Welcome to the Museum

ADMIT ALL

Botanicum

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BIG PICTURE PRESS

Royal Botanic Gardens Kew

Algae

Earth was formed around 4600 million years ago. Within 800 million years, fossil evidence indicates the presence of the first plants on Earth; the algae. Algae range in size from single cells to giant seaweeds. The features that link them together as a distinctive plant group are that, although they use sunlight and carbon dioxide from the air to make food (a process called photosynthesis), they don't have roots, stems or leaves and they lack a layer of cells surrounding their reproductive cells.

Algae are most commonly found in water, with different species adapted to live in freshwater and saltwater environments. Some species live on land, often in inaccessible locations like rocky crevasses in the highest mountains or buried in the soils of the deepest valleys. This fondness for living in out-of-the-way places, and their often very small size, makes it difficult to count how many different types of algae there are on the planet. Estimates vary hugely – from 36,000 to 10 million species. Algae are split into 12 groups or algal divisions, called phyla. The three most successful and abundant are red algae, green algae and diatoms.

Key to plate

***1:* Amphitetras antediluviana**
Width: 0.125mm
This is a marine micro-alga called a diatom. Diatoms are often tiny, and usually single-celled. They are important because they are incredibly good at photosynthesis and play an important role in regulating the amount of carbon dioxide in the air.

***2:* Fossil segment of red algae**
Bangiomorpha pubescens
Length: 0.225mm
This fossil filament was found in sediments from Arctic Canada and has been dated to around 1.2 billion years ago. It shows characteristic disc-shaped cells surrounded by a sheath, which are features also seen in the filaments of modern-day red algae.

***3:* Fossil segment of green algae**
Cladophora sp.
Length: 0.075mm
Cladophora are one of the earliest recognisable green algae in the fossil record and are very similar in shape to their modern counterparts. They have been found in fossil deposits dating to around 800 million years ago. These green algae were the precursor to all land plants.

***4:* Lyrella hennedyi var. neapolitana**
Length: 0.06mm
This marine diatom is called *lyrella* because it looks a bit like the musical instrument, the lyre.

***5:* Rhaphoneis amphiceros**
Length: 0.06mm
This is often found attached to sand grains in shallow marine waters.

***6:* Acetabularia acetabulum**
Height: 0.5–10cm
This green alga is found in subtropical marine waters and, although it is a single-celled organism, it is very large in size and has a complicated structure. It has a lower section resembling roots, which anchor the plant to rocks and a long stalk with umbrella-like structures at the end.

***7:* Red seaweed**
Bangia sp.
Height: 6cm
The earliest red alga in the fossil record is similar to the modern-day algae, red seaweed, in the algae family Bangiophyceae. This marine algae has long red filaments.

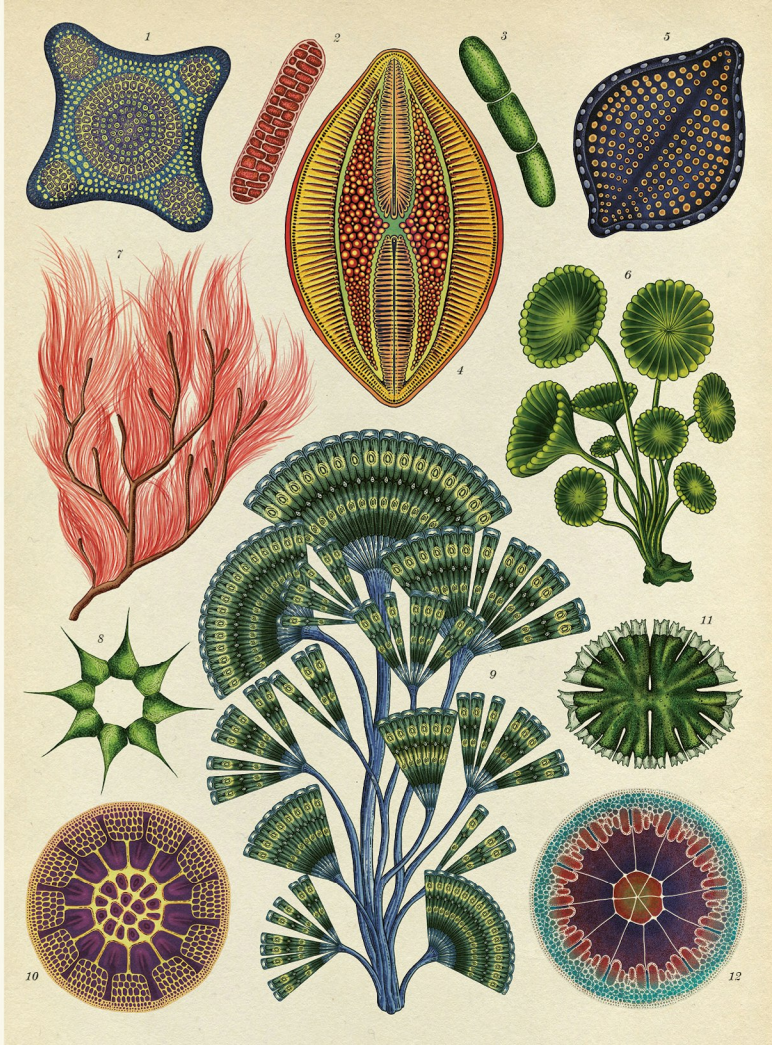
***8:* Pediastrum simplex**
Width: 0.06mm
This green alga has its cells arranged in a distinctive genetically determined shape, known as a coenobial colon. It resembles a flattened star.

***9:* Licmophora flabellata**
Height: 0.5mm
Found in shallow marine environments such as estuaries, this diatom has distinctive fans and branching stalks. A sticky substance is secreted from the base of the main stalk to enable this diatom to attach itself to rocks.

***10:* Asterolampra decora**
Width: 0.08mm
A round- and saucer-shaped marine diatom most commonly found in tropical waters.

***11:* Micrasterias rotata**
Width: 0.18mm
This is a single-celled, fresh-water green alga that is often found in acidic peatland environments. These algae are usually highly symmetrical in shape.

***12:* Asterolampra vulgaris**
Width: 0.08mm
Another marine diatom in the Asterolampra family (see plate 10) but distinguished by its different patterning.



Bryophytes

Plants started to move out of their watery environment and live on land from around 470 million years ago. These earliest land plants evolved from green algae and were similar to present-day liverworts, hornworts and mosses, which are collectively known as bryophytes. Bryophytes have none of the firm tissue (vascular tissue) that enabled later plants to stand upright. This makes bryophytes soft to the touch, and also unable to grow beyond about 50cm in height. They have root-like structures called rhizoids that allow them to capture nutrients from the soil, and a rather unusual reproductive cycle that involves alternating between two different life forms, a leafy (vegetative) form called a gametophyte and a form that disperses spores called a sporophyte. The leafy form is most commonly seen growing in moist, damp environments. In this form, the plant has male and female organs, which sometimes grow on the same plant and sometimes on separate plants.

The female organs are called archegonia and are bottle-shaped. The male organs are called antheridia and are oval-shaped. Spermatozoids are released from the male organs to fertilise the egg cells in the bottle-shaped female organs. The female egg, once fertilised is called a zygote and grows to produce a second, different, life form called a sporophyte. Spores are produced in the sporophyte and once ripe, they are released into the soil to grow into the leafy form (the gametophyte) and the process starts all over again.

Key to plate

1: **Smooth hornwort**
Phaeoceros laevis
Height: 5cm

2: **Yellow moose dung-moss**
Splachnum luteum
Height: sporophyte 15cm
The sporophyte has a bright yellow parasol-like structure. Insects, rather than wind, disperse the spores.

3: **Reproductive cycle of moss**
a) Male antheridium releasing spermatozoids b) Female archegonium containing egg c) Once the egg is fertilised a zygote grows d) The mature sporophyte at the top of the moss plant e) Spores are released. They will grow into gametophytes and the process will begin again.

4: **Moss capsules**
Capsule height: 2–4mm
a) *Climacium dendroides* b) *Tetraphis pellucida* c) *Sphagnum palustre* d) *Plagiomnium cuspidatum*
These are the spore-bearing capsules, which have special hoods to protect the spores inside.

5: **Crescent-cup liverwort**
Lunularia cruciata
Width: thallus (plant body) 12mm

6: **Stiff apple moss**
Bartramia ithyphylla
Height: shoots up to 4cm

7: **Umbrella liverwort**
Marchantia polymorpha
Length: thallus (plant body) 4–6cm; female receptacles 20–45mm

8: ***Asterella australis***
Length: thallus (plant body) 4cm

Fungi and Lichens

Two groups of organisms were vital in helping plants gain a hold on dry land around 470–400 million years ago – fungi and lichens.

There's an important point to note here – although this is a book about plants, fungi are not plants. They don't make food by photosynthesis, don't have roots and they reproduce with spores. They are included here because they were historically treated as plants, and because they are involved in the functioning of plant ecosystems: they help to break down plant litter and animal remains in soil, ensuring that there are sufficient nutrients for plants to take up for growth. Fungi are also an important food source for animals and humans. Yeast, for example, which is a fungus, is an essential ingredient in bread and beer. At the same time, fungi are also responsible for some of the most toxic poisons and most dangerous diseases of both humans and animals. Many fungi are highly poisonous and should never be touched or eaten when found growing in the wild.

Lichens are not plants either. They are a collaboration between a fungal element and photosynthesising algae. The organic acid released from rock-inhabiting lichens is thought to have been important for breaking down rocks to make soil in the earliest land environments.

Lichens are also able to survive in harsh places with extreme climates, an ability that would have been essential for early life on land. Species of lichen are found on rocks growing at the top of the highest mountains and in the hottest and coldest deserts. Some even produce their own sunscreen in the form of sun-protecting pigments. Production of the pigments is triggered by high levels of sunlight and this enables these lichens to grow in open environments with little or no shade.

Key to plate

1: **Bird's nest fungus**
Cyathus striatus
Diameter: 1cm
These tiny fungi hold their spores in disc-shaped packets resembling eggs in a nest, and raindrops cause these 'eggs' to spring out and disperse.

2: **Red *Marasmius***
Marasmius haematocephalus
Height: 2–3cm
These small, umbrella-like fungi play an important role in recycling the litter layer on forest floors.

3: **Pixie-cup lichen**
Cladonia chlorophaea
Height: 1–4cm
These lichens produce stalked cups which bear the fruiting structures. In European folklore these tiny cups are thought to be used by pixies or wood fairies to sip the morning dew.

4: **Leathery goblet**
Cymatoderma elegans
Height: 15cm
The cap of this fungus opens to a wide funnel and can often be found containing water, hence its name.

5: **Veiled lady**
Phallus indusiatus
Height: 25cm
This distinctive fungus has been used for centuries as a charm in folklore and traditional medicine.

6: **Enokitake mushroom**
Flammulina velutipes (cultivated form)
Height: 10cm
Commonly used in east Asian cooking, this mushroom is cultivated in a carbon dioxide-rich environment to create long, thin stems.

7: **Turkeytail fungus**
Trametes versicolor
Diameter: 4–10cm
So-named because its radiating growth resembles the fanned tails of turkeys.

8: **Golden shield lichen**
Xanthoria parietina
Diameter: up to 10cm
This lichen is bright yellow-orange in sunny places but a dull green when in the shade because it makes its own sunscreen in the form of a sun-protecting pigment.

9: **Fly agaric**
Amanita muscaria
Diameter: 8–20cm
This toadstool is often represented in fairy stories. Its toxic chemicals cause hallucinations.

10: **Lane Cove waxcap**
Hygrocybe lanecovensis
Height: up to 5cm
An endangered fungus, first collected in 1998 and known from a single parkland in Sydney, Australia.

Club Mosses, Horsetails and Whisk Ferns

The common names we use for plants are sometimes not an accurate reflection of scientific definitions. Club mosses, for example, are not actually mosses, in fact they are vascular plants. This means that they contain a well-developed system of specialised cells, known as vascular bundles, which allow the plants to grow upright and much taller than bryophytes, which lack a vascular system (see pages 10–11). Horsetails and whisk ferns also contain vascular strands.

These three groups of plants, which reproduce by spores, have ancient lineages and are often referred to as 'living fossils' because there are fossil remains dating from 400–370 million years ago that are very similar in structure to the club mosses, horsetails and whisk ferns we see growing today, but with one important difference: the present-day plants are small herbs – usually less that 1m in height. By comparison, their ancestors were giants. Horsetail and lycophyte trees (related to club mosses), towering up to 40m in height, dominated the early Carboniferous landscapes (see pages 18–19). The giant tree-forms of these plants met the fate of most species of life on Earth – extinction, out-competed by better adapted rivals so that all we are now left with are the miniature forms that were able to survive.

Key to plate

1: **Club moss**
Selaginella lepidophylla
Height: 10cm
Club mosses have small, scale-like leaves wrapped all around their stems.

2: **Whisk fern**
Psilotum complanatum
Height: up to 75cm
This species of whisk fern is usually found hanging from the trunks of trees in tropical regions. It does not have roots or leaves but it has small scales on the stem.

3: **Horsetail**
Equisetum hyemale
Cone height: 1cm
Cone
The spores of horsetails come from sporangia, which are produced at the margin of polygonal structures grouped into a 'cone'. These cones are usually situated at the apex (top) of the plant.

4: **Field horsetail**
Equisetum arvense
Diameter: 3–5mm
Section through stem
This section through a young horsetail stem shows how vascular bundles (the round circular sections) extend up through the whole plant stem. These woody strands allow the upward movement of water and sap throughout the plant.

5: **Field horsetail**
Equisetum arvense
Height: 20–50cm
The vegetative shoots of field horsetails have whorled branches and look feathery. The actual leaves are small, papery, and fused into a sheath on the stem. The cones that contain the spores are found on pale, fertile shoots, which grow before the bigger green vegetative ones. Field horsetails grow in damp or wet places.

6: **Sporophyll of a club moss**
Lycopodium clavatum
Sporophyll length: 2–2.5mm
Sporophylls are tiny leaves that bear the sporangia (spore-production centres).