Plants

Dusky Rock Moss (*Andreaea rothii*) by JC Schou, Biopix. CC BY-NC

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Introduction

A plant is any one of the vast number of organisms within the biological kingdom Plantae; in general, these species are considered of limited motility and generally manufacture their own food. They include a host of familiar organisms including trees, forbs, shrubs, grasses, vines, ferns, and mosses. Conventionally the term plant implies a taxon with characteristics of multicellularity, cell structure with walls containing cellulose, and organisms capable of photosynthesis. Modern classification schemes are driven by somewhat rigid categorizations inherent in DNA and common ancestry.[1]

Taxonomy and terminology

Throughout most of the history of science from Aristotle to Linnaeus and into the 20th century, species were divided into two kingdoms: animals and plants. Driven by DNA characterizations and other modern analysis, fungi and bacteria have now been removed to separate kingdoms; in particular, fungi have cell walls that contain chitin rather than cellulose. Lichens, which are a symbiotic association of a fungal and photosynthetic organism, are generally not considered plants in the purest sense of taxonomy, although earlier classification schemes viewed them as plants. Viruses are also not considered to be plants, since they do not have a cell of their own, but inhabit a host cell of another organism; moreover, in many classifications they are not considered a living organism at all. Myxomycetes, or slime molds, are also not considered plants, but rather are heterotrophs that can ingest bacteria, fungal spores, and other items.

The scientific study of plants, known as botany, has identified about 350,000 extant taxa of plants, defined as seed plants, bryophytes, ferns and fern allies. As of 2008, approximately 400,000 plant species have been described,[2] of which roughly ninety percent are flowering plants.

Vascular plants have lignified tissue and specialized structures termed xylem and phloem, which transport water, minerals, and nutrients upward from the roots and return sugars and other photosynthetic products. Vascular plants include ferns, club mosses, flowering plants, conifers and other gymnosperms. A scientific name for this vascular group is Tracheophyta.[3]

The major divisions of Plantae are:

Anthocerotophyta (hornworts: nonvascular plants with one chloroplast per thallus cell)

Bryophyta (mosses: nonvascular plants with wiry stems that reproduce by spores)

Cycadophyta (cycads: nonflowering vascular plants with large pinnately compound leaves)

Ginkgophyta (gymnosperm with one extant tree species, Ginkgo biloba)

Gnetophyta (woody plants having some angiosperm and some gymnosperm features)

Lycopodiophyta (vascular fern allies without seeds or flowers, having single microphyll leaf veins)

Magnoliophyta (flowering plants that have vascular systems and are seed producing)

Marchantiophyta (liverworts: nonvascular plants with one-celled rhizoids)

Pinophyta (gymnosperm conifers that have vascular systems and cones, but no flowers)

Pteridophyta (ferns: vascular plants lacking flowers and seeds, reproducing by spores)

Several groups of algae are under debate as to whether they should be included in Plantae; however, we will follow a definition of plants that excludes algae. Green plants, often termed Viridiplantae, derive the majority of their energy from sunlight via photosynthesis and are a subset of Plantae.

Structure in this group is fairly diverse, but almost all species retain a few basic characters that help to identify them as ciliates. The first character is the presence of cilia on at least one developmental stage of the organism. Modifications from the full body covered norm include a single ring of cilia, grouped ciliary organelles called cirri, and restriction of cilia to feeding tentacles. Most species also bear toxicysts that are most likely used to capture and stun prey. These toxicysts can be found around the mouth, along the length of tentacles or anywhere else on the surface of the cell body.

Morphology

Plant morphology involves the study of organism structures, including reproductive structures, and also addresses the pattern of development of these structures as the plant matures.[4] For vascular plants the principal structures involved are roots, stems, and leaves; for flowering plants the development of floral structures and seeds is of great importance in plant identification. When structures in different species are thought to result from common, inherited genetic pathways, those structures are termed homologous. For example, cacti spines share the same fundamental structure and development as leaves of other vascular plants, thus cactus spines are homologous to leaves. Plant morphology observes both the vegetative structures of plants and reproductive structures. The vegetative structures of vascular plants includes the study of the shoot system, composed of stems and leaves, as well as the subsurface or root system. The reproductive structures are more varied, and are usually specific to a particular group of plants, such as flowers and seeds for flowering plants, sori for ferns, and capsules for mosses. Analysis of plant reproductive structures has led to the discovery of the alternation of generations present in most plants (as well as algae). This area of plant morphology overlaps with the study of biodiversity and plant systematics.

Plant structure manifests at a range of geometric scales. For the genetic level, intricate microbiology analysis of DNA and RNA structure is required. At the cellular level, optical microscopy must be used. At the macroscopic scale, the visually observable architecture of a plant's structure is under scrutiny. Plant morphology also addresses the pattern of development: the process by which structures originate and mature as a plant grows. While animals produce all the body parts they will ever have from early in their life, plants periodically produce new tissues and structures throughout their life cycles. A living plant continues to have embryonic tissues even in advanced stages of development.[5] The way in which new structures mature as they are produced may be affected by the point in time when the plant begins to develop, as well as by the habitat.

Metabolism and growth

Plant growth is governed by environmental and ecological factors. Chief environmental factors include meteorological parameters such as temperature, precipitation, wind velocity, and available sunlight, and edaphic factors such as soil nutrients, soil moisture, soil granularity and compaction, as well as topographic factors. Ecological factors include competition for water, nutrient, and light resources from other members of the plant community, as well as herbivory and trampling factors. In addition, the presence of plant diseases plays a role in the successful growth and propagation of plant species. In the last millennium, the role of humans has become a major factor in habitat destruction and fragmentation, and there is evidence of the imprint of humans on selective cultivation of species.

The majority of biomass created by a plant is typically derived from the atmosphere. Through a process known as photosynthesis, most plants use the energy in sunlight to convert carbon dioxide from the atmosphere, plus water, into simple sugars, which are used as building blocks and form the main structural components. Chlorophyll, a molecule that lends a green appearance, is typically present in plant leaves as well as and often in other plant parts to absorb sunlight to power the photosynthetic process. Parasitic plants, conversely, derive nutrient resources from a host. Carnivorous plants actually capture small animal prey to gain many essential nutrients. Plants typically depend on soil for architectural support and water uptake, but also obtain nutrients such as nitrogen and phosphorus from soil. Epiphytic and lithophytic plants often depend on rainwater or other sources for nutrients. Some specialized vascular plants, such as mangroves, can grow with their roots in anoxic conditions.

Ecology

Plants constitute most of the primary production of the Earth's ecosystems; that is, they produce the bulk of the biomass from light, carbon dioxide, and basic nutrients.[6] The cornerstone of this primary productivity is photosynthesis, which has radically altered the composition of early Earth's atmosphere, resulting in air that is 21% oxygen. Animals rely on oxygen as well as food sources for herbivores; plants also provide shelter and nesting locations for many species.

Land plants are key components of the water cycle and several other biogeochemical cycles. Some plants have coevolved with nitrogen- fixing bacteria,[7] making plants an important part of the nitrogen cycle. Plant roots play an essential role in soil development and prevention of soil erosion.

The majority of plants have fungi associated with their root systems in a kind of mutualistic symbiosis known as mycorrhiza; an important function of this type of symbiosis is the enhancement of phosphorus uptake.[8] The fungi help the plants gain water and mineral nutrients from the soil, while the plant gives the fungi carbohydrates manufactured in photosynthesis. Some plants serve as homes for endophytic fungi that protect the plant from herbivores by producing toxins.[9] In fact, most plants contain a variety of endophytic micro-organisms, each of which produces a unique set of chemicals that can be useful to the host plant.

Various forms of parasitism are also fairly common among plants, from the semi-parasitic mistletoe that merely extracts nutrients from its host, but also has photosynthetic capability, to the fully parasitic toothwort that acquire all their nutrients through conduits to the roots of other plants.

Plant associations

In a given ecosystem there is typically a well-defined plant association, which commonly is characterized by a canopy layer, an intermediate (or shrub) layer, and an understory or forest floor layer. In the case of grasslands, tundras, and certain other treeless habitats, the upper one or two layers may be absent, although in those cases there are often material differences in the grassland plant height layering. A given plant association will, of course, be dependent on certain soil types, meteorology, and mixture of fauna; moreover, the plant association may manifest marked seasonal differences in temperate and boreal settings, although this appearance will simply conceal certain plants that are dormant or leafless in a given season.[10] Characterization of a plant association is helpful to botanists as a guide to plant identification and other ecological research; furthermore, understanding of a plant association is critical to studies of plant succession, where environmental changes in a given landscape lead to a series of plant communities, before a stable equilibrium is attained.[11]

Interactions with humans

Most of the human diet is plant derived; in addition, a large fraction of raw materials for shelter, clothing and other life necessities of Homo sapiens is obtained from plant products. Furthermore, countless medicinal extracts have been produced from plants. Tree rings are a method of dating in archaeology and serve as a record of past climates. Basic biological research has often been done with plants, such as use of pollen core records to study the distant past or the pea plants used to derive Mendel's laws of genetics. The field of ethnobotany studies plant use by indigenous cultures, which helps to conserve endangered species as well as discover new medicinal herbs. Gardening is the top leisure activity in many world regions.

Plants have served as a source of interest to humans for millennia beyond their use as food. Gardening for ornamental purposes and use of cut flowers for decoration have been noted at least as early as the Bronze Age by Egyptian, Cretan, and Celtic cultures, for example. Early scientists such as the Greeks spent considerable effort engaging in describing and characterizing morphology of various species. Plants have been an important element of human art, with elements of plant architecture appearing as ornamentation for ceramics and other decoration in Neolithic and Bronze ages in China, Crete, Southern Africa, British Isles, Egypt, and in the Mayan civilizations. As an example, glyphs found in Middle Minoan pottery as early as 1850 BC contain designs of olive sprig, saffron, wheat, and silphium.[12] In the history of art, plants played an important role as subjects in classical still-life paintings, and may have reached a crescendo with obsessions by 18th- and 19th-century European printmakers in creating myriads of botanical prints.

Specific to gardening, plants have been used throughout history not only as adornment for indoor and outdoor spaces of human habitation, but also to modify microclimates for more comfortable habitation. For example, treelines and shrub borders have been used, particularly in the last millennium in Europe to provide windscreens for livestock and separation of pastures to secure livestock ownership. Landscaping has also been used for centuries as a method of microclimate amelioration for human habitation, including wind protection, thermal buffering, and atmospheric humidity modification.

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