MAGILL'S ENCYCLOPEDIA OF SCIENCE

PLANT LIFE

Volume 1

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Acid Precipitation–DNA: Recombinant Technology

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Salem Press, Inc.
Pasadena, California
Hackensack, New Jersey

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Some of the updated and revised essays in this work originally appeared in *Magill's Survey of Science: Life Science* (1991), *Magill's Survey of Science: Life Science, Supplement* (1998), *Natural Resources* (1998), *Encyclopedia of Genetics* (1999), *Encyclopedia of Environmental Issues* (2000), *World Geography* (2001), and *Earth Science* (2001).

∞ The paper used in these volumes conforms to the American National Standard for Permanence of Paper for Printed Library Materials, Z39.48-1992 (R1997).

Library of Congress Cataloging-in-Publication Data

Magill's encyclopedia of science : plant life / edited by Bryan D. Ness.

p. cm.
Includes bibliographical references (p.).
ISBN 1-58765-084-3 (set : alk. paper) — ISBN 1-58765-085-1 (vol. 1 : alk. paper) — ISBN 1-58765-086-X (vol. 2 : alk. paper) — ISBN 1-58765-087-8 (vol. 3 : alk. paper) — ISBN 1-58765-088-6 (vol. 4 : alk. paper)
1. Botany—Encyclopedias. I. Ness, Bryan D.
QK7 .M34 2002
580'.3—dc21

2002013319

First Printing

PRINTED IN THE UNITED STATES OF AMERICA

AQUATIC PLANTS

Categories: Economic botany and plant uses; *Plantae*; water-related life

Aquatic plants are any "true" plants, members of the kingdom Plantae, *that are able to thrive and complete their life cycle while in water, on the surface of water, or on hydric soils.*

Hydric soils develop when the ground is flooded or ponded long enough during the growing season to become anaerobic (depleted of oxygen) in the rooting zone. These soils include organic (peats and mucks) and inorganic (mineral) sediments. Aquatic plants grow in fresh, brackish, and salt water but are most common in fresh water. Their habitats include flowing waters (rivers, streams, brooks), standing waters (lakes, ponds), and *wetlands* (bogs, fens, marshes, swamps), which are categorized as *riverine*, *lacustrine*, and *palustrine* communities, respectively. Wetland plants are sometimes referred to as *helophytes*. Marshes are dominated (that is, more than half covered) by herbaceous species and swamps by woody species. Bog plants are aquatics that grow in acidic organic soils. Fen plants occur in alkaline organic soils.

Aquatic plants (also known as *hydrophytes*, *macrophytes*, and *water plants*) occur throughout the plant kingdom. The term "macrophyte" distinguishes them from microscopic aquatic algae, which are not true plants. Aquatic plants have evolved repeatedly, having more than 250 independent origins by some estimates. They occur occasionally in spore-producing plants such as ferns, liverworts, lycopods, and mosses but are relatively rare among nonflowering seed plants (gymnosperms), with bald cypress (*Taxodium*) a notable exception. Flowering plants (angiosperms) contain the greatest hydrophyte diversity, with more species proportionally in monocotyledons than in dicotyledons. Nevertheless, fewer than 2 percent of flowering plant species are aquatic.

Life-Forms

Regardless of their taxonomic affinities, aquatic plants are often classified ecologically by their life-forms. Categories include the following:

- Floating (*acropleustophytes*), with stems and leaves floating completely on the water surface and stems not rooted in the bottom, such as duckweed (*Lemna*) and water hyacinths (*Eichhornia*).
- Emergent (*hyperhydrates*), with stems and leaves extending mainly above the water surface and stems rooted in the bottom, such as cattails (*Typha*) and reeds.
- Phragmites (*planmergents* or *ephydrates*), floating-leaved, with some or all leaves floating on the water surface and stems rooted in the bottom, such as floating-leaved pondweed (*Potamogeton natans*), water chestnut (*Trapa natans*), and water lily (*Nymphaea*).
- Submersed (*hyphydrates*), with stems and leaves completely under water and stems rooted in the bottom, such as Eurasian water milfoil (*Myriophyllum spicatum*) and wild celery (*Vallisneria*).
- Suspended (*mesopleustophytes*), with stems and leaves completely under water and stems not rooted in the bottom, such as the bladderwort (*Utricularia vulgaris*) and the coontail (*Ceratophyllum*).

Benthophyte and *pleustophyte* are used respectively to differentiate between forms that are either rooted in the substrate or unrooted. Species with elongate, leafy stems are termed *vittate* or *caulescent* (such as coontail). Those with leaves clustered in a basal rosette are *rosulate* (such as wild celery), and those not clearly differentiated into stems and leaves are *thalloid* (such as duckweed). Species whose floating or emergent leaves differ morphologically from their submersed leaves are *heterophyllous* (such as floating-leaved pondweed).

Adaptations

Water plants are anatomically and structurally reduced. Watermeal (*Wolffia*), the world's smallest angiosperm, contains plants only 0.4 millimeter long. Submersed species often lack water-

conducting tissue (xylem), mechanical tissue (sclerenchyma), and cuticle. Some lack roots entirely. Support and floatation of underwater stems are accommodated by buoyant tissue (aerenchyma) and extensive air spaces (lacunae) which also transport oxygen throughout the plant. Submersed plants usually possess either highly dissected (compound) or thin, ribbonlike leaves. Some leaves become fenestrate, that is, lacking tissue between the veins. Such leaf shapes increase surface area-to-volume ratios for more efficient nutrient uptake and to reduce damage from water currents.

Floating leaves are normally flat and circular, with stomata on their upper surfaces. They may reach 2.5 meters in diameter (such as *Victoria*). For stability, the stalks (petioles) of most floating leaves are positioned centrally by emargination of the base, as in the water lily, or are peltate by complete fusion of leaf lobes, as in the water shield (*Brasenia*) and *Victoria*. Physiological adaptations enable aquatic plants to tolerate deleterious effects of anaerobic hydric soils.

Reproduction

Most aquatic plants are perennials that reproduce vegetatively (asexually). Species survive winters or other unfavorable periods as intact plants, by dying back to dormant stem apices, by means of modified stems (rhizomes, stolons, tubers), or by use of specialized dormant structures (*hibernacula*) in the sediment. "Winter buds" are a kind of hibernaculum; buds are insulated by normal foliage leaves on shortened internodes. They usually remain attached to the plant. *Turions* are specialized hibernacula that produce modified, morphologically distinct leaves to protect the enclosed buds. Turions always detach from the plant and function as propagules for dispersal. Water plants also disperse vegetatively by fragmentation of stems, which are characteristically brittle, due to the lack of mechanical tissue. Detached stems can establish themselves by production of adventitious roots.

The few aquatic plants that are annuals produce seeds as their dormant stage. Some aquatic annuals also multiply vegetatively by fragmentation during the growing season. Generally, sexual reproduction is rare in submersed species, more common in floating-leaved species, and quite common in emergent species (and annuals).

Pollination in water plants is facilitated by insects (entomophily), wind (anemophily), and water (hydrophily). Most aquatics are insect-pollinated; about one-third of them are wind-pollinated. Less than 5 percent of aquatic species are hydrophilous, with pollen transported on the water surface (ephydrophily) or under the water surface (hyphydrophily). Most marine angiosperms (seagrasses) are hydrophilous.

Seeds, fruits, and vegetative propagules are dispersed locally by water currents and more widely by waterfowl. Waterfowl transport propagules in plumage, in mud adhering to their feet, and by excretion of seeds consumed as food. Many water plants are distributed broadly, with some species achieving worldwide distributions.

NOAA/National Estuarine Research Reserve Archive

A freshwater pond with large water lilies near Charleston, South Carolina.

Uses

Aquatic plants are important economically. Foods include rice (*Oryza sativa*), which sustains more human life than any other plant on earth. Aquatic plants are important horticulturally as aquarium and water-garden ornamentals. Some aquatic plants, such as the water hyacinth, are invasive weeds that interfere with shipping, irrigation, or recreation and cost millions of dollars to eradicate. The beauty of many water plants, especially water lilies, has inspired art and religion since ancient times.

Donald H. Les

See also: Adaptations; Angiosperm evolution; Angiosperms; Eutrophication; Invasive plants; Marine plants; Peat; Pollination; Rice; Wetlands.

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ARCHAEA

Categories: Bacteria; evolution; paleobotany; taxonomic groups

The domain Archaea *represents a diverse group of prokaryotes originally found in environments once considered to be hostile to life, now known to be widely distributed in nature.*

The cycling of plant nutrients, such as carbon, nitrogen, and sulfur, requires the activity of microorganisms that convert these elements to forms readily available to plants. These microorganisms, which are generally found in both soil and water, include both prokaryotic organisms of the domain *Bacteria* and the domain of prokaryotes called *Archaea*, which play significant roles in nutrient cycling. Along with *Eukarya*, to which protists, fungi, plants, and animals belong, the *Archaea* form one of the three domains of life. The *Archaea* are related to both *Bacteria* and *Eukarya* and, in some respects, appear to be more closely related to *Eukarya*. Biochemical and genetic studies, including information obtained from whole genome sequencing, suggest that *Archaea* may be closely related to an ancestor that gave rise to both *Bacteria* and *Eukarya*. Thus, *Archaea* may provide some insight into the processes that resulted in the evolution of higher lifeforms, including plants and animals.

A Third Domain

For more than fifty years, biologists categorized living organisms into two groups based on their cellular organization and complexity: prokaryotes (originally all classified in kingdom *Monera*), the single-celled organisms whose chromosomes are not compartmentalized inside a nucleus (which include the domain *Bacteria*), and eukaryotes, consisting of all other organisms, whose cells contain a nucleus. In the late 1970's studies on a unique group of microorganisms led investigators to question the accepted classification of prokaryotes. Originally called *Archaebacteria* by molecular biologist Carl Woese and his colleagues in 1977, these microorganisms were isolated from environments charac-