By carefully studying the characteristics of organisms he grouped similar species into the same genus. This formed the basis of the Linnaean system with the similar genera (plural of genus) placed in an order, similar orders placed in a class and similar classes placed in a kingdom. His book *Philosophia Botanica* (1751) gives details on his naming system and how to keep a journal on travels. His next book *Species Planarum* (1753) is considered to be the beginning of botanical nomenclature. The Linnaean system has since been expanded with additional classification levels and the other characteristics, such as DNA sequencing, are now used in the classification process.

Carolus Linnaeaus Joseph Banks

Figure 3.1 Carolus Linnaeus and Joseph Banks.

Joseph Banks (1743-1820)

When Captain James Cook set sail on the HMS Endeavour 1768-1771, Joseph Banks was on board as the naturalist and botanist. He had previously sailed on the HMS Niger to Newfoundland and Labrador documenting many birds including the Great Auk which became extinct in 1844. On his voyage with Captain Cook Banks collected many specimens and made scientific descriptions. The journey visited South America and in the Pacific visited Tahiti, the Polynesian Islands, New Zealand and the east coast of Australia. His extensive collection of plant material included a herbarium with about 110 new genera and 1300 new species. He is credited with introducing eucalypts, acacias and mimosa to the Western world. Many plants have been named in his honour, including the genus *Banksia*. When the colony of NSW was established Banks was in contact with the three earliest governors (Arthur Phillip, John Hunter and Philip Gidley King) receiving specimens of trees and plants. He also gave advice on the development of agriculture in the colony.

Jean Baptiste Lamarck John Gould

Figure 3.2 Jean Baptiste Lamarck and John Gould.

Jean Baptiste de Lamarck (1744-1829)

In his book *Flore Francais* Lamarck made a catalogue of French plants using identification keys similar to the current-day dichotomous keys. He compared different characteristics so that the key could be used to find the identity of a particular plant. The book and Lamarck's method attracted the attention of other scientists such as Georges Buffon. As a zoologist Lamarck ignored the Linnaean classification of animals without backbones as either insects or worms and named the entire group invertebrates. Lamarck separated the eight-legged arachnids from six-legged insects and separated the echinoderms such as starfish from crustaceans such as crabs and shrimps. He published his work in his book *Natural History of Invertebrates*. Lamarck is mainly known today for his theory of evolution by the inheritance of acquired traits.

John Gould (1804-1881)

Gould was an English ornithologist and bird artist who studied the birds that had been collected from around the world and sent to the Zoological Society of London and other institutions.

Gould studied the birds brought by Darwin from the Galapagos Islands and identified them as new species of finches. In 1838 Gould travelled to Australia, collected specimens and his work was published in his book *The Birds of Australia*. He also published *Monograph of the Macropodidae, or Family of Kangaroos* and *The Mammals of Australia*. Several organisms have been named after him, e.g. Gould's petrel and Gould's sunbird. Of the 745 species of Australian birds, Gould is credited with describing around 44%. It is believed he described between 300 to 328 new species of Australian birds and 45 new species of Australian mammals. The Gould League was founded in Australia in 1909.

Charles Darwin | Alfred Russel Wallace | Adolf Engler

Figure 3.3 Charles Darwin, Alfred Wallace and Adolf Engler.

Charles Darwin (1809-1882)

Darwin was an English naturalist who travelled on the HMS Beagle (1831-1836) collecting specimens and making descriptions of many plants and animals. He published his notes in a book *Zoology of the Voyage of HMS Beagle*. His observations led to his development of the theory of evolution by natural selection. When Alfred Russel Wallace wrote to him in 1858 asking for comments on the same idea of natural selection they made a joint presentation to the Linnaean Society in 1858. Darwin then published his book *On the Origin of Species* in 1859. The book was a bestseller and brought the theory of evolution to public attention. He continued to investigate several areas and published more books, e.g. *Fertilisation of Orchids*, *The Variation of Animals and Plants under Domestication, The Power of Movement in Plants* and *The Descent of Man, and Selection in Relation to Sex*.

Alfred Russel Wallace (1823-1913)

Wallace was a British naturalist, explorer and geographer who travelled to many places in the world collecting data about different species and their distribution. He identified the Wallace line which runs between Indonesia and Australia separating the animals of Asian origin (e.g. placental mammals) from animals of Australian origin (e.g. marsupial and monotreme mammals).

Wallace is considered to be the 'father of biogeography'. Wallace also cofounded the theory of evolution by natural selection with Charles Darwin. He had written to Darwin sending a brief essay on his theory of evolution asking for Darwin's advice. While he was still abroad his work was jointly published with work by Charles Darwin in 1858, in London at a meeting of the Linnaean Society. Wallace disagreed with Darwin suggesting bright colours, e.g. on caterpillars and butterflies were a warning colouration and not necessarily for sexual selection as proposed by Darwin. Wallace suggested the 'Wallace effect' as part of the steps in speciation (formation of a new species). When two populations of a species have diverged past a certain point, a hybrid from a mating between the two groups is less fit than either parent. The hybrid dies and the two groups become more isolated leading to two different species. This is the Wallace effect which is still being investigated for validity.

Adolf Engler (1844-1930)

Engler was a German botanist who believed classification systems should reflect evolutionary history. With Karl AE von Prantl, he produced *Die Naturlichen Pflanzeenfamilien* (The natural plant families) which shows how simple structures give rise to more complex structures. It classifies 'plants' from algae to flowering plants. He believed gymnosperms with their naked seeds, e.g. in cones were more primitive than angiosperms with their protected seeds developed from within the flower. This was the first major system for phylogenetic classification. The Engler system is used today to put plants into herbaria and floras but his ideas of primitive/advanced are no longer applied. Engler was one of the first to show the important link between geology and biodiversity and he defined biogeographical regions in 1879.

QUESTIONS

1. Define taxonomy.
2. Construct a table to summarise the work of Carolus Linnaeus, Joseph Banks, Jean Baptiste Lamarck, John Gould, Charles Darwin, Alfred Russell Wallace and Adolf Engler.

4 Classification

Humans like to construct classification systems and put things into groups. Aristotle (384-322 BCE) placed specimens into groups according to distinguishing features. His student Theophrastus (c. 370-285 BCE) classified plants, e.g. herbs, shrubs and trees, by the way they grew and their flower structure.

Need for classification

Classification sorts things into groups and assists scientists in several ways.

- It makes communication between scientists more precise and simpler, e.g. rather than describe an animal with a three-part body and three pairs of legs, you can use the group name 'insect'.
- It provides a quick and accurate description of a particular organism, e.g. 'mammal' immediately provides information about the way it feeds its young, body temperature regulation etc.
- It assists in the identification of an unknown organism.
- It shows trends in the development within the group.
- It shows evolution from simple to complex structures.

Selection criteria

Classification systems use **structural characteristics** to distinguish different organisms and split them into groups. Structural characteristics include features such as presence of legs, number of legs, type of skeleton and type of internal transport system. There are several reasons why structural characteristics are used.

- Structural features are usually more constant and usually do not dramatically change over time.
- Organisms with one structural feature in common frequently have other features in common, e.g. vertebrates have a backbone but also have a digestive system with two openings and a closed circulatory system.
- There is a wide range of structural characteristics which allows divisions into groups to be based on precise details.

The binomial system

In 1737 **Carolus Linnaeus** divided matter into three kingdoms – animal, vegetable and mineral. He placed organisms into a large group called an order and then a subgroup called genus and then into species. He suggested organisms should be called by their genus and species name. For example, humans are in the genus *Homo* and our species is *sapiens*, so our name is *Homo sapiens*. This is called the **binomial nomenclature** (two-name system). Binomial nomenclature avoids the problem of different countries and different languages having different common names for the same organism. There are several rules to follow when using the binomial system.

- The genus name comes first and begins with a capital letter.
- The species name follows and begins with a lower case letter. The species name is often Latinised and is a descriptive.
- Both names are *italicised* or underlined.

Table 4.1 Classification of humans.

Taxon	Human classification	Reason why humans in this category
Kingdom	Animalia	Eukaryote heterotroph, multicellular, no cell wall.
Phylum	Chordata	Notochord, gill slits, hollow, dorsal nerve cord.
Class	Mammalia	Hair/fur, mammary glands to suckle young.
Order	Primate	Opposable thumb, binocular vision, short nose, bicuspid teeth.
Family	Hominidae	No tail, upright gait, arms shorter than legs.
Genus	*Homo*	Bipedal, s-shaped spine, flat face.
Species	*sapiens*	Large cerebral cortex, great capacity to learn, speech.

Levels of organisation

There are now seven basic levels in our classification system, from the term covering the greatest number of organisms – kingdom – through phylum, class, order, family, genus and species. More levels can be made by using super-, sub- or infra-, e.g. humans are in the **subphylum 'Vertebrata'**. At the species level, other characteristics besides structural characteristics are often used in classification. A **species** is usually defined as a group of living things that can interbreed to produce fertile offspring. However, it has been found that problems arise with this definition when studying a particular 'species' which may change across a geographic region; adjacent groups can interbreed but the end groups cannot interbreed. How many species are present? To overcome this problem, a species has been defined as a group of organisms sharing a common gene pool. Each level in a classification system indicates the possession of certain characteristics (see Table 4.1).

QUESTIONS

1. Use an historical example to show how humans have placed living things into groups.
2. Discuss two reasons why scientists need to classify organisms.
3. Describe the selection criteria used to divide organisms into groups.
4. Explain why structural characteristics are used in classification systems.
5. What is meant by binomial nomenclature?
6. Outline the benefit of binomial nomenclature.
7. Outline the main features of the binomial system.
8. State the seven basic levels of classification from the term covering the greatest number of organisms.
9. How is a species defined?
10. How do the levels of classification assist scientists?
11. The family Canidae includes all dog-like carnivorous animals that mainly eat meat. The family has 12 genera and about 34 living species. The domestic dog varies in appearance from a mastiff and great dane to a chihuahua. Explain why all dogs are placed in the same species.
12. Mammals (class Mammalia), birds (class Aves) and reptiles (class Reptilia) all belong to the phylum Chordata. Use Table 4.1 to identify the features mammals, birds and reptiles have in common.
13. Baboons are found in Africa and Arabia. They have long dog-like muzzles, a short tail, binocular vision and an opposable thumb and big toe. Why are baboons classified as a primate like humans but not in the family Hominidae?
14. Figure 4.1 shows the plant Australian dusty miller, *Spyridium parvifolium*, which is an erect shrub about three metres high with rounded leaves.

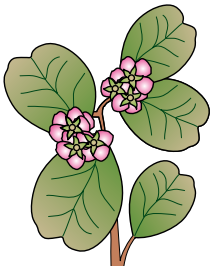


Figure 4.1 *Spyridium parvifolium.*

Which of the following plants would be most similar to *Spyridium parvifolium*?
(A) *Rubus parvifolius.*
(B) *Spyridium eriocephalum.*
(C) *Oxylobium parviflorum.*
(D) *Plectranthus parviflorus.*

15. Which of the following correctly lists classification levels from the grouping with the fewest number of members to the grouping with the largest number of members?
(A) Species, genus, family, order.
(B) Kingdom, phylum, class, order.
(C) Species, family, phylum, order.
(D) Family, order, phylum, class.
16. In the binomial system of nomenclature, which levels of classification are used?
(A) Family then genus.
(B) Species then genus.
(C) Genus then species.
(D) Species then family.
17. What is the main criteria used to classify organisms?
(A) Structural features.
(B) Behavioural features.
(C) Biochemical features.
(D) Physiological features.
18. In the classification hierarchy, which of the following would have members more alike than members of the same family?
(A) Genus (B) Class
(C) Order (D) Phylum
19. Which of the following levels of classification has the greatest different kinds of organisms?
(A) Genus (B) Class
(C) Order (D) Phylum
20. Figure 4.2 shows the satin bowerbird, *Ptilonorhynchus violaceus*, which is found along the east coast of Australia. It belongs to the family Ptilonorhynchidae.

Figure 4.2 Satin bowerbird.

Which of the following is most likely to be the class level for this bird?
(A) Amphibia (B) Aves
(C) Reptilia (D) Mammalia
21. Who introduced the binomial system?
(A) Alfred Wallace (B) Adolf Engler
(C) Charles Darwin (D) Carolus Linnaeus
22. Why do scientists create classification systems?
(A) To assist communication.
(B) To identify unknowns.
(C) To show evolutionary trends.
(D) All of the above.

5 Different Classification Systems

The development of different classification systems has followed the development of technology as new instruments and new methods of investigation have provided greater details about the structure and biochemistry of organisms. This new knowledge requires a revision of previous systems and new classification systems are constructed to take account of the new knowledge.

Early classification systems placed living things into two broad kingdoms: Plantae and Animalia. The invention of the electron microscope showed that bacteria were different as they do not have a nucleus or any other membrane organelles. **Prokaryotes** do not have membrane-bound organelles, e.g. nucleus (e.g. bacteria) while **eukaryotes** have membrane-bound organelles (have a nucleus, e.g. plants and animals). The bacteria (prokaryotes) were therefore placed into a separate kingdom called the **Monera**.

Traditionally the fungi (yeast, mushrooms, moulds) were classified as plants as they are not motile. However, since they are heterotrophs and do not contain chlorophyll, a new kingdom was made for the **Fungi**.

In 1969 Robert Whittaker devised a five kingdom system. It included the four existing kingdoms – plant, animal, Monera and Fungi – and a fifth kingdom called **Protista** which he created for the other eukaryotic organisms that do not show the distinctive traits of these groups. This solved the classification problem for organisms like *Euglena*, which is a unicellular, motile autotroph. The Protista is a mixed group which has unicellular, colonial and multicellular members; some are autotrophs, others heterotrophs, others have both forms of nutrition; and they have various types of reproduction. The Protista includes the protozoans (unicellular animals) and the algae.

Carl Woese proposed the **Three Domains** as a new classification system – domain Eubacteria (now **Bacteria**), domain Archaeobacteria (now **Archaea**) and domain **Eukarya**. A study of the prokaryotes showed that the Kingdom Monera should be split into two separate groups. The original domain system was based on the structure of ribosomal RNA. Classification now also looks at the DNA sequences of the genes coding for the enzyme RNA polymerase which is involved in protein synthesis. This led to the six kingdom system.

In recent years, the analysis of DNA and proteins in different species has shown which organisms are most closely biochemically related. This has led to modifications of evolutionary paths and relationships and of classification systems.

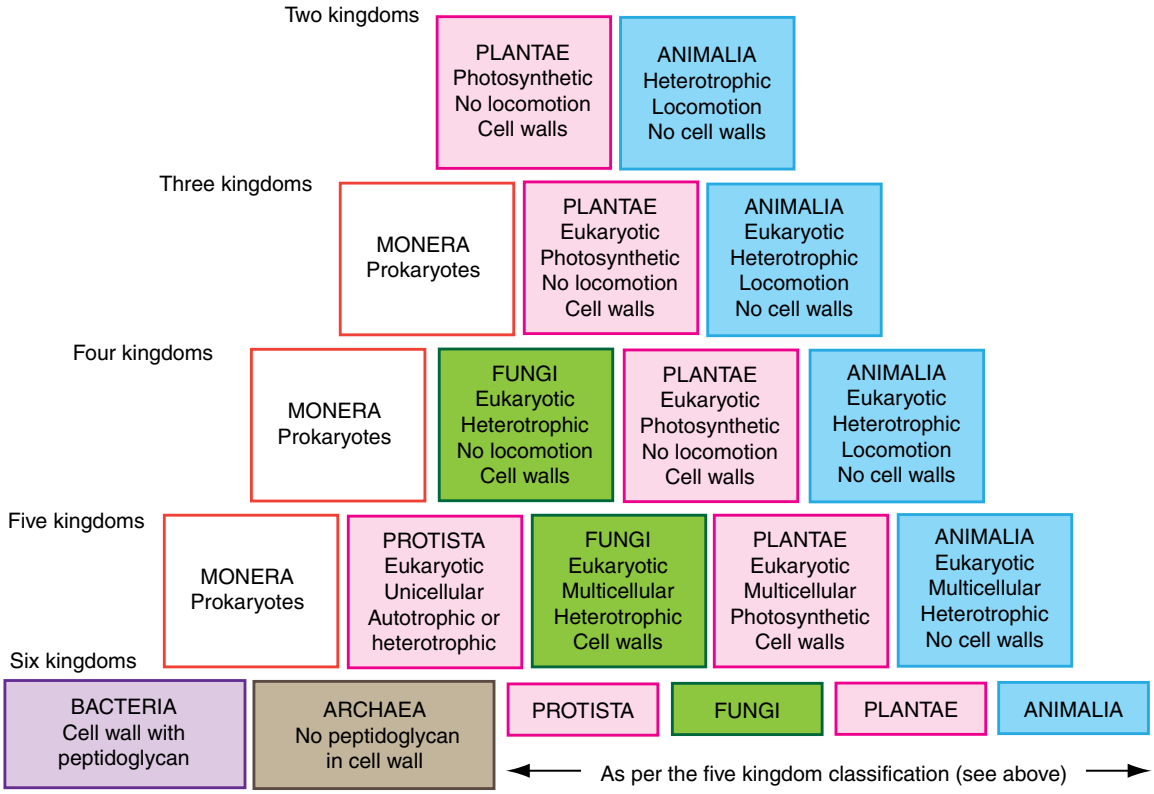


Figure 5.1 Examples of classification systems.

Table 5.1 Features used in the six kingdom classification system.

Feature	Bacteria	Archaea	Protista	Fungi	Plant	Animal
Unicellular or multicellular	Unicellular	Unicellular	Unicellular or multicellular	Unicellular or multicellular	Multicellular	Multicellular
Nucleus	No nucleus	No nucleus	Cells have a nucleus	Cells have a nucleus	Cells have a nucleus	Cells have a nucleus
Histones associated with DNA	Absent	Present	Present	Present	Present	Present
Cell wall	Have a cell wall	Have a cell wall	Some have cell wall	Have a chitin cell wall	Have a cellulose cell wall	No cell wall
Nutrition	Autotrophs and heterotrophs	Autotrophs and heterotrophs	Autotrophs and heterotrophs	Heterotrophs	Autotrophs	Heterotrophs
Organ system	None	None	None	None	Complex organ systems	Complex organ systems
Examples	Gram positive bacteria Gram negative bacteria	Methanogens Thermophiles Halophiles	Protozoa Algae Foraminifera Dinoflagellates	Yeast Mould Mushrooms Toadstools	Mosses Ferns Conifers Flowering plants	Sponges Jellyfish Insects Starfish

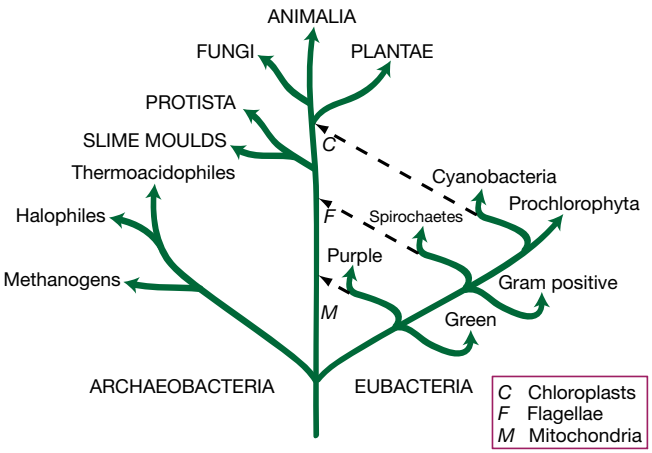


Figure 5.2 Classification kingdoms based on chemical evidence.

Thus classification systems are designed by people to organise knowledge into a logical order. They are arbitrary, open to debate and are modified when new knowledge becomes available.

QUESTIONS

1. Name the two kingdoms which were used to classify all organisms for many years.
2. What is the difference between a prokaryote and a eukaryote?
3. Use an example to show how a change in technology led to a revision of the biological classification system.
4. Discuss why the fungi were hard to classify in the two kingdom system.
5. Compare the two kingdom system with the five kingdom system, giving an advantage and a disadvantage of each.
6. How has the optical microscope changed the classification of living things?
7. Explain what the following statement means. ‘At one stage snow geese and blue geese were classified as separate species. Inbreeding led to their reclassification as one species’.
8. Explain why the organism in Figure 5.3 was difficult to classify in the two kingdom system.

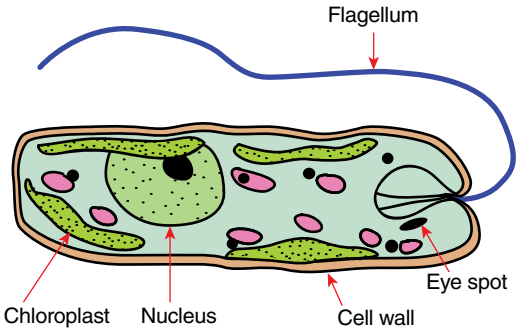


Figure 5.3 Unicellular organism.

9. What was Robert Whittaker’s contribution to the classification of living things?
10. From Table 5.1, which of the six kingdoms contain prokaryotes and which kingdoms contain eukaryotes?
11. When Carl Woese began studying the structure of ribosomal RNA he found that some prokaryotes were more closely related to the eukaryotes than other prokaryotes.
    (a) What was his solution?
    (b) Research has shown there is immense genetic diversity among the prokaryotes. Why could this research lead to further modification of the classification system with new kingdoms or domains being created?

12. The Archaea have some traits in common with the bacteria and some traits with the eukaryotes. Identify one feature the Archaea have in common with each other domain.
13. Which kingdom has organisms that obtain nutrition by both autotrophic and heterotrophic means?
    (A) Plant (B) Animal
    (C) Protista (D) Fungi
14. Classification systems are based on comparisons and hierarchical groupings. Which classification system was used by Linnaeus?
    (A) Two kingdom system.
    (B) Three kingdom system.
    (C) Four kingdom system.
    (D) Five kingdom system.
15. When using the five kingdom classification system, in which kingdom would you place an organism that was eukaryotic, unicellular and autotrophic?
    (A) Plant kingdom. (B) Protista.
    (C) Animal kingdom. (D) Monera.
16. Figure 5.4 shows two different evolutionary trees for living things.

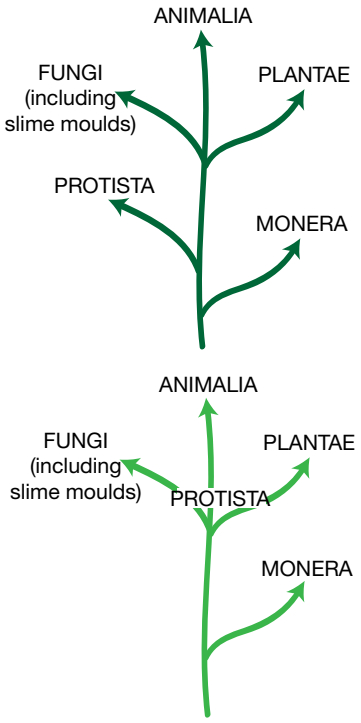


Figure 5.4 Two different evolutionary trees.

In what way do these two evolutionary trees differ?
(A) Which species are members of the Fungi kingdom.
(B) The number of kingdoms.
(C) When plants, animals and fungi diverged.
(D) The evolutionary role of Protista.

Use the following information for the next TWO questions. Figure 15.5 shows an evolutionary tree that has been worked out for different groups of organisms using DNA evidence and similarities in the amino acid sequences.

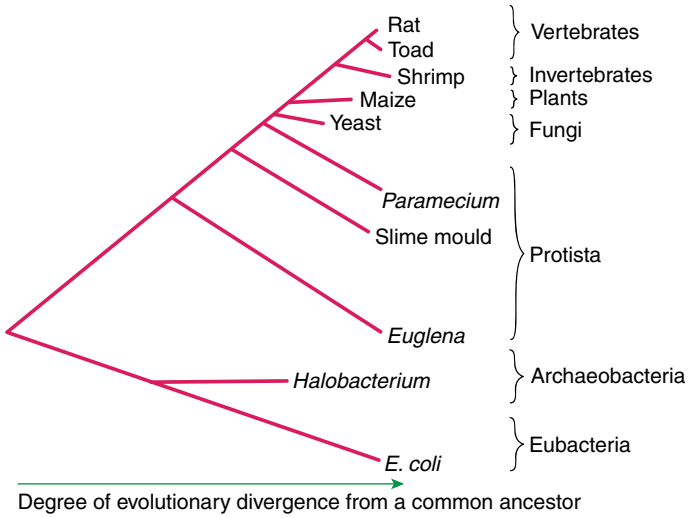


Figure 5.5 Evolutionary tree from DNA evidence.

17. According to this classification system, which two groups would be most closely related?
    (A) Eubacteria and archaeobacteria.
    (B) Rats and toads.
    (C) Shrimps and maize.
    (D) Slime mould and euglena.
18. What conclusion can be drawn from this evolutionary tree?
    (A) Relationships show divergence from a common ancestor.
    (B) *E.coli* is the most primitive organism alive today.
    (C) Plants are more primitive than vertebrates.
    (D) *Euglena* has become less complex over time.
19. Why are biological classification systems arbitrary?
    (A) Body structures change and evolve.
    (B) Different species have different structural features.
    (C) They are designed by humans.
    (D) There is great variation within a species.
20. Who introduced the five kingdom system of classification?
    (A) Watson and Crick.
    (B) Urey and Miller.
    (C) Linnaeus.
    (D) Whittaker.

Answers

1 Assumed Knowledge

1. Biodiversity refers to the amount of variation within a group.
2. Classification: 1. Makes communication between scientists more precise and simpler. 2. Provides a quick and accurate description of a particular organism. 3. Assists in the identification of an unknown organism.
3. A species is a group of organisms that can interbreed to produce fertile offspring. They share a common gene pool.
4. Ecosystem is the living and non-living components of a self-contained system.
5. Biotic features are the living features and the abiotic features are the non-living features.
6. Cycles of materials include the cycling of the elements carbon and oxygen in the carbon/oxygen cycle, the nitrogen cycle, the phosphorus cycle etc. These cycles are important as the amount of matter is finite and materials need to be recycled so that new organisms can grow and develop.
7. Human activities that affect ecosystems include introducing foreign species into an area, which can threaten native species by competition or predation; cutting down trees which removes habitats and food sources; damming rivers and thus changing river flow patterns, which affects water levels for the breeding of fish and wading birds. By causing changes in the distribution and abundance of native species, humans have a great impact on ecosystems causing some species to flourish, while other species become extinct.
8. One strategy is the creation of national parks where native species are protected and the quality of the environment is maintained, but they also provide recreational areas for human activities. This strategy balances the need for conservation with the need of human activities.
9. (a) The environment is everything that surrounds an organism, including both the biotic and abiotic features.
   (b) The biosphere is the areas of the world, including land, water and air, where living organisms are found. The hydrosphere is the areas of the world covered in water, e.g. oceans, lakes, rivers. The lithosphere is the areas of the world made of rocky substances, e.g. continents.
10. An adaptation is a characteristic which helps an organism survive in its environment.
11. The webbing between the toes of a frog is an adaptation for an aquatic environment to assist swimming in water.
12. (a) Plankton is a name given to the microscopic producers and consumers that float in water.
    (b) Phytoplankton is the producers, e.g. algae, diatoms, while zooplankton is the consumers, e.g. ciliates, flagellates, rotifers, tiny crustaceans.
13. A producer is an organism that can make organic compounds from inorganic raw materials. Consumers are organisms that need to use another living organism as a source of food. Decomposers are organisms that help break down dead bodies or wastes of other organisms, recycling nutrients to the soil.
14. Producer → consumer → decomposer
15. (a) A food chain shows the feeding relationship between different species. It shows how energy and matter is passed in an ecosystem.
    (b) Wood → termite → skink → currawong
16. A food web shows the interconnected relationships between organisms in an ecosystem.
17. Food webs are different to food chains in that the food web consists of many interconnecting and interacting food chains. Food webs are more complicated than food chains.
18. Feral species means a domestic species that has gone wild, e.g. when people release domestic cats into the wild, for whatever reason, the cats become 'feral cats'.
19. A population is a group of individuals of one species in a particular area at a particular time.
20. (a) The binomial system uses the genus and species names, e.g. *Macropus rufus* to identify this particular species of kangaroo. This stops confusion which can be caused if common names are used and different areas have different common names for the same species.
    (b) A red kangaroo will lie down in the shade in the middle of a hot day to conserve energy and protect itself from the heat of the midday sun.
21. Predation is a relationship where one organism (predator) eats the other (prey).
22. (a) At the pole the habitat is snow and ice with little vegetation; this changes to low shrubs and lichens, then coniferous forest, then grassland and deciduous forest and then rainforest, desert and grassland.
    (b) As you go from the equator to the poles and from sea level up a high mountain there is a similar change in habitat. They both start with rainforest, desert, grassland and then change to deciduous forest, coniferous forest, low shrubs and lichen and then snow and ice. Differences would be shown from a careful study of individual species present rather than a broad category such as 'deciduous forest'. Each area would have species unique to that area. There would also be abiotic differences relating to the differences in altitude, e.g. lower air pressure and less oxygen available at the top of high mountains.

2 The Biosphere

1. The biosphere is the sum total of all areas including land, water and air where livings things are found.
2. The lithosphere is the outer, rigid solid shell of rock on Earth consisting of the crust and part of the upper mantle. The hydrosphere is the combined mass of water found on, under and over the surface of the Earth. The atmosphere is the body of air surrounding the planet.
3. The pedosphere is the outermost layer of the Earth where the lithosphere, hydrosphere, atmosphere and biosphere interact to form soil.
4. The three functions of the biosphere are: 1. The biosphere converts energy from sun/chemical sources to organic material. 2. Harvests elements and minerals essential for life from other spheres. 3. Responds to changes by adjusting food webs.
5. A biome is a large geographical area that has a specific climate and sustains distinctive communities of plants and animals and can be any of the world's major ecosystems.
6. Australian biomes include desert, grassland and temperate forest.
7. (a) Tundra is dry and cold.
   (b) Tropical rainforest is wet and hot.
   (c) Desert is dry and hot.
   (d) Grassland is fairly dry and warm

3 18th and 19th Century Naturalists

1. Taxonomy is the naming and classification of organisms placing organisms into specific categories based on a set of characteristics.
2.

Naturalist	Dates	Contribution to science
Carolus Linnaeus	1707-1778	Collected specimens and described many organisms. Father of taxonomy. Introduced the binomial system of nomenclature to refer to organisms by their genus species name. Introduced a nested hierarchy to classify organisms by a set of characteristics into kingdom, class, order, genus, species.
Joseph Banks	1743-1820	Collected specimens and described many plants and animals while travelling on HMS Endeavour. Introduced many Australian species to the Western world.

Jean Baptiste de Lamarck	1744-1829	Used identification keys similar to the current-day dichotomous keys. Suggested the theory of evolution by the inheritance of acquired characteristics.
John Gould	1804-1881	Gould taxonomically classified and drew the birds collected from the Galapagos Islands that became known as Darwin's finches. Described and drew Australian fauna and published *The Birds of Australia* and *The Mammals of Australia*.
Charles Darwin	1809-1882	Collected specimens and described many plants and animals while travelling on HMS Beagle. Cofounder of the theory of evolution by natural selection with Alfred Russel Wallace. Published *On the Origin of Species* in 1858 which brought the theory of evolution to the attention of the public.
Alfred Russel Wallace	1823-1913	Identified the Wallace line between South-East Asian animals and Australian animals. Father of biogeography. Cofounder of theory of evolution by natural selection with Charles Darwin.
Adolf Engler	1844-1930	Produced the first major system for phylogenetic classification. Showed the important link between geology and biodiversity.

4 Classification

1. Aristotle (384-322 BCE) placed specimens into groups according to distinguishing features and his student Theophrastus (c. 372-287 BCE) classified plants, e.g. herbs, shrubs and trees, by the way they grew and their flower structure.
2. Scientists need to make classification systems as these systems make communication between scientists more precise and simpler. For example, rather than describe an animal with a three-part body and three pairs of legs, you can use the group name 'insect'. Classification systems also provide a means to identify an unknown organism as the scientist can refer to a classification key to work out what the organism actually is.
3. Selection criteria are based on structural characteristics to distinguish different organisms and split them into groups. Structural characteristics include features such as presence of legs, number of legs, type of skeleton, type of internal transport system.
4. Structural characteristics are used because: 1. They are usually more constant and rarely change over time. 2. Organisms with one structural feature in common often have other features in common. 3. There are many different structural characteristics to use to divide organisms into groups.
5. Binomial nomenclature refers to the two-name system used to describe an organism. It uses the genus and species names, e.g. humans are *Homo sapiens*.
6. The benefit of binomial nomenclature is that one type of organism may have many different common names according to different countries and different languages and this system gives it one specific scientific name.
7. The main features of the binomial system are: 1. The genus name comes first and begins with a capital letter. 2. The species name follows and begins with a lower case letter. 3. Both names are italicised or underlined.
8. Levels of classification are: kingdom, phylum, class, order, family, genus, species.
9. A species is traditionally defined as a group of living things that can interbreed to produce fertile offspring. However, it has been found that problems arise with this definition when studying a particular 'species' which may change across a geographic region; adjacent groups can interbreed but the end groups cannot interbreed and a species has been redefined as a group of organisms sharing a common gene pool.
10. Each level in a classification system indicates the possession of certain characteristics. This assists the scientist as it gives information about the organism, e.g. if the organism belongs to the order Primates, the scientist knows it has binocular vision, bicuspid teeth and short nose.
11. All dogs are placed in the same species as they can interbreed to produce fertile offspring. The differences in appearances from mastiff and great dane to chihuahua does not affect the ability for sperm from different varieties to fertilise an egg from another dog variety.
12. All chordates have a notochord, gill slits and hollow dorsal nerve chord at some stage of development. Thus mammals, birds and reptiles will all have these features as they are all chordates. They also are eukaryotic, heterotrophic, multicellular and their cells do not have a cell wall as they all belong to the animal kingdom.
13. Baboons are classified in the order Primates with humans as they have an opposable thumb and binocular vision. However, they are not in the family Hominidae as they have a tail and do not have an upright gait.
14. B
15. A
16. C
17. A
18. A
19. D
20. B
21. D
22. D

5 Different Classification Systems

1. Two kingdoms were Plantae and Animalia.
2. Prokaryotes do not have membrane-bound organelles (e.g. nucleus) while eukaryotes do have membrane-bound organelles (do have a nucleus).
3. The invention of the electron microscope led to a change in the biological classification system. The electron microscope showed that bacteria were different as they do not have a nucleus or any other membrane organelles. Early classification systems placed living things into two broad kingdoms, Plantae and Animalia, and this new knowledge about internal cell structure led to the bacteria being placed into a separate kingdom called the Monera.
4. Traditionally, in the two kingdom system, the fungi (yeast, mushrooms, moulds) were classified as plants as they are not motile. However, since they do not contain chlorophyll and cannot photosynthesise, they are heterotrophs and cannot really be classified as plants. Therefore a new kingdom was made for the fungi.
5. The two kingdom system classifies everything as plant or animal while the five kingdom system places organisms into plant, animal, Monera, Fungi, or Protista. The benefit of the two kingdom system is that it works well for familiar organisms and most organisms visible to the naked eye can be quickly classified. The disadvantage of the system is that there are many organisms that possess characteristics that do not fall into this simple system, e.g. *Euglena*, which is a unicellular, motile autotroph. The five kingdom system has the advantage of distinguishing the prokaryotes (bacteria) into their own kingdom Monera and places the fungi, which do not photosynthesise in their own kingdom. The disadvantage of the five kingdom system is that it creates a kingdom called Protista which contains a wide variety of organisms such as protozoans and algae and their main similarity is just that they are eukaryotes.
6. The optical microscope shows internal cell structure. Before the use of the optical microscope organisms were classified into two kingdoms – plant and animal. The optical microscope showed that there were fundamental differences between the plants/animals and the bacteria. The bacteria did not have a nucleus and were hence put into their own kingdom – the Monera.

7. The statement means that earlier observations of snow geese and blue geese had found enough differences in appearance, habit etc to classify them into separate species. However, inbreeding showed that a mating between the two led to fertile offspring and hence the snow geese and blue geese needed to be reclassified into the same species to show this relationship.
8. The two kingdom system classifies all organisms as either plant or animal. This organism would be hard to classify in this system as it has a chloroplast and cell wall like a plant, but a flagellum and eye spot like an animal.
9. Robert Whittaker devised the five kingdom system in 1969 in which he separated out the Protista from Monera, fungi, plants and animals. This solved the problem for organisms like *Euglena* which are unicellular, motile and autotrophic and hard to classify in the previous systems.
10. Bacteria and Archaea contain prokaryotes while fungi, protista, plants and animals contain eukaryotes.
11. (a) Woese suggested the prokaryotes (bacteria) should be split into two groups – the Eubacteria (true bacteria) and the Archaeobacteria (ancient bacteria). From this he suggested there should be three domains.
    (b) Advances in technology and research into more and more prokaryote species show differences between different groups. If sufficient data is collected to show distinct branching on the tree of life, then new kingdoms or domains will be created to include this information into our classification system.
12. Archaea are like the bacteria in that they do not have a nucleus and membrane-bound organelles. The Archaea are like eukaryotes in that they have histones associated with their DNA.
13. C
14. A
15. B
16. D
17. B
18. A
19. C
20. D

6 Features Used in Animal Classification

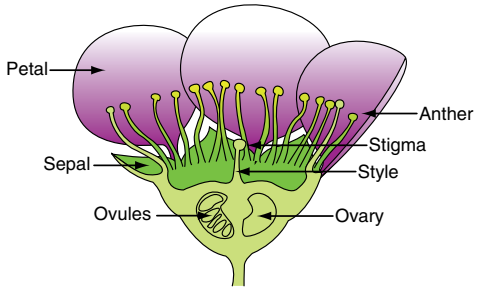
1. A vertebrate is an animal with a backbone (vertebral column) while an invertebrate is an animal that does not have a backbone.
2. A classification based on a single feature such as vertebrate/invertebrate and the presence/absence of a backbone provides a grouping that has limited use and puts highly diverse organisms into a single category.
3. Animals can be classified on physical features such as body symmetry, tissue layers, body cavity, outer covering, number of openings to the digestive system and the structure of other organ systems.
4. Germ layers are embryonic tissue layers that will form animal structures.
5. A diploblast has two germ layers, e.g. jellyfish and corals, while triploblasts have three germ layers, e.g. worms, arthropods and vertebrates.
6. (a) Ectoderm gives rise to the outer covering of the animal.
   (b) Mesoderm gives rise to muscles and most organs between the digestive tract and the outer covering of the animal.
   (c) Endoderm gives rise to the lining of the digestive tract.
7. The coelom is a fluid-filled body cavity formed within the mesoderm.
8. Sexual reproduction involves two parents producing offspring that have a unique combination of genes inherited from the union of the gametes from each parent. Asexual reproduction involves one parent producing offspring identical to the parent.
9. A hermaphrodite is an organism with both male and female gonads and can sexually function as both male and female in reproduction.
10. (a) Fertilisation is the union of two gametes (e.g. sperm and ovum).
    (b) Internal fertilisation involves the union of the gametes within the female's body while external fertilisation occurs outside the female's body with gametes released into the environment.
11. The only mammals that lay eggs are the monotremes.
12. Amphibian eggs do not have a shell and dry out quickly, birds lay eggs in a hard calcareous shell while reptilian eggs have a leathery shell.
13. Animal A (*Mytilus*) belongs to phylum Mollusca, animal B (*Hydra*) belongs to phylum Cnidaria and animal C (*Ascaris*) belongs to phylum Nematoda.
14. A = saw shark, B = cat shark, C = whale shark, D = seven-gilled shark, E = requiem shark, F = hammerhead shark.

7 Dichotomous Keys for Plants

1. Dichotomous keys are used to identify and describe different organisms.
2. A dichotomous key is designed so that there are two alternatives at each step.
3. When constructing dichotomous keys it is important to use structural features whenever possible as these characteristics are often more consistent than other features. Secondly, if using size and colour, a range is frequently used rather than exact details as these features often vary within a species, especially if moving from one area to another.
4. There are many, many possible keys. The following key is just one example.

1	(a)	Fruit is a gumnut.	Go to 4
	(b)	Fruit is not a gumnut.	Go to 2
2	(a)	Has pneumatophores.	*Avicennia*
	(b)	No pneumatophores.	Go to 3
3	(a)	Large orange flower.	*Banksia*
	(b)	White flower.	*Pittosporum*
4	(a)	Smooth bark.	Go to 5
	(b)	Rough bark.	*E. piperita*
5	(a)	Leaves paler on undersurface.	*E. pilularis*
	(b)	Leaves not paler on undersurface.	*Angophora*

5. Yes, it is highly possible to construct another key for these six trees of the Sydney region. Neither key is 'more' correct. Keys are a tool. If both keys enable a person to identify any of these trees then both fulfil their purpose and both keys are 'correct'.
6. Labelled flower A = petal, B = sepal, C = ovules, D = anther, E = stigma, F = style, G = ovary.



7. To distinguish the orchid from the flannel flower you would use the number of petals, the number of sepals, the presence/absence of a labellum, the symmetry of the petals in the flower and the evenness of the size of the petals.
8. (a) Plant X is white box and plant Y is sunshine wattle.
   (b) The characteristics used to identify the white box are: bark is short and fibrous, leaves not all bipinnate, stem not jointed, ridged, and leaves reduced to ribs on stem, veins in leaf reticulate. The characteristics used to identify the sunshine wattle are: leaves 3.5 to 20 cm long, leaves all bipinnate, stem not jointed, ridged, and leaves reduced to ribs on stem, veins in leaf reticulate.
   (c) The red mahogany and the white box are the most closely related as they both belong to the same class of flowering plants (the dicotyledons), the same family (Myrtaceae) and the same genus (*Eucalyptus*) while the cabbage tree palm is a monocotyledon.