

**ASA GRAY**



***THE ELEMENTS  
OF BOTANY, FOR  
BEGINNERS AND  
FOR SCHOOLS***

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# **The Elements of Botany, For Beginners and For Schools**

**Enriched edition.**

*Introduction, Studies and Commentaries by Lance Thomas*

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# Introduction

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Between the unruly wealth of leaf, stem, and flower and the disciplined order of scientific names, Asa Gray's *The Elements of Botany* guides beginners to transform looking into knowing, showing how the fleeting particulars of a plant's form can be patiently gathered, compared, and expressed in clear terms, and how a garden's multiplicity, once bewildering, becomes an intelligible pattern through careful observation, steady vocabulary, and an accessible method that turns curiosity into practice while honoring the living subject that first captured the student's eye, and, in that conversion, offers the novice a durable way to think with plants.

As a scientific primer written for general education, this work belongs to the tradition of nineteenth-century natural history instruction, aligned with the needs of classrooms and independent learners. Asa Gray, a prominent American botanist, shaped English-language botany for beginners through clear terminology and practical organization, and this volume reflects that pedagogical mission. It introduces students to the study of plants as a systematic inquiry rather than a casual pastime, presenting botany as a discipline that can be learned by anyone willing to observe closely. Its origin in an era of expanding public science education gives it both clarity of purpose and enduring accessibility.

Readers begin with fundamental features of plant life and move outward to patterns that help identify and relate

species, encountering definitions that are carefully built from ordinary observation. Gray's voice is measured and encouraging, prioritizing precision without pedantry, and his style privileges short, comprehensible steps over grand abstraction. The tone is patient, methodical, and welcoming, inviting the learner to test each idea against specimens at hand. Rather than dazzling with novelty, the book assembles a toolkit: terms, distinctions, and procedures for noticing, comparing, and classifying plants within the systems of his time, always returning to what can be seen and examined.

Central themes emerge from this approach: the habit of close observation, the discipline of naming, and the relation between structure and function as a basis for comparison. The book insists that language is not ornament but instrument, enabling learners to carry their findings from field to desk and back again. It emphasizes repeatable method over authority, inviting students to verify claims through their own scrutiny. By demonstrating how patterns arise from many small particulars, Gray shows how careful attention yields understanding without reducing living organisms to mere labels, making the study of plants both intellectually coherent and ethically attentive to their complexity.

Though designed for schools, the book speaks as readily to a solitary reader as to a room of pupils, because it anchors progress in tangible experience: comparing leaves, noticing symmetry, tracing parts to their roles. The organization encourages mastery through accumulation rather than spectacle, so that confidence grows with each new term put to use. Gray anticipates common confusions and resolves them by returning to observable features, modeling a way to ask better questions. The effect is a primer that teaches

how to learn botany, not merely what to recite, and that fosters a durable curiosity capable of guiding future study.

For contemporary readers, this text offers two kinds of value: a foundation and a perspective. Many morphological terms and distinctions that structure modern field guides and courses are articulated here with unusual clarity, and the practice of careful seeing remains indispensable even in an age shaped by microscopes and genomes. At the same time, the book provides a window into the history of science education, revealing how an accessible style can lower barriers to entry without sacrificing rigor. It invites today's students, educators, gardeners, and naturalists to cultivate attention, precision, and patience as habits that enrich both study and stewardship.

To read *The Elements of Botany* now is to encounter a careful mind building a bridge between curiosity and system, a model of how to learn from the living world with respect and discipline. The book's enduring strength lies not only in its facts but in its method, which equips readers to keep learning beyond its pages. As a historical artifact, it illuminates the aims of early scientific education; as a practical guide, it still helps newcomers begin. In each role, it affirms that attention is a learned skill, and that such attention can turn familiar plants into lasting teachers.

# Synopsis

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Asa Gray's *The Elements of Botany, For Beginners and For Schools* introduces botany as a coherent study of plant form, function, and relationship, organized for classroom use. Gray frames the subject by clarifying what counts as a plant and how observation, comparison, and precise description ground botanical knowledge. He sets out a progressive plan: begin with what can be seen, name it accurately, relate parts to wholes, and only then generalize. The opening chapters establish vocabulary and method, emphasizing that consistent terminology and attention to common structures allow novices to move from familiar specimens to a systematic understanding of the plant kingdom.

From this foundation, the text surveys external structure, treating roots, stems, and leaves as the principal organs of vegetation. Gray catalogs their forms, attachments, and modifications, showing how growth patterns, leaf arrangement, and venation can be recognized and described. He stresses the link between form and office, explaining how organs anchor, support, and nourish the plant, while also noting frequent departures from simple types. Variation is organized rather than anecdotal: students learn to distinguish ordinary from altered structures and to read buds, nodes, and internodes as recurring units. The aim is to supply a stable descriptive framework that will support later analysis.

The discussion turns to the organs of reproduction, where flowers are analyzed into their constituent parts and positions. Gray explains common floral plans and the ways sepals, petals, stamens, and pistils are arranged, united, or omitted. He extends this to inflorescences, fruits, and seeds, establishing the sequence from blossom to embryo and seedling in broad outline. Rather than treating examples in isolation, the exposition compares structures to reveal shared patterns across diverse plants. By connecting the morphology of flowers and fruits with their roles in perpetuating the species, the book equips beginners to recognize diagnostic features that matter in identification and classification.

Complementing morphology, the work introduces basic plant physiology in accessible terms. Gray describes how plants take in materials, elaborate their own substance, and sustain growth, relating roots to absorption, leaves to the transformation of raw materials, and stems to transport. Processes such as transpiration, respiration, and the changes that accompany germination are outlined to show how living tissues act over time. Environmental conditions—light, temperature, moisture, and soil—are treated as influences that alter rate and habit rather than as vague externalities. In this way, the exposition connects observable organs with the unseen operations that animate them, completing a first view of plant life.

With structures and functions in hand, Gray introduces classification as an attempt to express natural affinities. He explains taxonomic ranks from species through genera and families, and the basis on which botanists diagnose and compare them. The book contrasts artificial arrangements, useful for convenience, with more comprehensive natural groupings that reflect multiple characters. Readers are shown how consistent differences in flowers, fruits, and

vegetative parts yield definitions, and how named groups aid communication and study. Nomenclature and description are presented as tools bound to evidence, reinforcing the earlier insistence on careful observation and the measured use of technical language.

The survey culminates in an outline of major divisions of plants, distinguishing seed-bearing forms from spore-bearing ones and noting their salient traits. In seed plants, Gray emphasizes the organization of embryo, seed, and the varied structures that support them, while in ferns, mosses, and allied groups he highlights characteristic organs and modes of reproduction in general terms. The account balances unity and diversity: recurring plans are traced across wide variety, and exceptional cases are used to test rules without overwhelming the beginner. By assembling a broad map of plant kinds, the text prepares students to place new specimens within an intelligible order.

Throughout, *The Elements of Botany* remains a primer for study as much as a compendium of facts. It models how to examine a specimen, frame a description, compare like with like, and evaluate similarities and differences with restraint. The closing emphasis falls on the discipline of attention that underlies reliable natural history and on the utility of a common vocabulary across classrooms. Without presuming prior expertise, Gray offers a durable structure within which further knowledge can accumulate. Its continued resonance lies in establishing habits of inquiry about plant form, function, and relationship that still anchor introductory botany and guide more advanced work.

# Historical Context

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In the United States during the antebellum decades, botany moved from a specialist pursuit into classrooms and local field clubs. Asa Gray (1810–1888), trained as a physician in New York and soon the nation’s most prominent botanist, wrote *The Elements of Botany* for beginners within this expanding educational landscape. American colleges and academies sought reliable science texts, and Gray, already collaborating with established botanists, offered a concise, systematized introduction. The book addressed students in schools and young colleges, reflecting the growing expectation that natural history should be part of general education and that American flora could furnish exemplary material for instruction.

Classification was in transition when Gray prepared his school manual. The Linnaean “sexual system,” still useful for identification, was giving way to the “natural system” of Antoine-Laurent de Jussieu and Augustin-Pyramus de Candolle, which grouped plants by broader morphological affinities. Gray helped naturalize this approach in America, emphasizing organs, structures, and comparative characters over mere counting of stamens and pistils. By translating European taxonomic principles into clear English and illustrating them with familiar North American examples, he made current botanical theory accessible to novices. *The Elements* thus participated in updating classroom botany in line with the leading scientific standards of the day.

Gray's early career linked him to key institutions and mentors. He formed a lifelong partnership with John Torrey of New York, with whom he undertook the Flora of North America (1838–1843), an ambitious survey that organized the continent's plants. Trained in medicine, Gray brought a practitioner's precision to plant description and an interest in materia medica that many American students shared. His focus on careful terminology, diagnostic characters, and herbarium practice in *The Elements* reflects the professionalizing thrust of American botany, which was building collections, standardizing names, and aligning itself with international norms while documenting a rapidly expanding flora.

The textbook also emerged from a vibrant print culture that catered to schools and lyceums. Affordable wood-engraved illustrations and portable formats made scientific primers widely usable. In the United States, botany had become a favored subject in female seminaries and academies, propelled by authors such as Almira Hart Lincoln Phelps, whose popular manuals preceded Gray's. Publishers in New York, Philadelphia, and Boston sought authoritative, up-to-date treatments. Gray's *Elements* situated itself within that market by offering clear definitions, concise explanations, and examples drawn from American plants, positioning the work as both a teaching tool and a bridge between popular natural history and professional study.

Institutional supports for botany expanded as Gray was writing and teaching. Harvard University appointed him Fisher Professor of Natural History in 1842, giving him a base at the Cambridge Botanic Garden and access to students and collections. Nationally, the Smithsonian Institution, founded in 1846, fostered specimen exchange and publication, strengthening networks that fed classroom and research needs. Government-sponsored expeditions

and surveys gathered plants from the West and the Pacific, and Gray worked on many of these collections. The Elements distilled practices used in such institutions—careful observation, standardized vocabulary, and attention to local floras—into lessons intended for beginners and schoolrooms.

The book also reflects contemporary pedagogy. The common-school movement, energized by figures like Horace Mann after 1837, promoted graded instruction, teacher training, and uniform textbooks. Botanical primers were expected to be concise, cumulative, and suitable for recitation, while encouraging observation through schoolyard walks and home-made herbaria. Gray's Elements met these expectations by defining terms, organizing topics logically, and anchoring abstractions in nearby species that students could find. Its clarity made it adaptable for academies and normal schools, aligning practical field work with classroom drills and making botanical literacy attainable within the time and resources of mid-nineteenth-century American schooling.

Religious and philosophical currents also shaped how students read natural history. Before the public debates over evolution, American botany commonly echoed natural theology, presenting plant order and adaptation as signs of underlying design. Gray later became a prominent interpreter of Charles Darwin in the United States, arguing in essays and reviews that evolutionary theory could be reconciled with theism. The Elements, however, belongs to an earlier instructional moment: it avoids speculation, emphasizes empirical description, and treats classification as a tool for understanding nature's order. That framing mirrored the cultural preference for harmonizing scientific study with moral and civic education.

As a schoolbook rooted in American examples and contemporary taxonomy, *The Elements of Botany* condensed a maturing scientific enterprise for novice readers. It balanced European-derived theory with local practice, encouraged field observation, and supplied a common vocabulary useful to both amateurs and professionals. Appearing amid expanding institutions, new networks of exchange, and a democratizing school system, the work helped standardize how plants were described and recognized. In doing so, it recorded the optimism of its era—the belief that disciplined study of nature belonged to the many—and it quietly prepared students for the more sweeping scientific debates that soon followed.

# **The Elements of Botany, For Beginners and For Schools**

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# PREFACE.

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This volume takes the place of the author's LESSONS IN BOTANY AND VEGETABLE PHYSIOLOGY, published over a quarter of a century ago. It is constructed on the same lines, and is a kind of new and much revised edition of that successful work. While in some respects more extended, it is also more concise and terse than its predecessor. This should the better fit it for its purpose now that competent teachers are common. They may in many cases develop paragraphs into lectures, and fully illustrate points which are barely, but it is hoped clearly, stated. Indeed, even for those without a teacher, it may be that a condensed is better than a diffuse exposition.

The book is adapted to the higher schools, "How Plants Grow and Behave" being the "Botany for Young People and Common Schools." It is intended to ground beginners in Structural Botany and the principles of vegetable life, mainly as concerns Flowering or Phanerogamous plants, with which botanical instruction should always begin; also to be a companion and interpreter to the Manuals and Floras by which the student threads his flowery way to a clear knowledge of the surrounding vegetable creation. Such a book, like a grammar, must needs abound in technical words, which thus arrayed may seem formidable; nevertheless, if rightly apprehended, this treatise should teach that the study of botany is not the learning of names and terms, but the acquisition of knowledge and ideas. No effort should be made to commit technical terms to memory. Any term used in describing a plant or explaining its structure can be looked up when it is wanted, and that should suffice. On the other hand, plans of structure, types, adaptations, and modifications, once understood, are not

readily forgotten; and they give meaning and interest to the technical terms used in explaining them.

In these "Elements" naturally no mention has been made of certain terms and names which recent cryptogamically-minded botanists, with lack of proportion and just perspective, are endeavoring to introduce into phanerogamous botany, and which are not needed nor appropriate, even in more advanced works, for the adequate recognition of the ascertained analogies and homologies.

As this volume will be the grammar and dictionary to more than one or two Manuals, Floras, etc., the particular directions for procedure which were given in the "First Lessons" are now relegated to those works themselves, which in their new editions will provide the requisite explanations. On the other hand, in view of such extended use, the Glossary at the end of this book has been considerably enlarged. It will be found to include not merely the common terms of botanical description but also many which are unusual or obsolete; yet any of them may now and then be encountered. Moreover, no small number of the Latin and Greek words which form the whole or part of the commoner specific names are added to this Glossary, some in an Anglicized, others in their Latin form. This may be helpful to students with small Latin and less Greek, in catching the meaning of a botanical name or term.

The illustrations in this volume are largely increased in number. They are mostly from the hand of Isaac Sprague.

It happens that the title chosen for this book is that of the author's earliest publication, in the year 1836, of which copies are rarely seen; so that no inconvenience is likely to arise from the present use of the name.

ASA GRAY.

CAMBRIDGE, MASSACHUSETTS,  
*March, 1887.*



# **ELEMENTS OF BOTANY.**

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# SECTION I. INTRODUCTORY.

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1. BOTANY is the name of the science of the vegetable kingdom in general; that is, of plants[1q].

2. Plants may be studied as to their kinds and relationships. This study is SYSTEMATIC BOTANY. An enumeration of the kinds of vegetables, as far as known, classified according to their various degrees of resemblance or difference, constitutes a general *System of plants*. A similar account of the vegetables of any particular country or district is called a *Flora*.

3. Plants may be studied as to their structure and parts. This is STRUCTURAL BOTANY, or ORGANOGRAPHY. The study of the organs or parts of plants in regard to the different forms and different uses which the same kind of organ may assume—the comparison, for instance, of a flower-leaf or a bud-scale with a common leaf—is VEGETABLE MORPHOLOGY, or MORPHOLOGICAL BOTANY. The study of the minute structure of the parts, to learn by the microscope what they themselves are formed of, is VEGETABLE ANATOMY, or HISTOLOGY; in other words, it is Microscopical Structural Botany. The study of the actions of plants or of their parts, of the ways in which a plant lives, grows, and acts, is the province of PHYSIOLOGICAL BOTANY, or VEGETABLE PHYSIOLOGY.

4. This book is to teach the outlines of Structural Botany and of the simpler parts of the physiology of plants, that it may be known how plants are constructed and adapted to their surroundings, and how they live, move, propagate, and have their being in an existence no less real, although more simple, than that of the animal creation which they support. Particularly, this book is to teach the principles of the

structure and relationships of plants, the nature and names of their parts and their modifications, and so to prepare for the study of Systematic Botany; in which the learner may ascertain the name and the place in the system of any or all of the ordinary plants within reach, whether wild or cultivated. And in ascertaining the name of any plant, the student, if rightly taught, will come to know all about its general or particular structure, rank, and relationship to other plants.

5. The vegetable kingdom is so vast and various, and the difference is so wide between ordinary trees, shrubs, and herbs on the one hand, and mosses, moulds, and such like on the other, that it is hardly possible to frame an intelligible account of plants as a whole without contradictions or misstatements, or endless and troublesome qualifications. If we say that plants come from seeds, bear flowers, and have roots, stems, and leaves, this is not true of the lower orders. It is best for the beginner, therefore, to treat of the higher orders of plants by themselves, without particular reference to the lower.

6. Let it be understood, accordingly, that there is a higher and a lower series of plants; namely:—

PHANEROGAMOUS PLANTS, which come from seed and bear *flowers*, essentially stamens and pistils, through the co-operation of which seed is produced. For shortness, these are commonly called PHANEROGAMS, or *Phænogams*<sup>[1]</sup>, or by the equivalent English name of FLOWERING PLANTS.<sup>[1]</sup>

CRYPTOGAMOUS PLANTS<sup>[2]</sup>, or CRYPTOGRAMS, come from minute bodies, which answer to seeds, but are of much simpler structure, and such plants have not stamens and pistils. Therefore they are called in English FLOWERLESS PLANTS. Such are Ferns, Mosses, Algæ or Seaweeds, Fungi, etc. These sorts

have each to be studied separately, for each class or order has a plan of its own.

7. But Phanerogamous, or Flowering, Plants are all constructed on one plan, or *type*<sup>[2q]</sup>. That is, taking almost any ordinary herb, shrub, or tree for a pattern, it will exemplify the whole series: the parts of one plant answer to the parts of any other, with only certain differences in particulars. And the occupation and the delight of the scientific botanist is in tracing out this common plan, in detecting the likenesses under all the diversities, and in noting the meaning of these manifold diversities. So the attentive study of any one plant, from its growth out of the seed to the flowering and fruiting state and the production of seed like to that from which the plant grew, would not only give a correct general idea of the structure, growth, and characteristics of Flowering Plants in general, but also serve as a pattern or standard of comparison. Some plants will serve this purpose of a pattern much better than others. A proper pattern will be one that is perfect in the sense of having all the principal parts of a phanerogamous plant, and simple and regular in having these parts free from complications or disguises. The common Flax-plant may very well serve this purpose. Being an annual, it has the advantage of being easily raised and carried in a short time through its circle of existence, from seedling to fruit and seed.

## FOOTNOTES:

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[1] The name is sometimes *Phanerogamous*, sometimes *Phænogamous* (*Phanerogams*, or *Phænogams*), terms of the same meaning etymologically; the former of preferable form, but the latter shorter. The meaning of such terms is explained in the Glossary.



## SECTION II. FLAX AS A PATTERN PLANT.

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8. **Growth from the Seed.** Phanerogamous plants grow from seed, and their flowers are destined to the production of seeds. A seed has a rudimentary plant ready formed in it—sometimes with the two most essential parts, i.e. stem and leaf, plainly discernible; sometimes with no obvious distinction of organs until germination begins. This incipient plant is called an EMBRYO.

9. In this section the Flax-plant is taken as a specimen, or type, and the development and history of common plants in general is illustrated by it. In flax-seed the embryo nearly fills the coats, but not quite. There is a small deposit of nourishment between the seed-coat and the embryo: this may for the present be left out of the account. This embryo consists of a pair of leaves, pressed together face to face, and attached to an extremely short stem. (Fig. [2-4](#).) In this rudimentary condition the real nature of the parts is not at once apparent; but when the seed grows they promptly reveal their character—as the accompanying figures (Fig. [5-7](#)) show.

**16** 'Monoëcious' (monoecious) denotes plants that bear both male (staminate) and female (pistillate) flowers on the same individual, as contrasted with dioecious (separate-sex) plants; the text gives *Ricinus* (castor-oil plant) as an example.

**17** *Æstivation* (modern spelling 'aestivation') denotes the arrangement or folding of the petals or sepals inside a flower bud before anthesis (the flower opening), and is used as a diagnostic character; Gray also notes the alternative term 'Præfloration.'

**18** *Compositæ* is the older Latin name for the plant family now usually called *Asteraceae* (also *Compositae*), which includes daisies, sunflowers, asters and dandelions; the *æ* ligature reflects nineteenth-century typographic convention.

**19** A technical botanical term for the female reproductive parts of a flower taken collectively — basically the pistil(s), carpels, ovary, style, and stigma.

**20** A coherent mass or packet of pollen (plural *Pollinia*) produced by plants such as orchids and milkweeds, which is transferred as a unit during pollination.

**21** Describes a stamen arrangement with six stamens of which four are longer than the other two, a condition characteristic of the mustard family (*Cruciferous*, modern family name *Brassicaceae*).

**22** An older 19th-century generic name for the lotus plants now usually placed in the genus *Nelumbo*; historically treated alongside water-lilies in botanical works of that period.

**23** A botanical term meaning situated below the pistil or ovary; in hypogynous flowers the disk or other floral parts

are attached beneath a superior ovary.

**24** A flattened hypogynous disk underlying the ovary that may remain or fall away at maturity; the term is used in the text for such a structure (for example in the Rue family).

**25** A short, thick appendage at or near the hilum of certain seeds; the text gives the seed of *Ricinus* (castor bean) as an example showing a caruncle.

**26** The scar on a seed left where the seed-stalk (funiculus) fell away or where the seed was attached directly to the placenta; it marks the point of attachment.

**27** Here used for the living substance of cells in which life is said to reside; the text describes it as essential to growth and composed chiefly of carbon, hydrogen, oxygen, and nitrogen.

**28** A thin ring of forming tissue between the wood and the bark composed of actively dividing cells; in modern botany this is called the vascular cambium and produces new xylem (wood) inward and new phloem (inner bark) outward. Gray also notes the older meaning of 'cambium' as nutritive juice, a historical usage rather than current technical terminology.

**29** An older name for the fibrous inner bark, equivalent to the phloem in modern terms; it contains bast fibers and sieve cells that conduct nutrients and in some species furnish fibers used for cordage (e.g., flax, hemp).

**30** Refers to the very large coniferous trees of California commonly called redwoods; in current taxonomy the name may be used with reference to species such as *Sequoia sempervirens* (coast redwood) or *Sequoiadendron*

giganteum (giant sequoia), though the text does not specify which species.

**31** A Linnaean term meaning 'hidden marriage' applied to 'flowerless' plants whose reproductive organs were not obvious; historically this group included ferns, mosses, algae and fungi, but modern classification separates these into distinct lineages.

**32** An older botanical term for the whole leaf of a fern (including blade and stalk); early botanists used it as a special name for fern-leaves but today it simply means a fern leaf or large divided leaf.

**33** A shield-shaped membrane or scale that covers or protects a cluster of fern spore-cases (a sorus) in many fern species; it is a morphological feature used in fern identification.

**34** The free-living gametophyte stage of a fern, typically a small, often heart-shaped green thallus that develops from a spore and bears the sexual organs (antheridia and archegonia) that produce sperm and eggs.

**35** Joseph Pitton de Tournefort (1656–1708), a French botanist noted for an early artificial classification system based largely on the structure of the corolla and calyx, mentioned here as a once-prevailing system.

**36** The vegetative body of a fungus composed of a network of microscopic threadlike filaments called hyphae, which absorb nutrients from the substrate and form the basis of fungal growth and reproduction.

**37** A Vasculum is a flat tin botanical collecting box (likened to a candle-box or sandwich-case) used to carry freshly gathered plants so they remain cool and do not wilt; texts

recommend sizes to hold stems about a foot to fifteen inches long.

**38** Hortus Siccus is a Latin phrase literally meaning 'dry garden' and is used historically to denote a collection of dried, ticketed plant specimens — what is commonly called a herbarium.

**39** 'Corrosive sublimate' is the historical name for mercuric chloride (a mercury salt) that was commonly used as a preservative/insecticide for dried botanical specimens; it is highly toxic and its use has been largely discontinued for safety reasons.

**40** Ament is another name for a catkin: a slim, typically pendulous spike-like inflorescence bearing usually unisexual flowers, common on trees such as willows, birches, and oaks and often wind-pollinated.

**41** In mosses, the calyptra is the hood- or veil-like covering of the capsule (spore case), formed from maternal tissue of the gametophyte and usually shed as the capsule matures.

**42** An older spelling of 'phanerogamous', used in 19th-century botany to mean plants with conspicuous reproductive organs—i.e., seed-producing plants including flowering plants (angiosperms) and gymnosperms, as opposed to non-seed 'cryptogams'.

**43** A Latin-derived botanical term meaning the 'throat' or entrance of a calyx or corolla (the opening of a flower tube); it is unrelated to the modern French word 'faux' meaning 'false'.

**44** From Greek 'macro-' (long); in botany it denotes plants or leaves that are relatively large or long — i.e., large-leaved — often used in contrast to 'micro-' (small).