Angiosperms or Flowering Plants the Phylum Magnoliophyta

Today : overview of the morphology and evolution of the flower – optionally read "Flowers" pdf from Chpt. 6 in *Plant Systematics*, *2nd ed* – available at Canvas/Learn@UW

Angiosperms or Flowering Plants the Phylum Magnoliophyta

Lab next two weeks: (1) vegetative features & conifers – see "Vegetative" pdf from Chpt 9 in *Plant Systematics*; (2) finish overview of flower and examine floral, fruit, & inflorescence diversity – see also "Inflorescences" and "Fruit" pdfs at Canvas/Learn@UW

The Flower — Why Important?

The Flower — Why Important?

The Flower: most significant feature of angiosperms

1. unlike anything else in other plants & extremely variable & co-evolved with animals
2. floral features used in describing and id'ing
3. plant specimens (herbarium) must include flowers or derived features
4. classification of angiosperms relies on flowers

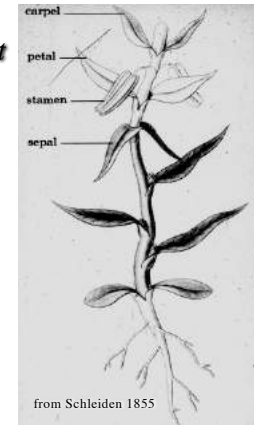*Calochortus* - fairy lanterns & mariposas (images: T. Givnish)

The Flower — What is it?

• specialized shoot = stem + leaves (folia)

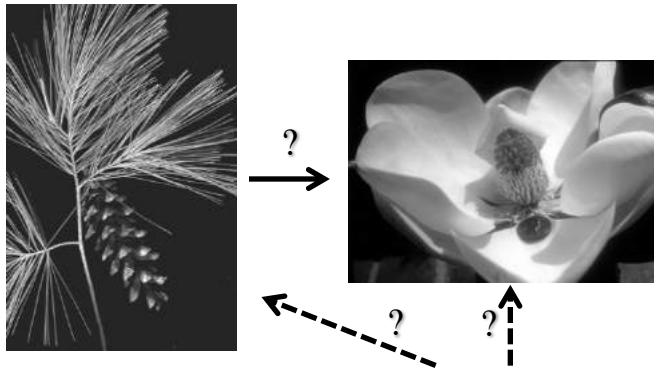• shoot is highly modified and determinate (ceased to grow)

The Flower — What is it?

• "foliar theory" of flower - J.W. von Goethe in *"Attempt to Interpret the Metamorphosis of Plants"* (1790)

carpel
petal
stamen
sepal

from Schleiden 1855

The Flower — What is it?

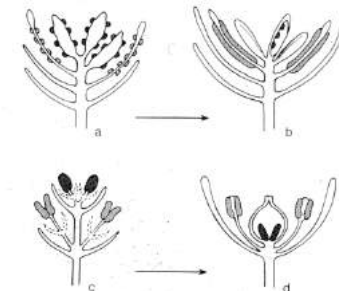• developmental/evolutionary origin of the flower still debated

?

? ?

The Flower — What is it?

• developmental/evolutionary origin of the flower still debated

1. Euanthial theory - (foliar theory) - *single* shoot, cone or strobilus

    ▢ anthers (male)
    ■ ovules (female)

2. Pseudanthial theory - *compound* shoot or cone, different shoots "coalesce" or "condense"

a   b
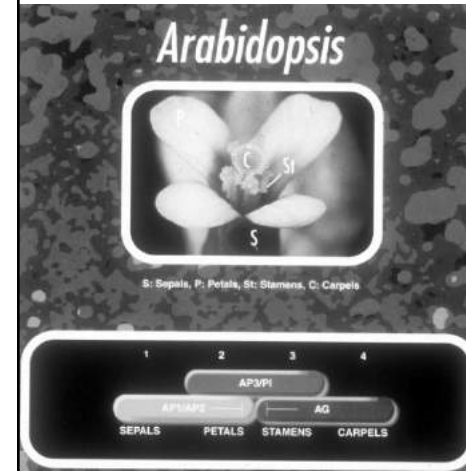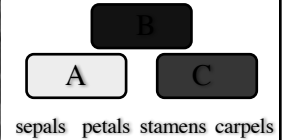c   d

The Flower — What is it?

• thus, a flower is a specialized shoot that:

1. is determinate (vs. indeterminate)

2. has a modified stem with compressed internodes

3. possesses modified leaves with various functions, these determined by gene arrays (e.g., ABC model)
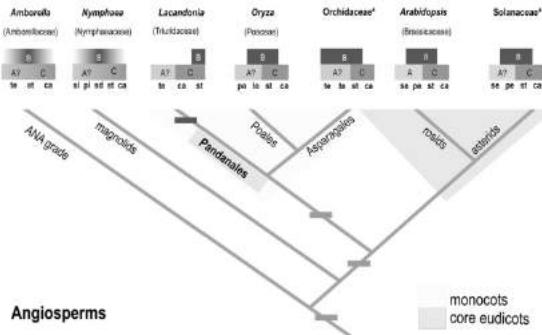

The Flower — What is it?

Arabidopsis

S: Sepals, P: Petals, St: Stamens, C: Carpels

The 'ABC' model of floral part identity

B

A   C

sepals petals stamens carpels

The Flower — What is it?

The Plant Cell, 2010

The evolution of the 'ABC' model of floral part identity

ABC model variations

Amborella (Amborellaceae) *Nymphaea* (Nymphaeaceae) *Lacandonia* (Triuridaceae) *Oryza* (Poaceae) Orchidaceae* *Arabidopsis* (Brassicaceae) Solanaceae*

ANA grade magnoliids Pandanales Poales Asparagales rosids asterids

Angiosperms

monocots
core eudicots

The Flower — What is it?

• thus, a flower is a specialized shoot that:

1. is determinate (vs. indeterminate)

2. has a modified stem with compressed internodes

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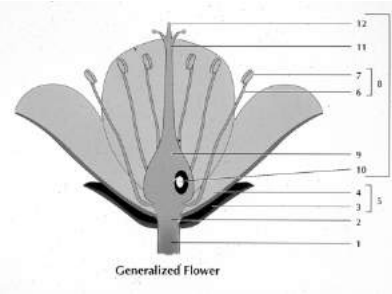4. often clustered in an inflorescence (larger branch)

3

The Flower

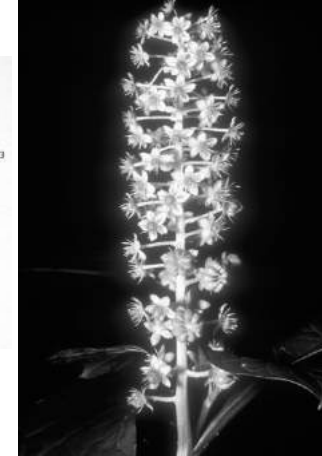read chpt 9 in *Plant Systematics*!

Generalized Flower
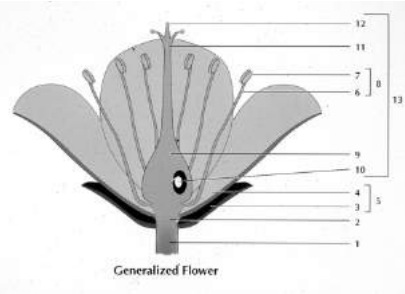
• 1st half deals with vegetative features - we will cover in lab 2 this week

• 2nd half deals with flowers/fruits - lab 3 next week

The Flower
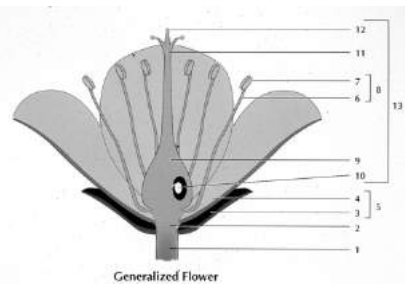

Generalized Flower

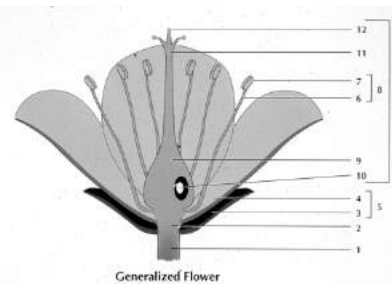1. Peduncle: floral stalk, the stem supporting the flower; sometimes referred to as the pedicel

The Flower

Generalized Flower

2. Receptacle: modified floral stem or axis from which arise the floral appendages or modified leaves

The Flower

Generalized Flower

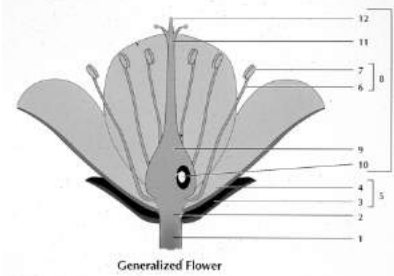3. Sepal: the outer whorl of leaves, green and protective; collectively called the calyx (CA)

The Flower

4. Petal: the second whorl of leaves, typically brightly colored, attracting pollinators; collectively called the corolla (CO)
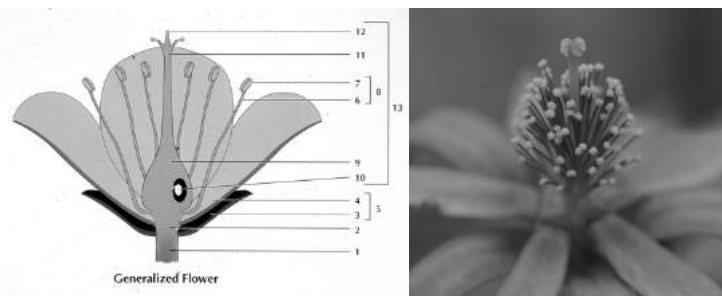
The Flower

5. Perianth: collective term for sepals and petals (P)

Tepals if both similar or if only one reduced set (sepals)
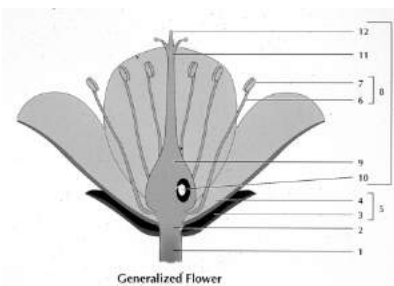
The Flower

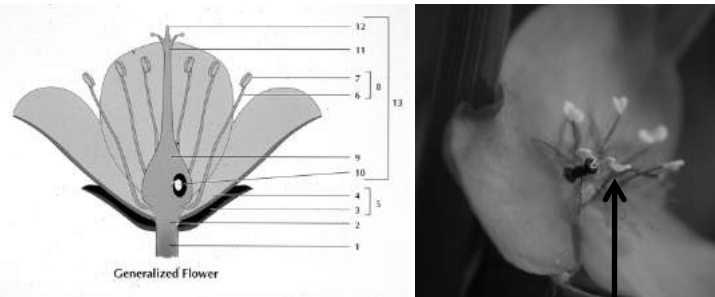8. Stamen: the male structure of flower comprising filament and anther

collectively, stamens are the androecium (= 'house of males') (A)
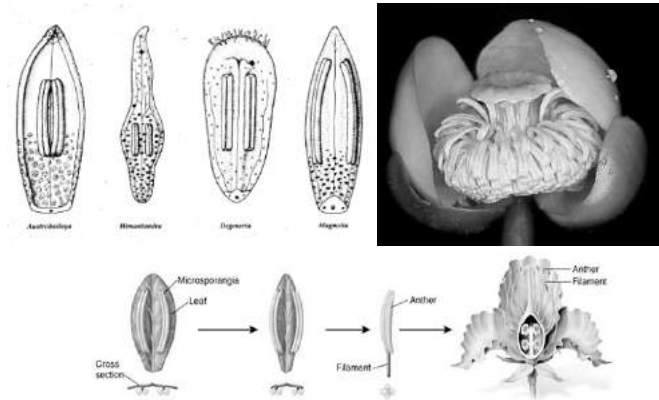
The Flower

6. Filament: slender stalk of the stamen supporting the anther; permits exsertion of anther with pollen out of flower
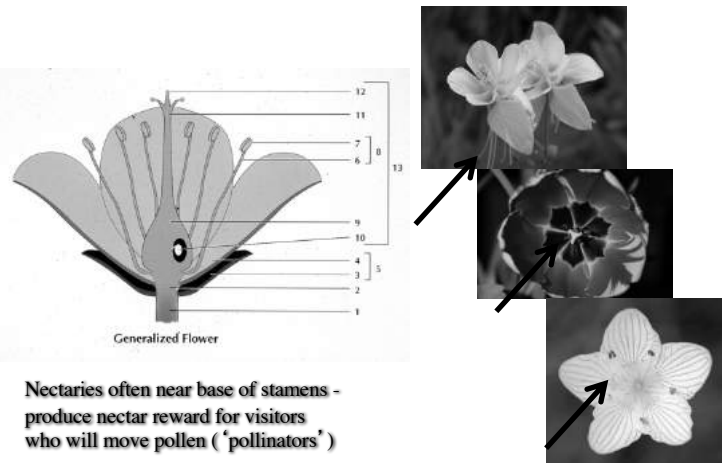
The Flower

7. Anther: fertile portion of stamen that dehisces to release pollen grains; composed of anther sacs
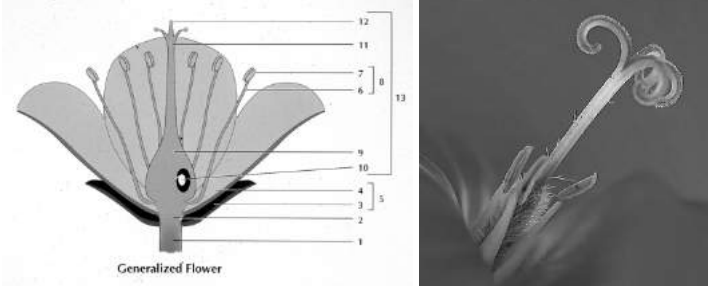
The Flower

• stamens can be leaf-like in primitive angiosperms!

The Flower

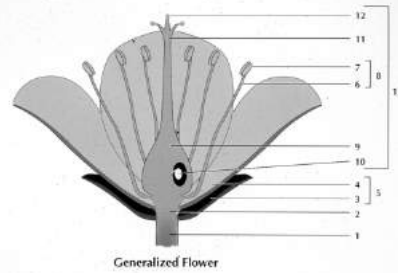Nectaries often near base of stamens - produce nectar reward for visitors who will move pollen ('pollinators')
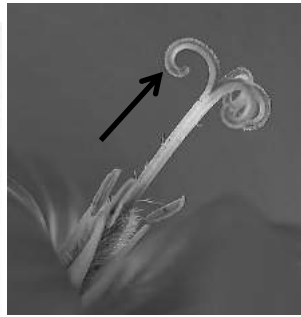
The Flower

13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

• all pistils (1 or more) are referred to as the gynoecium (= 'house of females') (G)
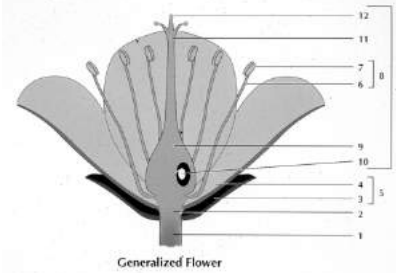
The Flower

13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)
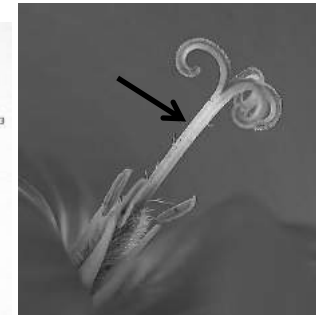
12. Stigma: receptive portion at top of style that receives and recognizes pollen
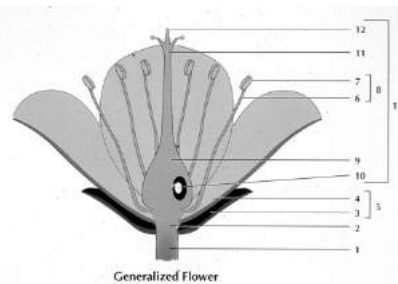
The Flower

13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

11. Style: slender stalk of pistil above ovary that the pollen tubes must pass through to reach eggs in ovules
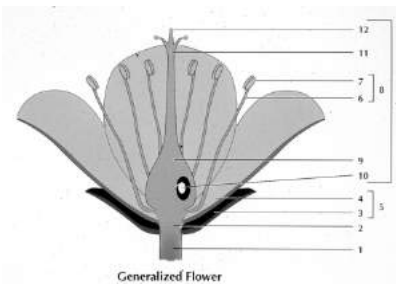
The Flower

13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

9. Ovary: basal portion of pistil that contains ovules; at maturity becomes fruit with seeds

The Flower

13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)
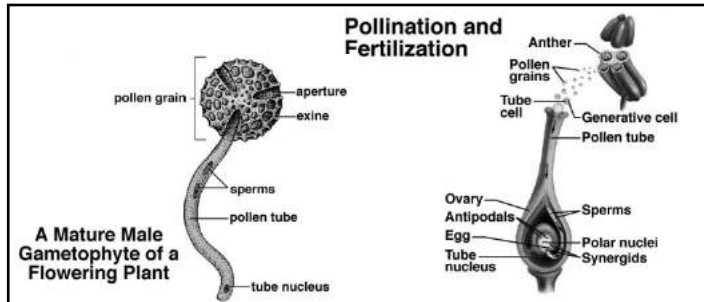
10. Ovules: fertile portions of pistil that contain a female gametophyte (embryo sac); develop into seeds after fertilization

The Flower

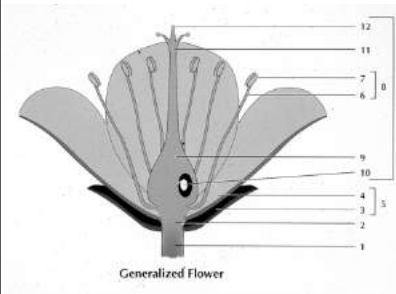**Pollination biology** — Study of the pollen, its transfer, and movement down the style

Pollination and Fertilization

A Mature Male Gametophyte of a Flowering Plant

The Flower

Generalized Flower
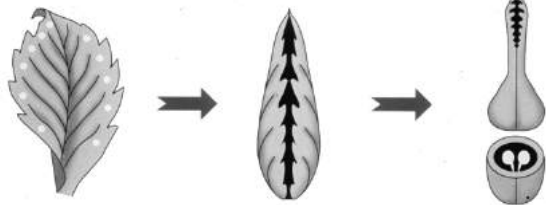
Pistil vs. carpel

How do you know?

3 examples

Carpels not fused
  1. Monocarpic
  2. Apocarpic
Carpels fused
  3. Syncarpic

The Flower

When pistil = carpel

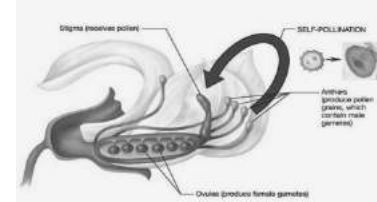1 floral 'leaf' in gynoecium   Folded 'leaf'   1 carpel = 1 pistil

The pistil (vase-shaped structure) is made up of ONE carpel

The Flower

When pistil = carpel

1. Monocarpic – when flower has only 1 pistil

legume flower

1 carpel = 1 pistil

This gynoecium is monocarpic (one carpel)

The Flower

When pistil = carpel

1. Monocarpic – when flower has only 1 pistil

legume flower

legume fruit

1 carpel = 1 pistil

This gynoecium is monocarpic (one carpel)

The Flower

When pistil = carpel

2. Apocarpic – when flower has 2+ pistils

• e.g., 6 leaves (carpels) separately form pistils

• then the flower has 6 carpels and 6 pistils,

6 fruits (pistils) from 1 flower
Gynoecium is apocarpic with 6 carpels and 6 pistils

Caltha palustris - Marsh marigold

The Flower

When pistil ≠ carpel

3 floral 'leaves' in gynoecium fuse

3 carpels = 1 pistil 3 styles

3 carpels = 1 pistil 1 style

3. Syncarpic – when flower has only 1 pistil but 2+ carpels

This gynoecium is syncarpic

This gynoecium is syncarpic

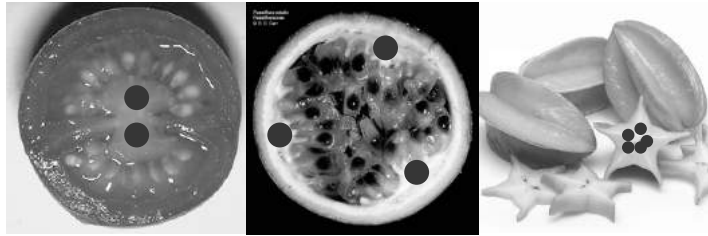## The Flower

tomato – 2 carpels   passion fruit– 3 carpels   starfruit – 5 carpels

3. Syncarpic – when flower has only 1 pistil but 2+ carpels

• number of fused carpels is often clear in a cross section of the fruit

9

The Flower

Placentation types - arrangement of ovules,
provides hints to the number of carpels

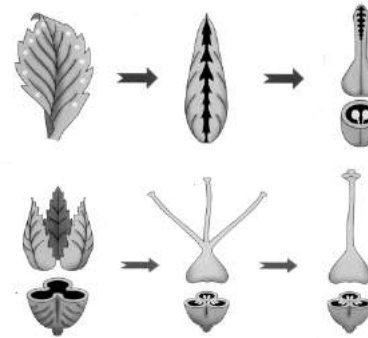tomato – 2 carpels   passion fruit– 3 carpels   starfruit – 5 carpels

● = placenta tissue   • number of fused carpels is often
clear in a cross section of the fruit

The Flower

Placentation types - arrangement of ovules,
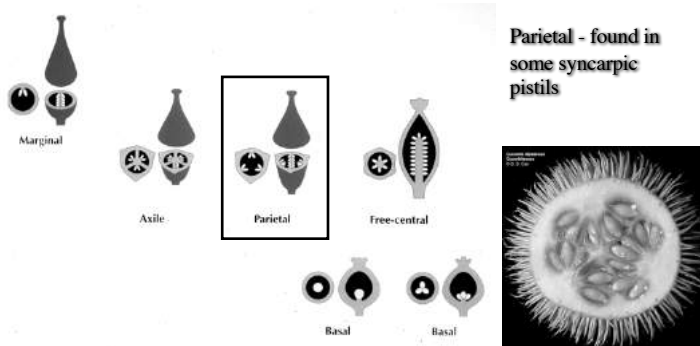provides hints to the number of carpels

Marginal - found in
almost all monocarpic or
apocarpic pistils

Axile - found in some
syncarpic pistils

The Flower

Placentation types - arrangement of ovules,
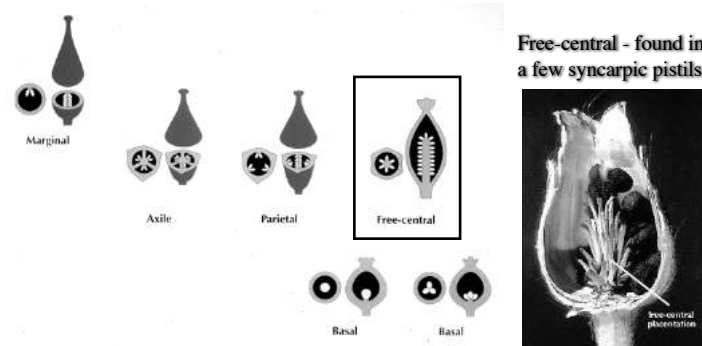provides hints to the number of carpels

Parietal - found in
some syncarpic
pistils

Marginal   Axile   Parietal   Free-central   Basal   Basal

The Flower

Placentation types - arrangement of ovules,
provides hints to the number of carpels

Free-central - found in
a few syncarpic pistils

Marginal   Axile   Parietal   Free-central   Basal   Basal

free-central
placentation

The Flower

Placentation types - arrangement of ovules, provides hints to the number of carpels

Basal - found in some monocarpic, apocarpic, or syncarpic pistils
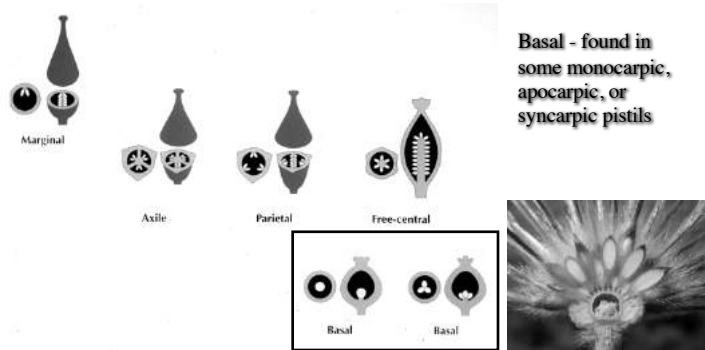
The Flower

Numerical plan - merosity, arrangement of perianth
• not necessarily stamens or carpels

perianth spiralled

Common in primitive angiosperms

perianth 5-merous

Common in eudicots

The Flower

Numerical plan - merosity, arrangement of perianth
• not necessarily stamens or carpels

perianth 4-merous

Occasional in eudicots

perianth 3-merous

Common in monocots & some primitive angiosperms
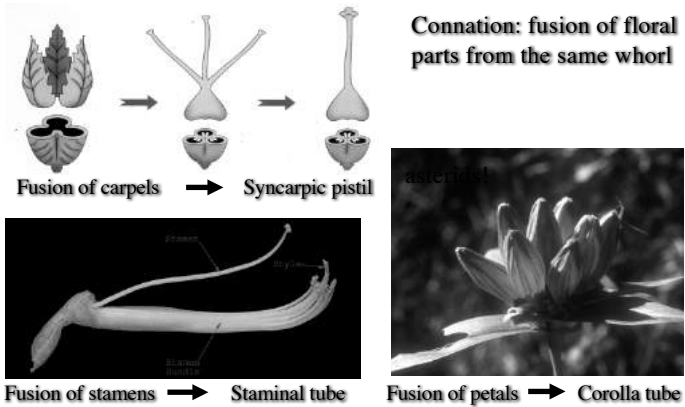
The Flower

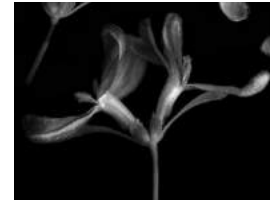**Symmetry plan - perianth arrangement important in pollination biology**

Flowers radially symmetrical

Flowers actinomorphic

Flowers bilaterally symmetrical

Flowers zygomorphic

The Flower

Connation: fusion of floral parts from the same whorl

Fusion of carpels → Syncarpic pistil

asteridsl

Fusion of stamens → Staminal tube

Fusion of petals → Corolla tube

The Flower
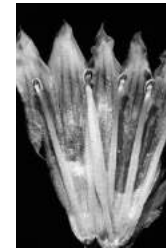
Adnation: fusion of floral parts from different whorls

• Simple adnation

Stamens fused onto inner surface of fused (connation) petals

• Complex adnation

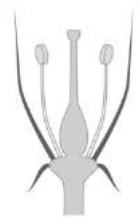Sepals, petals, and stamens fuse to form a hypanthium

The Flower

e.g., Drimys & sandwort

Adnation: fusion of floral parts from different whorls

No adnation!

Connation (fusion of similar parts) may or may not occur

Drimys winteri
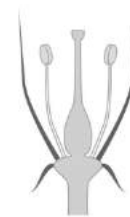Winteraceae

Ovary superior
Flower hypogynous
No hypanthium

The Flower

e.g., cherry & rose
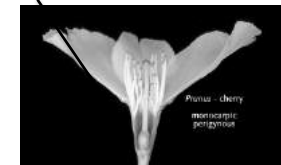
Adnation: fusion of floral parts from different whorls

Adnation of calyx, corolla, & stamens = hypanthium

hypanthium

Ovary superior
Flower hypogynous
No hypanthium

Ovary superior
Flower perigynous
Hypanthium present

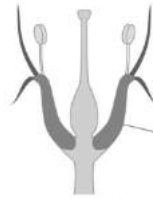Prunus - cherry
monocarpic
perigynous

The Flower

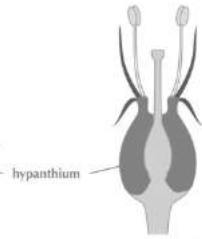e.g., feverwort, honeysuckle, apple

Adnation: fusion of floral parts from different whorls

Ovary superior
Flower hypogynous
No hypanthium

Ovary superior
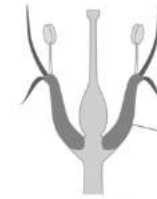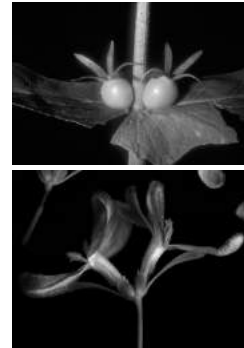Flower perigynous
Hypanthium present

Ovary inferior
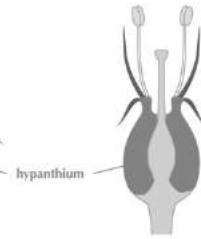Flower epigynous
Hypanthium present

The Flower

e.g., feverwort, honeysuckle, apple

Adnation: fusion of floral parts from different whorls

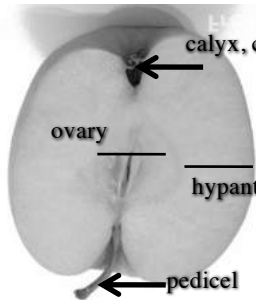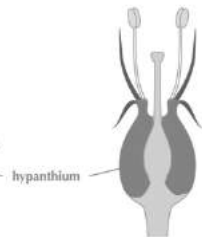Ovary superior
Flower perigynous
Hypanthium present

Ovary inferior
Flower epigynous
Hypanthium present

The Flower

e.g., feverwort, honeysuckle, apple

Adnation: fusion of floral parts from different whorls

calyx, corolla, stamens

ovary

hypanthium

pedicel

Ovary superior
Flower perigynous
Hypanthium present

Ovary inferior
Flower epigynous
Hypanthium present

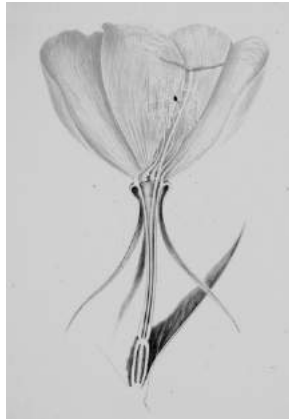## The Flower

Floral formula - shorthand notation

$$CA^4 \quad CO^4 \quad A^8 \quad G^4$$

4 sepals (**CA**lyx)
4 petals (**CO**rolla)
8 stamens (**A**ndroecium)
4 carpels (**G**ynoecium)

Oenothera biennis
Evening primrose
Onagraceae

The Flower

Floral formula - shorthand notation

$$CA^{4} \quad CO^{4} \quad A^{8} \quad G④ \leftarrow$$

4 sepals (**CA**lyx)
4 petals (**CO**rolla)
8 stamens (**A**ndroecium)
4 carpels (**G**ynoecium)

• Carpels fused = 1 pistil

Oenothera biennis
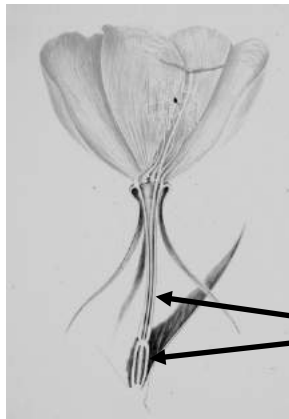Evening primrose
Onagraceae

The Flower

Floral formula - shorthand notation

$$CA^{4} \quad CO^{4} \quad A^{8} \quad \overline{G}④$$

4 sepals (**CA**lyx)
4 petals (**CO**rolla)
8 stamens (**A**ndroecium)
4 carpels (**G**ynoecium)

Carpels fused = 1 pistil
• Ovary inferior

Oenothera biennis
Evening primrose
Onagraceae

The Flower

Floral formula - shorthand notation

$$CA^{4} \quad CO^{4} \quad A^{8} \quad \overline{G}④$$

4 sepals (**CA**lyx)
4 petals (**CO**rolla)
8 stamens (**A**ndroecium)
4 carpels (**G**ynoecium)

Carpels fused = 1 pistil
Ovary inferior
• Hypanthium (+ hypanthium tube)

Oenothera biennis
Evening primrose
Onagraceae

The "flower" — what is it?

• a flower is a specialized shoot that:

1. is determinate (vs. indeterminate)

2. has a modified stem with compressed internodes

3. possesses modified leaves with various functions, these determined by gene arrays (e.g., ABC model)

4. often clustered in an inflorescence (larger branch)