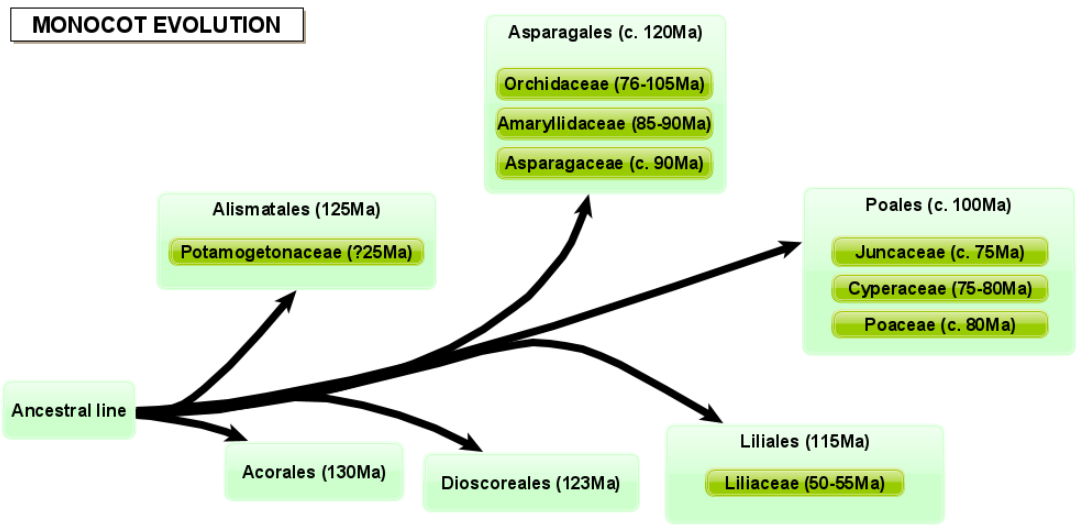
HAMPSHIRE FLORA GROUP WORKSHOPS: DEVELOPING IDENTIFICATION SKILLS

MODULE 3: MONOCOTS AND CARYOPHYLLALES

Monocots in context

In Module 1 we dealt with the evolutionary divergence of the main groups of seed plants and the broad classification of flowering plants that results from that in modern taxonomy. You may like to refer to pp. 35-42 of that module for an overview. From there you will know that the Monocots have a documented history going back to the early Cretaceous period (100-130Ma) and probably diverged from the main lineage of present-day Dicots a little earlier than that. If you pick up a modern technical Flora for most parts of the world today, you'll likely find that the Monocots are dealt with before the Eudicots, but Stace (2019) has stuck with the traditional British practice of putting them last. It really makes no difference to our understanding of them. Both lineages have perpetuated (or possibly re-invented?) some features of the Basal Angiosperms in at least a few member families.

Here's a reminder of the evolutionary history of the orders and the "big families" in the Monocots found in Britain. In this workshop we're going to be dealing mostly with the Amaryllidaceae, Asparagaceae, Iridaceae and Liliaceae; but we shall also take a look at three big Poales families, and briefly survey the Alismatales.



Let's also remind ourselves of some of the main traits of the Monocots, keeping in mind that exceptions crop up quite frequently and there is no field character that neatly differentiates Monocots from Dicots (not even the one seed leaf!). In fact, the two best characters (leaf development at the cellular level, and pollen characteristics) are not usable in the field. The rooting

anatomy is also good but not something you may always want to investigate, for several reasons. For comparisons of Monocots with the other groupings, the table on pp. 28-29 of Module 1 has more detail.

A word of advice: the Monocots include many families that are very difficult to formalise, because of the diversity of their flowering parts and the reappearance of similar features across orders and families. If you've used a family key in a "big Flora" such as Stace, you will notice that the same monocot family names crop up over and over again in different parts of the keys, more than in almost any dicot group. Don't be disheartened; although this can't be made easy, I hope the following account will help to highlight where features appear and where similarities exist.

Trait	**Exceptions: examples found in orders covered here**
Single seed-leaf (monocotyledonous)	
Mostly herbs	**Asparagales** (*Ruscus*)
Fibrous roots springing not from a tap-root but from the base of the stem or other parts of the stem, leaves in some cases, or from modified stems or shoots (rhizomes and stolons)	
Leaves mostly with parallel or subparallel (biconvergent) venation, major veins not reticulate (networked)	**Alismatales** (*Arum*) **Dioscoreales** (*Tamus*) **Liliales** (*Paris*)
Floral parts usually trimerous (in multiples of 3). The most important exceptions here for a British botanist are the Cyperaceae and Poaceae, which have very "non-standard" flowering morphology that needs to be learned.	**Alismatales** (*Arum*, Zosteraceae, Potamogetonaceae, Ruppiaceae) **Liliales** (*Paris*) **Asparagales** (*Maianthemum*) **Poales** (Typhaceae, Eriocaulaceae, Cyperaceae, Poaceae)

At this point it's worth considering the traits of the individual monocot orders found in the wild in Britain. However, some members only found planted in Britain don't follow these rules.

I am leaving Acorales and Alismatales out of this table because they differ considerably from the other orders and show a bewildering diversity of traits that is better treated separately. The Dioscoreales is an odd grouping and has just two quite different species in Britain: *Narthecium ossifragum* (Bog Asphodel) and *Tamus communis* (Black Bryony).

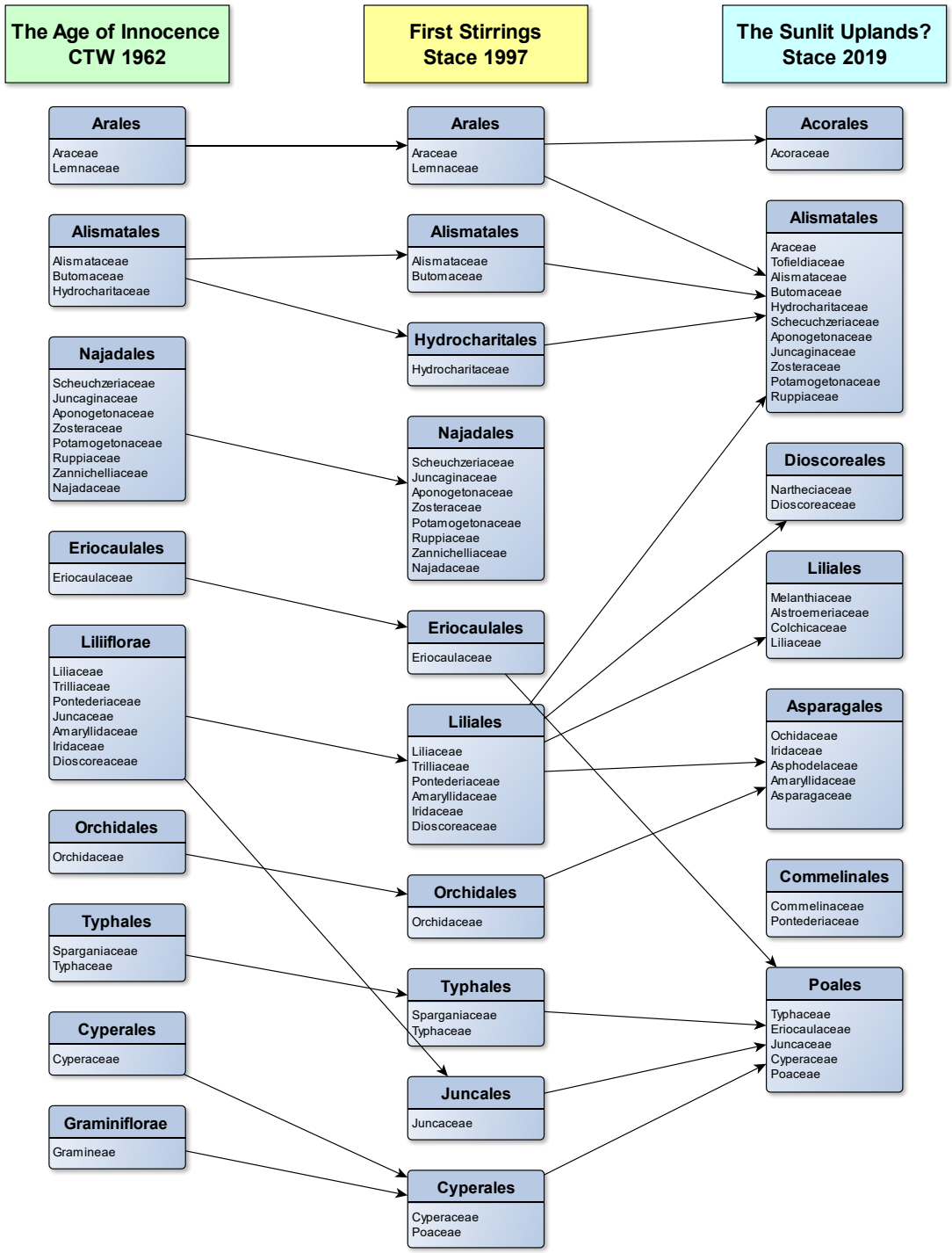
It's not worth spending too long trying to read simple diagnostic patterns out of the following table. The take-away message is that there is no straightforward set of criteria that demarcates one order from the next, and it's most useful for picking out exceptions, or ruling out some orders in certain cases. For instance:

- *bulbous plants are limited to just two orders, and they encompass virtually all of the non-aquatic plants with single-flowered inflorescences;*
- *while all orders have some 3-merous flowers, only a few have other counts;*
- *shrubby monocots are very rare in the British flora.*

Trait	Dioscoreales	Asparagales	Liliales	Poales
Aquatic or wetland	✓	✓		✓
Dry land	✓	✓	✓	✓
Herbs	✓	✓	✓	✓
Shrubs		✓		
Rhizomes / tubers / stolons	✓	✓	✓	✓
Corms	✓	✓	✓	
Bulbs		✓	✓	
Leaves whorled			✓	
Leaves alternate, spiralled or 2-ranked (distichous)	✓	✓	✓	✓
Leaf outline ± linear	✓	✓	✓	✓
Leaf outline broader	✓	✓	✓	✓
Leaf venation parallel / biconvergent	✓	✓	✓	✓
Leaf venation pinnate / palmate / reticulate	✓	✓		
Inflorescence of 1 or 2 flowers		✓	✓	
Inflorescence a raceme, spike or head	✓	✓	✓	✓
Inflorescence a panicle		✓		✓
Inflorescence an umbel		✓		
Inflorescence a cyme		✓		✓
Flowers bisexual	✓	✓	✓	✓
Flowers monoecious				✓
Flowers polygamous (i.e. some bisexual and others not)				✓
Flowers dioecious	✓	✓		✓
Perianth 0 or not obvious				✓
Perianth 1-2-merous				✓
Perianth 3-merous (both whorls similar)	✓	✓	✓	✓
Perianth 3-merous (differing whorls)		✓		✓
Perianth 4-merous			✓	
Perianth 8-merous to 12-merous			✓	
Perianth actinomorphic (rotational symmetry)	✓	✓	✓	✓
Perianth zygomorphic (mirror symmetry)		✓	(✓)	✓

Trait	Dioscoreales	Asparagales	Liliales	Poales
Flowers hypogynous (ovary superior)	✓	✓	✓	✓
Flowers perigynous (ovary superior but with perianth and stamens borne above the base of the ovary on a **hypanthium** - a saucer, cup or beer glass of outgrowth from the receptacle)		✓		
Flowers epigynous (ovary inferior)	✓	✓	✓	
Stamens 1		✓		
Stamens 1-3				✓
Stamens 1-8				✓
Stamens 2		✓		✓
Stamens 3		✓		✓
Stamens 4				✓
Stamens 6	✓	✓	✓	✓
Stamens 8-12			✓	
Styles 0 or insignificant		✓	✓	✓
Styles 1	✓	✓	✓	✓
Styles 2 or 3			✓	✓
Styles 3-branched, sometimes branching again		✓		
Stigmas capitate or discoid	✓	✓	✓	✓
Stigmas simple, ±elongated			✓	✓
Stigmas ±bifid	✓	✓		✓
Stigmas trifid		✓	✓	✓
Stigmas quadrifid			✓	
Ovary 1-celled		✓		✓
Ovary 2-celled				✓
Ovary 3-celled	✓	✓	✓	✓
Ovary 4-5-celled			✓	

The Great Upset



Monocot taxonomy has never been very straightforward, since any analysis based on morphology is bound to run into difficulty with exceptions. Taxonomic techniques now embrace molecular (DNA) analysis alongside better and more widely used mathematical and statistical tools for classifying through **phenetics** (based on what it looks like) and **cladistics** (based on what it came from; here, molecular evidence is often now paramount although

classical palaeontology also plays a part). Inevitably, this has revealed new and sometimes surprising relationships, leading to the now generally accepted APG IV classification. The biggest effects for us are these.

- A slightly smaller number of orders.
- The prominence of the large and diverse order Alismatales (which perhaps also ought to embrace Acorales, at least on molecular grounds). This makes it more difficult to undertake ID from a strictly 'top down' approach based chiefly on floral characters. This won't matter to you if you are using an artificial key; for instance, in the latest edition of Stace members of the Alismatales key out at 20 different places in the family key to catch all the oddballs.
- The breaking up of Liliales and the sometimes startling reassignment of taxa across four orders. This has resulted in one new, large order (Asparagales) and one radically revised one (Liliales); the creation of several new families; and the appearance of some genera in orders where they bear little resemblance to other members of the order. In this workshop session we'll concentrate on trying to shed some light on the fate of the old Liliales families, in particular those that were grouped together in Liliaceae by the eminent taxonomist Cronquist but later recognised as needing separation.

A quick jog through the Alismatales

Although not the main subject for this session, a summary of the British families of this order (along with Acoraceae) may be helpful. It really deserves a workshop of its own. This large order brings together many families (mostly aquatic or wetland), remarkably diverse in appearance, many of them with flowers that are minute, difficult to observe in the field, rarely present or completely absent in the British climate. They began to appear about 125 million years ago.

Therefore, it's much less practical to make a key based purely on floral morphology than for many groups. The following is not really for ID purposes but an attempt to demonstrate the complexity using a variety of other features, while keeping floral relationships in play. For identification of aquatic plants, you are likely to find a key such as that in Lansdown (2009) much more practical as it relies almost entirely on vegetative features at all the higher levels, and often down to species. For terrestrial plants, the 'spadix and spathe' inflorescences are distinctive; such plants can then easily be run down to genus and usually to species with any good field guide or technical Flora.

Trait					Families
Dry-land plants					**Araceae** (*Arum, Dracunculus, Arisarum*)
Wetland or aquatic plants	Tiny flowers in densely packed spike	Spike appearing lateral, overtopped by narrow leaf-like spathe			**Acoraceae**
		Spike terminal but accompanied by broad spathe, often enclosing spadix base and often overtopping spadix			**Araceae (***Lysichiton, Calla, Zantedeschia, Orontium*)
	Flowers tiny or not, not in densely packed spike	Free-floating plants	Plant forming stolons; lvs >2cm		**Araceae** (*Pistia*)
			Plant without stolons; lvs usu. <1cm		**Araceae** (*Spirodela, Lemna, Wolffia*)
		Rooted or suspended plants (when not fragmented); ovary superior	Tepals 0	Anthers 1, sessile	**Hydrocharitaceae (***Najas***)**
				Anthers 1, with filament	**Zosteraceae**
				Stamens 1-2	**Potamogetonaceae (***Zannichellia***)**
				Stamens 2 but bilobed, apparently 4	**Ruppiaceae**
			Tepals 1-2, conspicuous; inflorescence forked		**Aponogetonaceae**
			Tepals 4; stamens 4		**Potamogetonaceae**
			Tepals 6, all similar; stamens 6	Lvs Iris-like; flowering stems with 0 or few lvs	**Tofieldiaceae**
				Lvs linear; flowering stems leafy	**Scheuchzeriaceae**
				Lvs D-shaped or with furrowed face near base; stems with 0 or few lvs	**Juncaginaceae**
			Sepals 3 and petals 3, distinct; stamens 6 or numerous		**Alismataceae**
			Sepals 3 and petals 3, distinct only in colour; stamens 9		**Butomaceae**
		Rooted plants (when not fragmented); ovary inferior; floral parts very variable but often with antherless staminodes			**Hydrocharitaceae**

The Pondweed family: Potamogetonaceae

This is the largest family we have to contend with in Britain in the Alismatales, and the genus *Potamogeton* (Pondweeds) is a challenging one. Anyone wanting to study plants in this family is strongly recommended to use the BSBI Handbook (Preston (1995)), which covers the species and hybrids in *Potamogeton, Stuckenia* (formerly also in *Potamogeton*) and *Groenlandia*, but omits *Zannichellia*. The illustrations and descriptions of plant parts are invaluable.

Trait	Constant	Frequent	Exceptional
Perennial		All genera	
Annual			All genera
Leaves opposite or in whorls of 3	***Groenlandia***	***Zannichellia***	***Potamogeton*** ***Stuckenia***
Leaves alternate		***Potamogeton*** ***Stuckenia***	***Zannichellia***
Leaves all submerged	***Stuckenia*** ***Groenlandia*** ***Zannichellia***	***Potamogeton***	
Floating leaves present		***Potamogeton***	
Leaves narrow, ±linear	***Stuckenia*** ***Zannichellia***	***Potamogeton***	
Leaves more broadly linear, lanceolate, ovate or elliptical	***Groenlandia***	***Potamogeton***	
Leaves or phyllodes arising directly from the nodes	***Potamogeton***		
Leaves arising above the node from a sheath, tubular when young, often splitting with age	***Stuckenia*** ***Groenlandia*** ***Zannichellia***		
Stipules absent or merged into sheath	***Stuckenia*** ***Groenlandia*** ***Zannichellia***		
Stipules open		***Potamogeton***	
Stipules tubular at base at least when young		***Potamogeton***	
Flowers in short axillary spikes	***Potamogeton*** ***Stuckenia*** ***Groenlandia***		
Flowers solitary in leaf axils	***Zannichellia***		

Trait	Constant	Frequent	Exceptional
Flowers hermaphrodite	***Potamogeton*** ***Stuckenia*** ***Groenlandia***		
Flowers monoecious		***Zannichellia***	
Tepals 4	***Potamogeton*** ***Stuckenia*** ***Groenlandia***		
Tepals 0		***Zannichellia***	
Stamens 4	***Potamogeton*** ***Stuckenia*** ***Groenlandia***		
Stamens 1-2	***Zannichellia***		

- Annual and perennial individuals can occur in any species.
- Opposite and alternate leaves can occur together on an individual *Zannichellia* plant; the latter are found on some sterile shoots. Opposite leaves are a rare phenomenon on some *Potamogeton* and *Stuckenia* plants.
- Otherwise, "Frequent" and "Exceptional" refer to the number of species within the genus; plants of the same species will have the given character constantly, or almost so. Hybrids may be more variable.
- The leaf-base, sheath, stipule and ligule features are often key in identification of species, and unfortunately the same terminology is not used in all reference works. They need to be examined carefully and understood; the illustrations in Preston (1995) are helpful. In *Potamogeton* it is particularly important to dissect the base of stipules carefully when using the "open / closed" distinction.
- The *Stuckenia* species and hybrids might be confused with *Eleogiton fluitans*, Floating Club-rush, in the Cyperaceae when flowers or fruits are absent. However, *Stuckenia* plants have a ligule-like tip to their sheaths, which is absent in *Eleogiton*.

Floral formulae

Before we look at the more "lily-like" Monocot orders, it's time to reintroduce from Module 2 a convenient shorthand for describing flower structure, the **floral formula**.

The floral formula is an inventory of the various parts of the flower (perianth and sexual parts) with ornamentations on some of the symbols to denote positioning, fusion, and so on. There are different conventions for floral formulae, some more complicated than others. I am going to try to keep things as simple as I can.

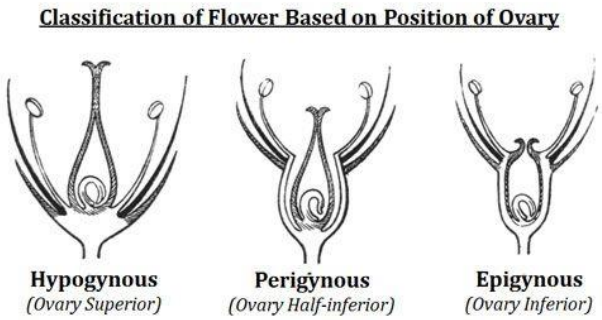
- **5** An exact count of parts
- **4-5** A range of typical values for the count
- **2+3** 5 altogether, two different from the other three
- **∞** Lots
- **4-5[-∞]** An exceptional extension to the range
- **(5)** A count of lobes, where the parts are fused
- **K** Calyx parts (e.g. K5 = 5 free sepals)
- **C** Corolla parts (e.g. C(4) = 4 fused petals)
- **P** Perianth parts (where there is no distinction or only one whorl)
- **A** Stamens (= "androecium")
- **A*** Staminodes lacking anthers
- **G** Carpels (= "gynoecium")
- **Ĝ** Means "ovary inferior"
- **G̲** Means "ovary superior"
- **⊕** Actinomorphic flower (radial symmetry)
- **Φ** Zygomorphic flower (mirror symmetry)
- **|** "or"

So, for instance, the general formula for the whole Juncaceae family is:

⊕ P3+3 A[3]6 G̲[1]3

or, "Radially symmetric; tepals in two whorls often different in appearance; stamens 6 or more rarely 3; ovary superior; carpels 3 or less frequently 1".

Here is a quick reminder of the ovary positions:



The Lily-like Orders: Liliales, Asparagales, and a bit of Dioscoreales

These are the orders and the families within them that we're concerned with. They began to appear 110-120 million years ago. Some of the more exotic or impersistent garden escapes have been left out. The bolded purple family names are where our attention will be focused.

DIOSCOREALES

Nartheciaceae

ASPARAGALES

Orchidaceae
Iridaceae
Asphodelaceae
Amaryllidaceae
Asparagaceae

LILIALES

Melanthiaceae
Colchicaceae
Liliaceae

Bog Asphodel: Nartheciaceae

This is a small family worldwide, with about 35 members in 5 genera. Very little apart from the molecular evidence takes it out of the Liliaceae, where it used to live happily, and into the arms of the Yams and Black Bryony. Our only British member, *Narthecium ossifragum*, shares the genus with 6 other species scattered across the temperate northern hemisphere, mostly with similar yellow starry flowers.

Like most members of the Iris family, Iridaceae, it has sword-like foliage, the leaves lying flattened against each other and folded flat into each other (equitant) at the base. Unlike the Iris family, it lacks nectaries on the outer wall of the ovaries; but this is probably not a feature you would notice most of the time. It is such a distinctive plant in Britain, with such a restricted habitat, that I doubt you will need much technical information to ID it. The floral formula is "classic" Monocot:

⊕ P3+3 A3+3 G3

Asparagales and Liliales

We need to treat these two orders together, since there are very few hard-and-fast traits to distinguish them morphologically. Even one of the best (presence or absence of nectaries on the ovary wall) doesn't hold consistently for all families; indeed, Orchidaceae (the biggest family of its order and in the world), breaks the "rules". It's at the family level that we shall do better looking for helpful features.

All families we are dealing with in Britain are perennials, except for some cultivated *Allium*s that are biennial. (There are also annual *Sisyrinchium* species elsewhere in the world, but not found in Britain.) They are predominantly **geophytes**: plants that perennate by organs below or near the soil surface, i.e. rhizomes, corms and bulbs. This enables individual plants to survive adverse seasons, particularly seasonal droughts, and explains why they form an important constituent of Mediterranean climate zones.

Trait	**Family**
Herbaceous plants	All
Woody plants	**Asparagaceae** (*Ruscus* and some woody garden escapes)
Rhizomes and/or tubers	**Orchidaceae** **Iridaceae** (some) **Asphodelaceae** **Amaryllidaceae (***Agapanthus***)** **Asparagaceae** (many) **Melanthiaceae**
Corms	**Iridaceae** (many) **Amaryllidaceae** (*Triteleia***)** **Colchicaceae**
Bulbs	**Iridaceae** (a few *Iris* spp.) **Amaryllidaceae** (most) **Asparagaceae** (many) **Liliaceae**
Leaves alternate	All
Leaves whorled	**Melanthiaceae** (*Paris, Trillium*) **Liliaceae** (some *Fritillaria*, some *Lilium*)

Trait	Family
Leaves reduced to insignificant scales	**Orchidaceae (***Epipogium, Corallorhiza***)** **Asparagaceae (***Asparagus, Ruscus***)**
Leaves linear, sword-like (ensiform) or narrowly lanceolate	All bar **Melanthiaceae**
Leaves not linear, sword-like or narrowly lanceolate	**Orchidaceae** (most genera and species) **Amaryllidaceae** (some *Allium*) **Asparagaceae** (*Convallaria***,** most *Polygonatum, Maianthemum*) **Melanthiaceae** **Liliaceae (***Erythronium***,** some *Tulipa, Fritillaria***,** some *Lilium*)
Leaves with parallel or biconvergent main veins; if reticulate, then primary veins obvious near to leaf edge and continuous from base	All
Leaves with pinnate or palmate venation; if reticulate, then outer veins not primary and continuous from base	**Melanthiaceae (***Paris, Trillium***)**
Perianths trimerous (**P3+3, P6, P(6)** or **P12**)	All
Perianths 4-merous (**P4** or **P8**)	**Asparagaceae** (*Maianthemum*) **Melanthiaceae (***Paris***)**
Stamens 1 or 2	**Orchidaceae**
Stamens 3	**Iridaceae**
Stamens 4	**Asparagaceae (***Maianthemum***)**
Stamens 6	**Asphodelaceae** **Amaryllidaceae** **Asparagaceae** **Melanthiaceae (***Trillium, Veratrum***)** **Colchicaceae** **Liliaceae**
Stamens 8-12	**Melanthiaceae (***Paris***)**

Trait	**Family**
Stigmas sessile	**Orchidaceae** **Liliaceae (***Tulipa***)**
Styles 1 (but often 3-lobed or 3-branched and sometimes branching repeatedly)	**Iridaceae** **Asphodelaceae** **Amaryllidaceae** **Asparagaceae** **Melanthiaceae (***Paris***)** Most **Liliaceae**
Styles 3	**Melanthiaceae (***Trillium, Veratrum***)** **Colchicaceae**
Stigma 1 (may be lobed or tiny)	**Asphodelaceae** **Amaryllidaceae** **Asparagaceae** **Melanthiaceae (***Trillium, Veratrum***)** **Colchicaceae**
Stigmas 3	**Orchidaceae** (usually only 2 functional) **Iridaceae** **Liliaceae**
Stigmas 4-5	**Melanthiaceae (*Paris*)**
Ovary inferior	**Orchidaceae** **Iridaceae** **Amaryllidaceae** (most)
Ovary superior	**Asphodelaceae** **Amaryllidaceae** (most *Allium, Nothoscordium, Agapanthus, Tristagma*) **Asparagaceae** **Melanthiaceae** **Colchicaceae** **Liliaceae**
Ovary 1-celled or a berry	**Orchidaceae** **Iridaceae** (*Iris* in part) **Asparagaceae** (many) **Melanthiaceae**
Ovary 3-celled	**Iridaceae** (most) **Asphodelaceae** **Amaryllidaceae** **Asparagaceae** (many) **Colchicaceae** **Liliaceae**

Where there is one option that is very much the commonest, I have bolded the trait. Here are a few messages that can be taken away from this table.

- If it's woody, it's either Asparagaceae or one of the exotics we haven't considered here, such as the Palms (Arecaceae).
- If it has corms or bulbs, it can't be Orchidaceae or Asphodelaceae.
- If it has anything but bulbs, it can't be Liliaceae.
- If it has broad leaves that are not sword-like, it won't be Iridaceae.
- If it has pinnate or palmate primary venation, it can only be Melanthiaceae (or not a member of these Orders): but watch out for some reticulated leaves that push the boundaries.
- Anything with floral parts in multiples of 4 and not 3 is Melanthiaceae, the rare *Maianthemum* or not a member of these Orders.
- Iridaceae can be told from all the similar members of other families by its 3 stamens.
- Most of these orders have one style or none; but you have to look carefully at the base of the style to be sure, as many are branched, sometimes from low down.
- If its ovary is single-celled or a berry, then it definitely won't be Liliaceae and it probably won't be Iridaceae. By the time fruits are ripe, internal divisions of the ovary may not always be obvious, but there are often clues in the form of the inner and outer walls or the presence of 3 pores or slits for seed dispersal.

The Poales – Fifty Shades of Brown…

…and some white, green, black and dull purple. (Actually, from a world perspective, this is a little bit unfair.)

This will be a brief section, because the two big families in Britain, Cyperaceae (Sedges) and Poaceae (Grasses) deserve, and have, workshops of their own. So we shall summarise the differences between the British families, and look in detail at just one in this module, Juncaceae (Rushes).

On best estimates, the Poales emerged about 100 million years ago, with some fossil evidence suggesting this might be extended to 115 million years. In that time, they have come to assume huge importance because of the prominence or dominance of three families (Juncaceae, Cyperaceae and particularly Poaceae) in non-forested parts of the world. The evolution and spread of large grazing mammals have aided this process, as there are several features of the order and of Monocots in general that help them survive grazing, such as the presence of **meristematic** tissue (tissue providing continued growth) in stems and at leaf bases.

A few families are prominent in other parts of the world, including the Bromeliads of central and southern America (Bromeliaceae) and the Rush-like Fynbos (Restionaceae) mostly of the southern hemisphere.

In Britain, we should briefly mention the Pipewort family (**Eriocaulaceae**), which has about 1,200 members world-wide but just one in Britain, found only in western Ireland and the western Highlands. It is monoecious, and its whitish flowers are in a tight head on a leafless stem, with the floral formula:
⊕ P(2)+2 A4 G2

Other than this, we have just four families to deal with; worldwide, they account for over 17,000 species. While there is no shortage of variety in such a large grouping, much of it is accounted for within a small number of groupings of somewhat similar genera or subgenera in each family.

Features of the main British Poales families

Trait	Family
Annuals	**Juncaceae** **Cyperaceae** (rare) **Poaceae**
Herbaceous rhizomatous perennials	**Typhaceae** **Juncaceae** **Cyperaceae** **Poaceae**
Herbaceous stoloniferous perennials	**Juncaceae** (rare) **Cyperaceae** (*Eleogiton*) **Poaceae**
Herbaceous perennials without obvious rhizomes or stolons	**Juncaceae** **Cyperaceae** **Poaceae**
Woody perennials	**Poaceae** (Bamboos)
Leaves cylindrical or apparently so	**Juncaceae** **Poaceae**
Leaves linear, clearly bifacial	All
Leaves oblong or elliptical	**Poaceae** (Bamboos)
Leaves without ligules	**Typhaceae** **Juncaceae** **Cyperaceae** (many non-*Carex* genera) **Poaceae** (*Echinochloa*)
Leaves with ligules, sometimes very short, partially fixed to leaf / blade junction and with a ± narrow free margin	**Cyperaceae**
Leaves with ligules free from base of leaf blade (sometimes reduced to hairs or a fimbriate membrane)	**Poaceae**
Flowers bisexual	**Juncaceae** **Cyperaceae** (non-*Carex* genera) **Poaceae**
Flowers monoecious	**Typhaceae** **Cyperaceae** (*Carex*) **Poaceae** (rare)
Flowers dioecious	**Cyperaceae** (*Carex*, rare)
Flowers never found	**Poaceae** (Bamboos)
Bracts absent	**Juncaceae** (*Luzula*)
Bracts present, obvious	**Juncaceae** (*Juncus*)
Bracts present but easily overlooked and/or mistaken for floral parts	**Typhaceae** **Cyperaceae** **Poaceae**
Perianth 0	**Cyperaceae**
Perianth of bristles or scales, often indeterminate in number and sometimes hard to discern	**Typhaceae** **Cyperaceae** (some non-*Carex* genera) **Poaceae**
Perianth 6-merous (**P3+3**)	**Juncaceae**

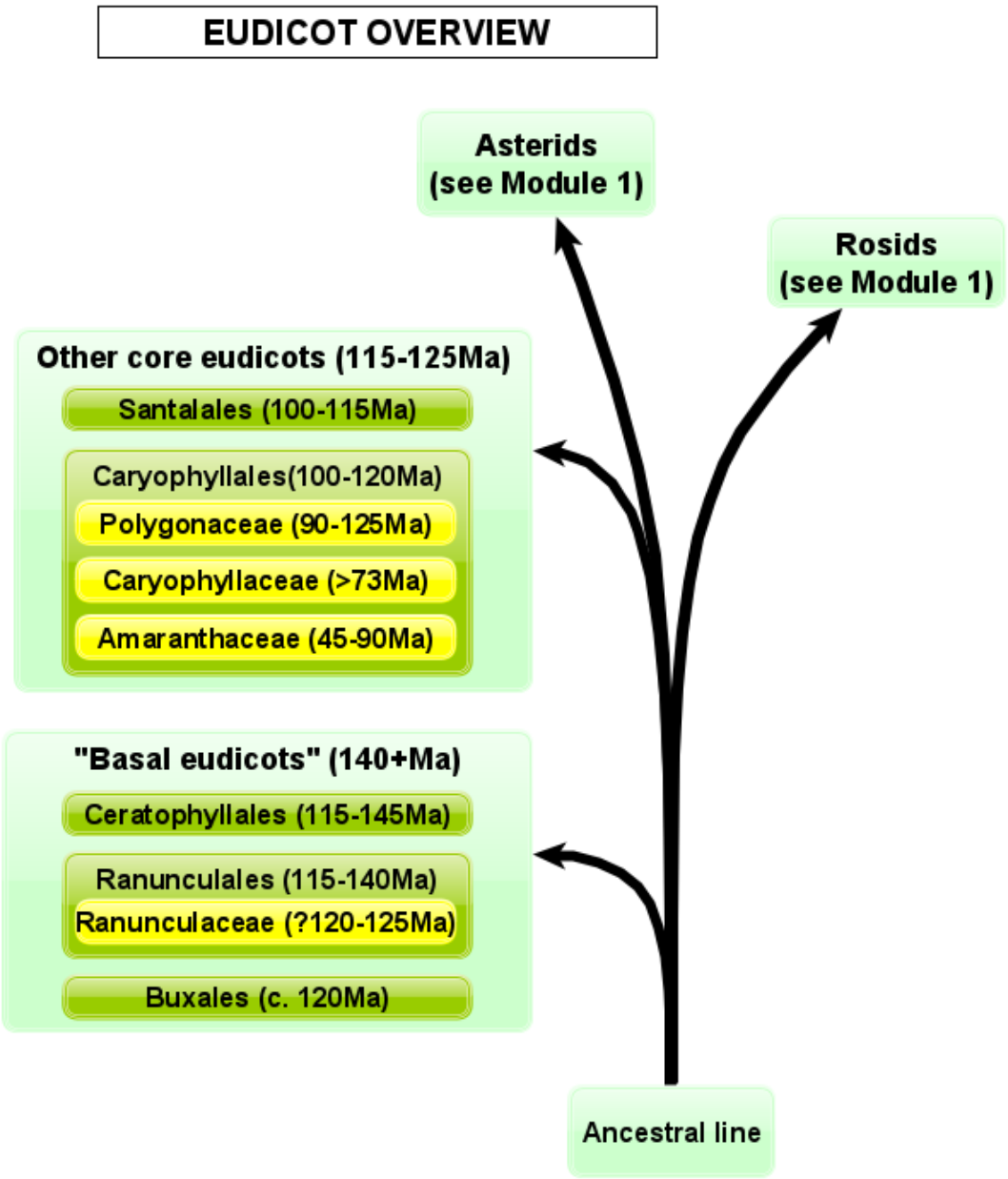
Trait	Family
Stamens 1	**Cyperaceae** (rare) **Poaceae** (rare)
Stamens 1-5	**Typhaceae (***Typha***)**
Stamens 2-3	**Cyperaceae** **Poaceae** (some)
Stamens 3	**Juncaceae** (some) **Poaceae** (most)
Stamens 3-8	**Typhaceae (***Sparganium***)**
Stamens 6	**Juncaceae** (most) **Poaceae** (a few Bamboos)
Styles 0 or 1	**Juncaceae** **Cyperaceae**
Styles 1	**Typhaceae** **Poaceae** (rare)
Styles 2	**Poaceae**
Styles 3	**Poaceae** (rare)
Stigmas 1	**Typhaceae** **Poaceae**
Stigmas 2	**Cyperaceae** **Poaceae**
Stigmas 3	**Juncaceae** **Cyperaceae** **Poaceae**
Ovaries superior	All
Ovaries 1	**Typhaceae** (*Typha*) **Juncaceae** **Cyperaceae** **Poaceae**
Ovaries 1-3, fused	**Typhaceae** (*Sparganium*)
Ovary 1-celled	**Typhaceae** (*Typha*) **Juncaceae** **Cyperaceae** **Poaceae**
Ovary 1-3-celled	**Typhaceae** (*Sparganium*)
Ovary 3-celled	**Juncaceae**

The floral and inflorescence structures of the Cyperaceae and Poaceae are highly distinctive and take some getting used to, and you will find them best covered in the workshop notes for Sedges and Grasses on the Hants Plants web site (https://hantsplants.uk/workshopnotes.php) for these families, or in the BSBI Handbooks: Jermy et al. (2007), Cope & Gray (2009).

Here are some further notes for distinguishing the "big three" families.

- Like many other monocots, grasses have leaves which (when not all basal) are arranged alternately up the stem. Unlike most, however, they are distichous (arranged in two ranks on opposite sides of the stem) rather than spiralling around the stem.
- Grass culm stems are generally hollow (this may not be obvious where there are several overlapping sheaths) and rounded or flattened. Flowering stems of Cyperaceae (Sedges) are rarely hollow and often more or less triangular in cross-section.
- Cyperaceae (Sedges) never have a second bract like the palea of a grass floret; those members of Poaceae (Grasses) that lack a palea all have hollow stems.
- Juncaceae (Rushes) have a regular symmetrical flower of 6 tepals, in outer and inner rows of 3 each.
- The somewhat hardened shoulder of cells that occurs where the leaf sheath meets the blade is characteristic of Poaceae.
- The ligule of Poaceae is usually free of the sheath and blade for most of its length. The typical Cyperaceae ligule is attached to the blade over the greater part of its length.

The “other core eudicots”



The “Other core eudicots” are a grouping united more by ancestry than any other features, having diverged from the route to the large and somewhat more homogeneous Asterid grouping, most of whose members have petals fused at least at the base. Three orders are placed together here.

- The **Berberidopsales**, the first to diverge from the Asterid line; a tiny order of just 4 species, none of which occurs in Britain.
- The **Santalales**, another relatively small order of about 450 species with an extremely high proportion of parasites and hemiparasites. It is

currently a bit of a rag-bag with family circumscriptions not fully worked out. Fortunately, we only have two species to worry about in Britain: Mistletoe (*Viscum album*), which will hardly be mistaken for anything else; and Bastard Toadflax (*Thesium humifusum*), which might at first glance be mistaken for a member of the Caryophyllaceae, but which can be distinguished by its combination of alternate leaves, absence of sepals, and single style.

- That leaves the **Caryophyllales**, a much larger order of roughly 12,000 species worldwide. Defining families through ancestry relationships is challenging in this order, and the current arrangement of families is a bit of a compromise between new evidence and botanical tradition. Typical (though not universal) traits of the order are: attachment of the ovules (**placentation**) within the ovary to a central free-standing column (free-central) or pedestal (free-basal); presence of betalain pigments, particularly prominent in families such as the Amaranthaceae (think beetroot or purple amaranth!) but absent from Caryophyllaceae, whose colouring (where it occurs) comes from anthocyanins; and a large proportion of stress-tolerant plants. The last include species tolerant of salt, drought (especially through succulence), low levels of nutrients, especially nitrogen (often carnivorous) and high levels of nitrogen (for instance, in many members of the Amaranthaceae).

Caryophyllales in Britain

The order in Britain includes the following families (native and introduced):

Frankeniaceae
Tamaricaceae
Plumbaginaceae
Polygonaceae
Droseraceae
Caryophyllaceae
Amaranthaceae
Aizoaceae
Phytolaccaceae
Nyctaginaceae
Montiaceae
Basellaceae
Portulacaceae

The "big three" are bolded and coloured in this list. We shall be dealing with Polygonaceae and Amaranthaceae in another family workshop, and Amaranthaceae already has a more detailed workshop devoted just to the family.

Family traits

The following table deals with these "big three" and the two other families with fairly numerous species found in the wild in Britain, the Thrift family (Plumbaginaceae) and the all-alien Dewplant family (Aizoaceae).

Trait	**Family**
Annual	All (**Aizoaceae**, only *Tetragonia*)
Herbaceous perennials	All
Woody perennials	**Plumbaginaceae** (*Limonium, Ceratostigma*) **Polygonaceae** (some *Polygonum*, some *Fallopia*, *Muehlenbeckia*) **Caryophyllaceae** (occasional) **Amaranthaceae** (some *Atriplex*, *Sarcocornia*, some *Suaeda*) **Aizoaceae**
Rhizomatous	**Polygonaceae** (some *Polygonum*, some *Koenigia*, *Bistorta, Reynoutria, Rheum,* some *Rumex*) **Amaranthaceae** (*Blitum*)
Stoloniferous	**Polygonaceae** (some *Bistorta*)
Leaves all basal or alternate, or at most subopposite	**Plumbaginaceae** **Polygonaceae** **Caryophyllaceae** (some) **Amaranthaceae** (most) **Aizoaceae**
Leaves opposite	**Caryophyllaceae** (most) **Amaranthaceae** (some, especially lower nodes in *Atriplex* and *Chenopodium*) **Aizoaceae**
Leaves whorled	**Caryophyllaceae** (some)
Leaves simple	All
Leaves entire	All
Leaves lobed or toothed	**Polygonaceae** (some *Rumex*) **Aizoaceae** (*Oscularia*)
Stipules absent	**Plumbaginaceae** **Caryophyllaceae** (many) **Amaranthaceae** **Aizoaceae**
Stipules present, not forming tubular sheath	**Caryophyllaceae** (subfamily **Paronychioideae**: *Corrigiola, Herniaria, Illecebrum, Polycarpon, Spergula, Spergularia*)
Stipules present as ± tubular sheath around stem (**ochrea**)	**Polygonaceae**

Trait	Family
Flowers bisexual	**Plumbaginaceae** **Polygonaceae** (most) **Amaranthaceae** (most)
Flowers monoecious	**Polygonaceae** (*Emex*) **Amaranthaceae** (*Atriplex, Amaranthus*)
Flowers dioecious	**Polygonaceae** (*Reynoutria, Muehlenbeckia, Rumex* subgenus Acetosa) **Amaranthaceae** (*Spinacia,* sometimes *Amaranthus*)
Flowers variable	**Polygonaceae** (some plants, functionally if not anatomically) **Amaranthaceae** (some plants)
Flowers actinomorphic or very nearly so	**All**
Perianth **K(5) C(5)**	**Plumbaginacae**
Perianth **P2-3|(2-3)+P2-3|(2-3)**	**Polygonaceae**
Perianth **K4-5 C0|4-5**	**Caryophyllaceae**
Perianth **P[0]1-5|(1-5)**	**Amaranthaceae**
Perianth **K4-5[6]|(4-5[6]) C0 A*∞**	**Aizoaceae**
Stamens 1-5	**Amaranthaceae**
Stamens 3-merous	**Aizoaceae**
Stamens 5	**Plumbaginaceae**
Stamens [3]6-9	**Polygonaceae**
Stamens [0-]8|10, usu. twice number of sepals	**Caryophyllaceae**
Styles 1	**Plumbaginaceae** (*Ceratostigma*)
Styles 2-3 or apparently so when low-branched	**Polygonaceae** (most) **Amaranthaceae**
Styles 2-5 (sometimes very short and appearing 0)	**Caryophyllaceae**
Styles 5	**Plumbaginaceae** (most)
Styles 3-20 (=ovary division)	**Aizoaceae**
Ovary superior	**Plumbaginaceae** **Polygonaceae** **Caryophyllaceae** (most, and in some genera stalked) **Amaranthaceae**
Ovary semi-inferior	**Caryophyllaceae** (*Corrigiola*, *Herniaria*) **Amaranthaceae** **Aizoaceae** (some)
Ovary inferior	**Aizoaceae** (some)
Ovary 1-celled	**Plumbaginaceae** **Polygonaceae** **Caryophyllaceae** **Amaranthaceae**
Ovary 3-20-celled	**Aizoaceae**

In addition:

- **Frankeniaceae (Sea Heath)**, with one British member, is distinctive. It is a low-growing, woody, evergreen perennial with small narrow leaves like many *Erica*s, and solitary pink flowers. The sepals are joined to more than half way but not to the extent found in some Caryophyllaceae. It usually grows near the coast.
- **Tamaricaceae (Tamarisks)** comprises just a couple of introduced species found near the coast. They are shrubs or small trees, and their racemes of flowers resemble catkins from a distance but are composed of tiny **K5 C5** flowers.
- **Droseraceae (Sundews)** comprises three native species and a couple of rarely naturalised ones. The sticky glandular hairs designed for insectivory make any other identification trait redundant; they actually share many features with Caryophyllaceae, but leaves are all basal.
- **Phytolaccaceae (Pokeweeds)** are uncommon garden escapes. They are highly distinctive: the flowers are in tight racemes opposite the leaves; the perianth is a single 5-tepalled whorl; the fruit are berry-like with 6-12 carpels each with a single style.
- **Nyctaginaceae (Marvel of Peru)** has a single garden escape species in Britain. With its spectacular brightly-coloured flowers, a fused ring of bracts (epicalyx) taking the place of a calyx and a long tubular corolla ending in 5 large lobes, it is unlikely to be mistaken for anything else in the order.
- **Montiaceae (Blinks)** could be mistaken for Caryophyllaceae but have **K2 C5** perianths. The superior ovary and up to 5 stamens distinguishes them from Portulacaceae.
- **Portulacaceae (Purslanes)** also have **K2 C5** perianths and so are easily distinguished from Caryophyllaceae. Unlike Montiaceae, the ovary is semi-inferior and there are more than 5 stamens.

Here are a few other tips for identification shortcuts for the main families.

- All **Aizoaceae** are succulent, and woody at the base to some degree.
- The only rhizomatous member of **Amaranthaceae is** *Blitum bonus-henricus* (Good King Henry).
- Opposite leaves are found only in the **Caryophyllaceae**, on the lower parts of stems in some **Amaranthaceae** and in the very distinctive **Aizoaceae**.
- Close inspection of the "whorled" leaves of *Spergula* shows that they are actually alternate, but closely clustered into a pseudo-whorl.
- On old or preserved material of **Polygonaceae**, the sheath-like stipules (ochreae) may be split or eroded. It's best to check fresh material.
- "Variable" flowers in the **Polygonaceae** and **Amaranthaceae** means a mixture of bisexual and (usually) female flowers on the same plant.

The Pink Family: Caryophyllaceae

Here is a family that worldwide has around 2,200 species; in Britain there are only around 70, but a few can present challenges for beginners because of similarities between species or variation within species. Despite this, it is one of the nicer families to get to grips with, because there are several common features and many of the differences organise themselves into distinct groupings (subfamilies).

All plants in Britain are herbaceous annual or perennials, although some genera (*Scleranthus, Herniaria, Spergularia, Dianthus*) can be a bit woody at the base.

Once you begin to know the family, there are only a few others you might mistake for it.

- **Portulacaceae** and **Montiaceae** are distinguished by having only 2 sepals.
- **Saxifragaceae** have 2 or 3 carpels; although these may be fused at the base, they will be separated at the top and will not form a single capsule.

This is a breakdown of the subfamilies into genera:

ALSINOIDEAE

Arenaria
Moehringia
Honckenya
Minuartia
Sabulina
Cherleria
Stellaria
Cerastium
Moenchia
Sagina
Scleranthus

PARENYCHIOIDEAE

Corrigiola
Herniaria
Illecebrum
Polycarpon
Spergula
Spergularia

CARYOPHYLLOIDEAE

Agrostemma
Silene
Saponaria
Vaccaria
Gypsophila
Petrorhagia
Dianthus

Subfamily and genus traits

Trait	Subfamily
Leaves opposite	**Alsinoideae** **Paronychioideae** (*Herniaria, Illecebrum, Polycarpon, Spergula, Spergularia*) **Caryophylloideae**
Leaves alternate	**Paronychioideae** (*Corrigiola, Polycarpon, Spergula*)
Leaves whorled in appearance	**Paronychioideae** (*Spergula*)
Stipules absent	**Alsinoideae** **Caryophylloideae**
Stipules present	**Paronychioideae**

Trait	Subfamily
Bracteoles absent	**Alsinoideae** **Paronychioideae**
Bracteoles present, not forming an epicalyx	**Caryophylloideae** (*Agrostemma, Silene, Saponaria, Vaccaria, Gypsophila*)
Bracteoles present, forming an epicalyx under the calyx	**Caryophylloideae** (*Petrorhagia, Dianthus*)
Perianth **K4 C0** (sepals sometimes joined at extreme base)	**Alsinoideae** (some *Sagina*)
Perianth **K4 C4** (sepals sometimes joined at extreme base)	**Alsinoideae** (some *Cerastium, Moenchia,* some *Sagina*)
Perianth **K5 C0** (sepals sometimes joined at extreme base)	**Alsinoideae** (*Cherleria,* some *Stellaria,* some *Sagina, Scleranthus*)
Perianth **K5 C5** (sepals sometimes joined at extreme base, petals sometimes tiny)	**Alsinoideae** (most) **Paronychioideae**
Perianth **K(5) C5**	**Caryophylloideae**
Petals thread-like	**Paronychioideae** (*Herniaria, Illecebrum*)
Petals entire at tip	**Alsinoideae** (most) **Paronychioideae** (*Corrigiola, Polycarpon, Spergula, Spergularia*) **Caryophylloideae** (*Agrostemma,* some *Silene, Saponaria, Vaccaria, Gypsophila*)
Petals emarginate or retuse to bifid or bluntly lobed at tip	**Alsinoideae** (*Stellaria, Cerastium*) **Paronychioideae** (*Polycarpon*) **Caryophylloideae** (most)
Petals toothed or fringed (frilly) at tip	**Caryophylloideae** (some *Silene, Dianthus*)
Petals differentiated into narrow base (claw) and broader apex (limb) held at an angle to base	**Caryophylloideae**
Petals not as above (but sometimes with narrowed base)	**Alsinoideae** **Paronychioideae**
Stamens 2x sepals	**Alsinoideae** (most) **Paronychioideae** (some) **Caryophylloideae**
Stamens fewer	**Alsinoideae** (some *Stellaria,* some *Cerastium, Moenchia,* some *Sagina,* sometimes *Scleranthus*) **Paronychioideae** (most)
Styles 0 (stigmas sessile)	**Paronychioideae** (*Illecebrum*)
Styles 2	**Alsinoideae** (*Scleranthus*) **Paronychioideae** (*Herniaria*) **Caryophylloideae** (*Saponaria, Vaccaria, Petrorhagia, Dianthus*)
Styles 3	**Paronychioideae** (*Corrigiola, Polycarpon, Spergularia*)
Styles 3-5	**Alsinoideae** (most) **Caryophylloideae** (*Silene*
Styles 5	**Paronychioideae** (*Spergula*) **Caryophylloideae** (*Agrostemma*)

Trait	Subfamily
Ovary superior, stalked (stalks sometimes short)	**Caryophylloideae** (*Silene, Saponaria, Vaccaria,Petrorhagia, Dianthus*)
Ovary superior, unstalked	**Alsinoideae** **Paronychioideae** (*Illecebrum, Polycarpon, Spergula, Spergularia*) **Caryophylloideae** (*Agrostemma, Gypsophila* sometimes *Dianthus*)
Ovary semi-inferior	**Paronychioideae** (*Corrigiola, Herniaria*)
Fruit an achene	**Alsinoideae** (*Scleranthus*) **Paronychioideae** (*Corrigiola, Herniaria*)
Fruit a capsule	**Alsinoideae** (most) **Paronychioideae** (*Illecebrum, Polycarpon, Spergula, Spergularia*) **Caryophylloideae** (most)
Fruit a berry	**Caryophylloideae** (one *Silene* sp.)

- The two big subfamilies of this family (**Alsinoideae** and **Caryophylloideae**) are, on the whole, long-established and mostly stable under recent research. The "odd one out" in Alsinoideae is *Scleranthus* (Knawels) whose members have 2 styles, and an achene rather than a capsule as fruit, arguing for a placement in Paronychioideae; but unlike all members of that subfamily, it lacks stipules.
- **Paronychioideae** are much more contentious. Arguments have been made for moving all except *Spergula* and *Spergularia* into a separate family **Illecebraceae** and throwing *Scleranthus* in with them; or then again, moving *Corrigiola* out into a separate family, or another existing family. Stace is sensibly taking a conservative view at present and keeping them together until the dust settles, as have other recent western European Floras.
- The members of **Paronychioideae** not in *Spergula* or Spergularia are those you are most likely not to recognise immediately as members of the family. In fact, the combination of prostrate to decumbent habit, stipules and rather inconspicuous 5-merous flowers with free perianth segments is fairly conclusive once you have ruled out Montiaceae and Portulacaceae.
- Tiny petals in the **K5 C5** perianth arrangement are found in several Paronychioideae genera and should be looked for carefully.

- There is a lot of variation in the degree to which the tips of petals are indented across the family. Some of the Alsinoideae (particularly *Stellaria*) are so deeply bifid that you may think you're dealing with 10 petals rather than 5. Check the bases carefully. On the other hand, some of the Caryophylloideae are so shallowly emarginate that you may have to flatten a petal carefully to check.
- Toothed or frilly petal tips are typical of *Dianthus* but very rare in *Silene* (*S. armeria*).
- The differentiation into claw and limb which characterises Caryophylloideae is a clinching feature for this subfamily but should not be confused with the abrupt narrowing at the base that occurs in *Stellaria* and *Cerastium*, for instance, where the two ends of the petal lie in the same plane.
- Another useful feature in dividing up the members of Caryophylloideae is the presence or absence of scales at the junction between claw and limb. *Agrostemma*, *Vaccaria, Gypsophila, Petrorhagia* and *Dianthus* don't have them. *Saponaria* has them. *Silene* has species entirely without scales, with inconspicuous scales and with conspicuous scales. A table is provided below.
- The character whereby the number of stamens doubles the count of perianth segments is highly characteristic of much of the family. Of course, other families like Geraniaceae can also do this, but Caryophyllaceae does not typically produce staminodes (sterile stamens with filaments but no anthers).
- The stalk (called a **carpophore**) that supports superior ovaries in some members of the Caryophylloideae can be very short, and needs looking for carefully if it is going to be used for diagnosis.
- Although the typical capsule in the family is an open single chamber, it has evolved by reduction from a multicellular ovary, and sometimes traces of the divisions (septa) can be seen in young capsules.

Petal scales in *Silene* (Campions)

Scales absent	*S. otites* *S. multifida*
Scales inconspicuous	*S. italica* *S. vulgaris* *S. acaulis* *S. dichotoma* *S. suecica*
Scales conspicuous (if sometimes small)	*S. nutans* *S. uniflora* *S. baccifera* *S. schafta* *S. armeria* *S. noctiflora* *S. latifolia* *S. dioica* *S. pendula* *S. gallica* *S. conica* *S. coronaria* *S. flos-cuculi* *S. chalcedonica* *S. viscaria* *S. suecica*

References and Further Study

All the books and material mentioned in the Module 1 notes are of value here too.

Cope, T. & Gray, A. (2009). *Grasses of the British Isles*, BSBI Handbook 13, BSBI, London.

Cullen, J. et al. (2011). *The European Garden Flora* edn. 2, vol. 1, Cambridge University Press, Cambridge. (For a key strictly to monocots, and species accounts for many garden plants outside the standard guides and Floras that may occur as garden throw-outs.)

Jermy, A.C. et al. (2007). *Sedges of the British Isles* edn. 3, BSBI Handbook 1, BSBI, London.

Jonsell, B. (ed.) (2001). *Flora Nordica,* vol. 2, Bergius Foundation, Stockholm. (For Caryophyllaceae and other families in the order.)

Lansdown, R.V. (2009). *A Field Guide to the Riverine Plants of Britain and Ireland*, Ardeola, Stroud.

Preston, C.D. (1995). *Pondweeds of Great Britain and Ireland*, BSBI Handbook 8, BSBI, London.

Sell, P.D. & Murrell, G, (2018). *Flora of Great Britain and Ireland*, vol. 1, Cambridge University Press, Cambridge. (For detailed species accounts in the Santalales and Caryophyllales orders.)

Stace, C.A. (2010, 2019). *New Flora of the British Isles*, 3rd / 4th editions, Cambridge University Press / C&M Floristics.