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)

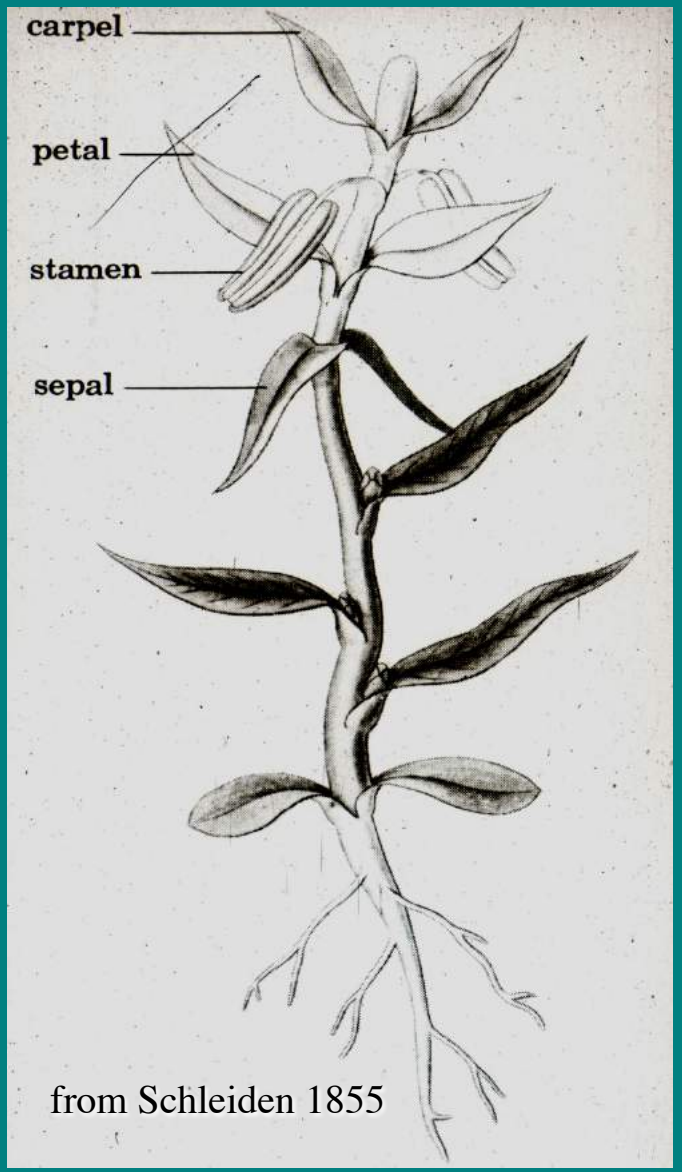
The Flower — What is it?

- 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)



from Schleiden 1855

The Flower — What is it?

- developmental/evolutionary origin of the flower still debated

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The Flower — What is it?

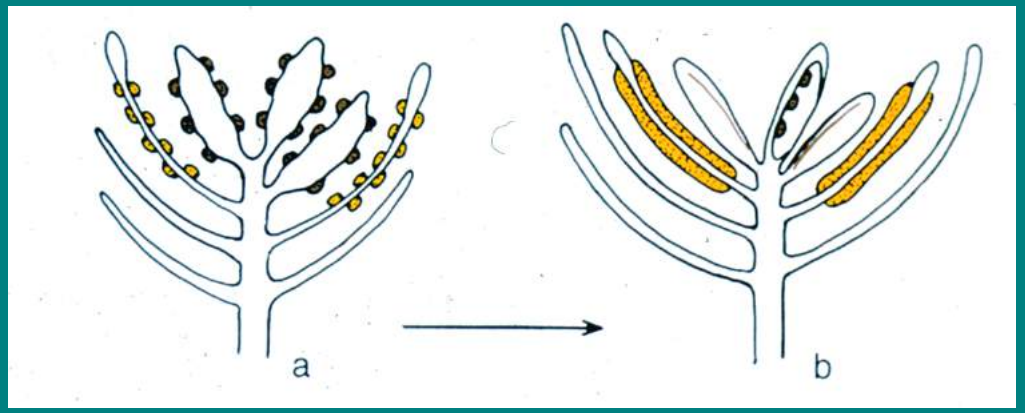
- developmental/evolutionary origin of the flower still debated

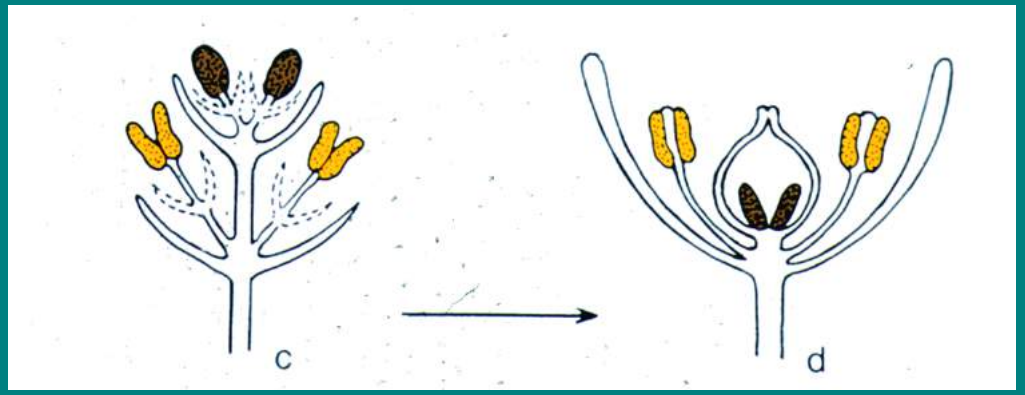
1. Euanthial theory - (foliar theory) - *single* shoot, cone or strobilus

   anthers (male)

   ovules (female)

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



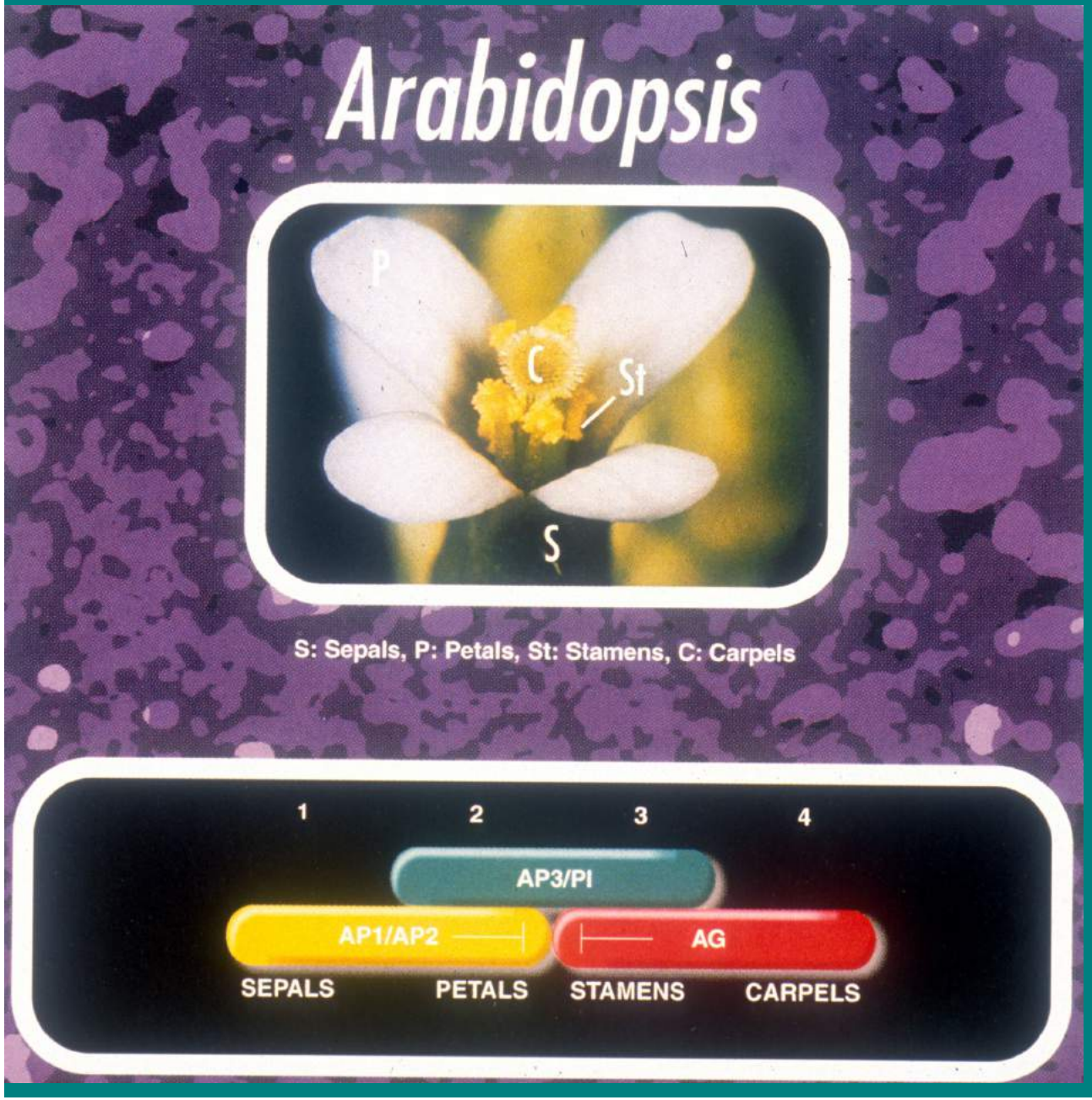


The Flower — What is it?

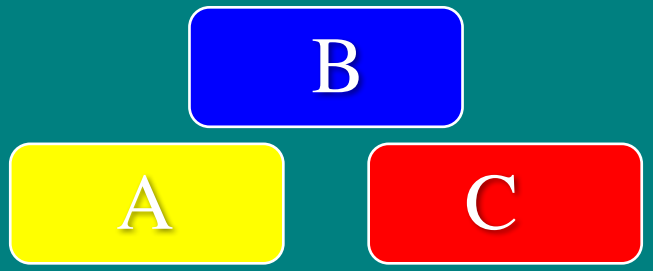
- thus, a flower is a specialized shoot that:

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?



The 'ABC' model of floral part identity

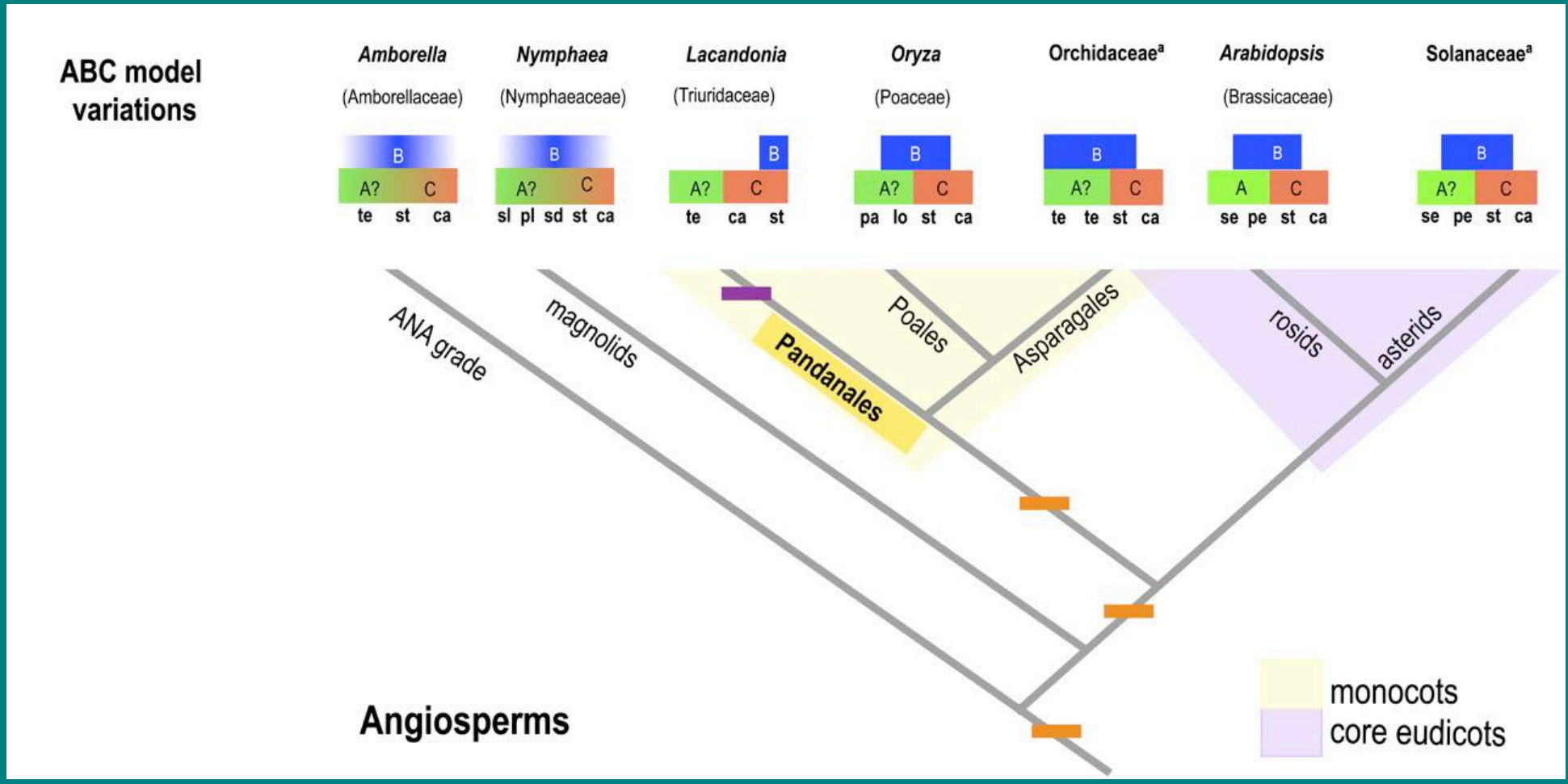


sepals petals stamens carpels

The Flower — What is it?

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

The Plant Cell, 2010



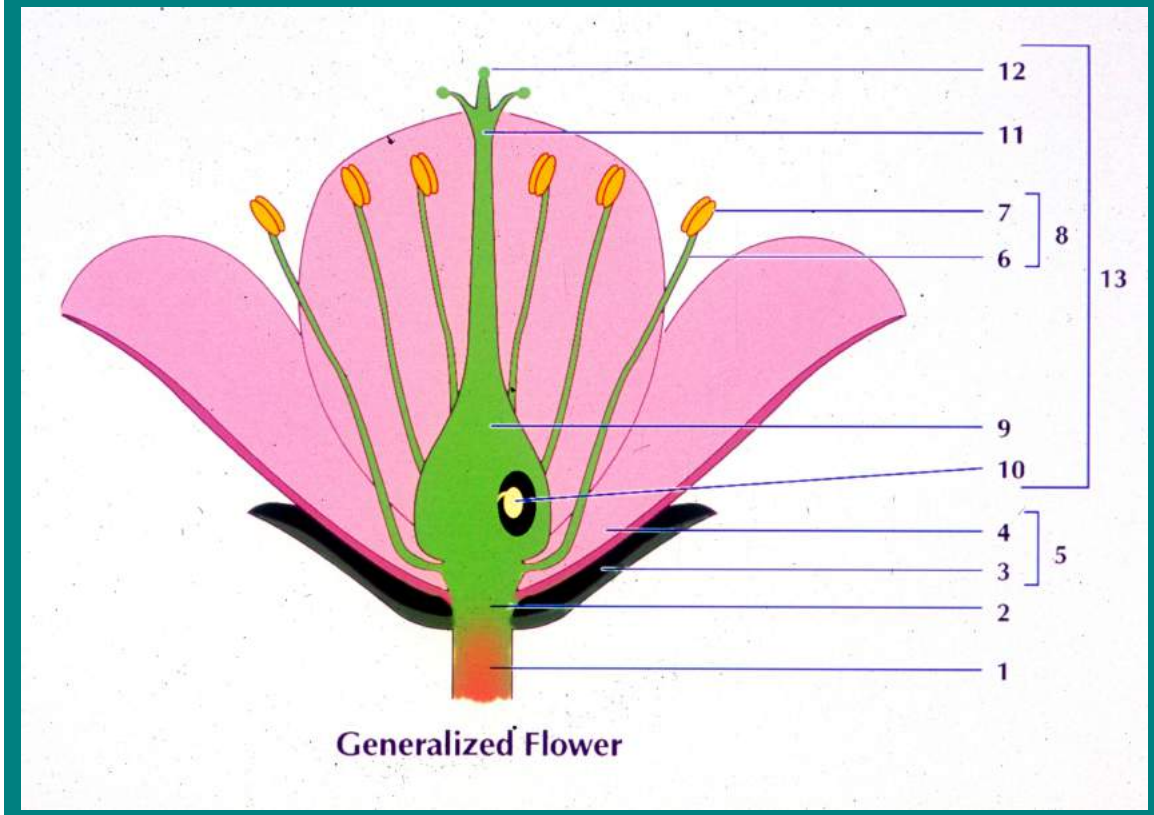
The Flower — What is it?

- 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)
4. often clustered in an inflorescence (larger branch)

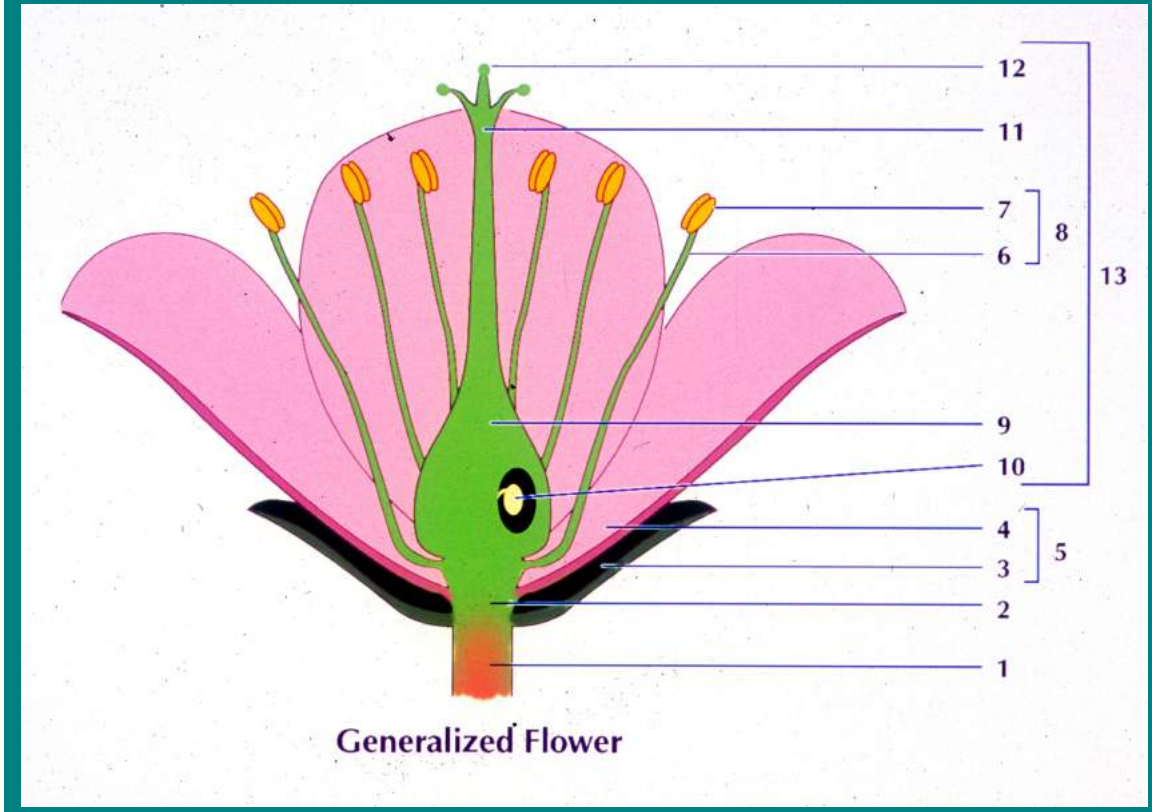
The Flower

read chpt 9 in *Plant Systematics*!



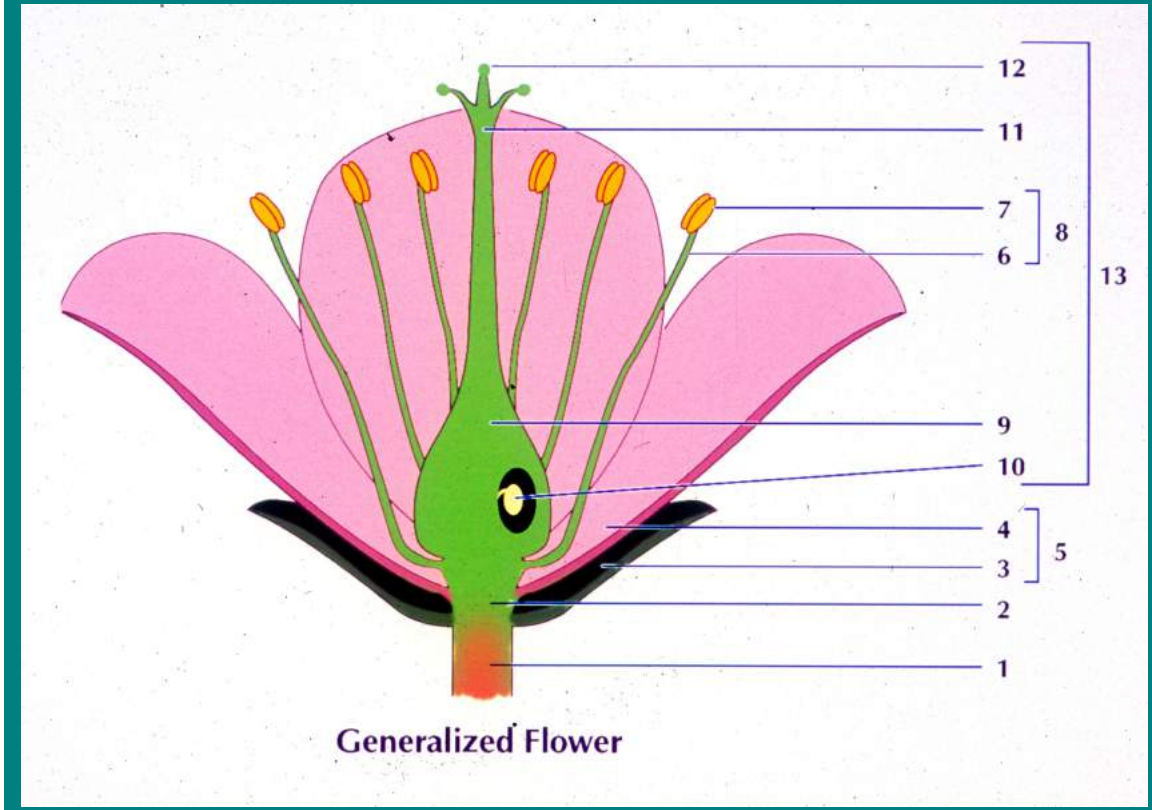
- 1st half deals with vegetative features - we will cover in lab 2 this week
- 2nd half deals with flowers/fruits - lab 3 next week

The Flower



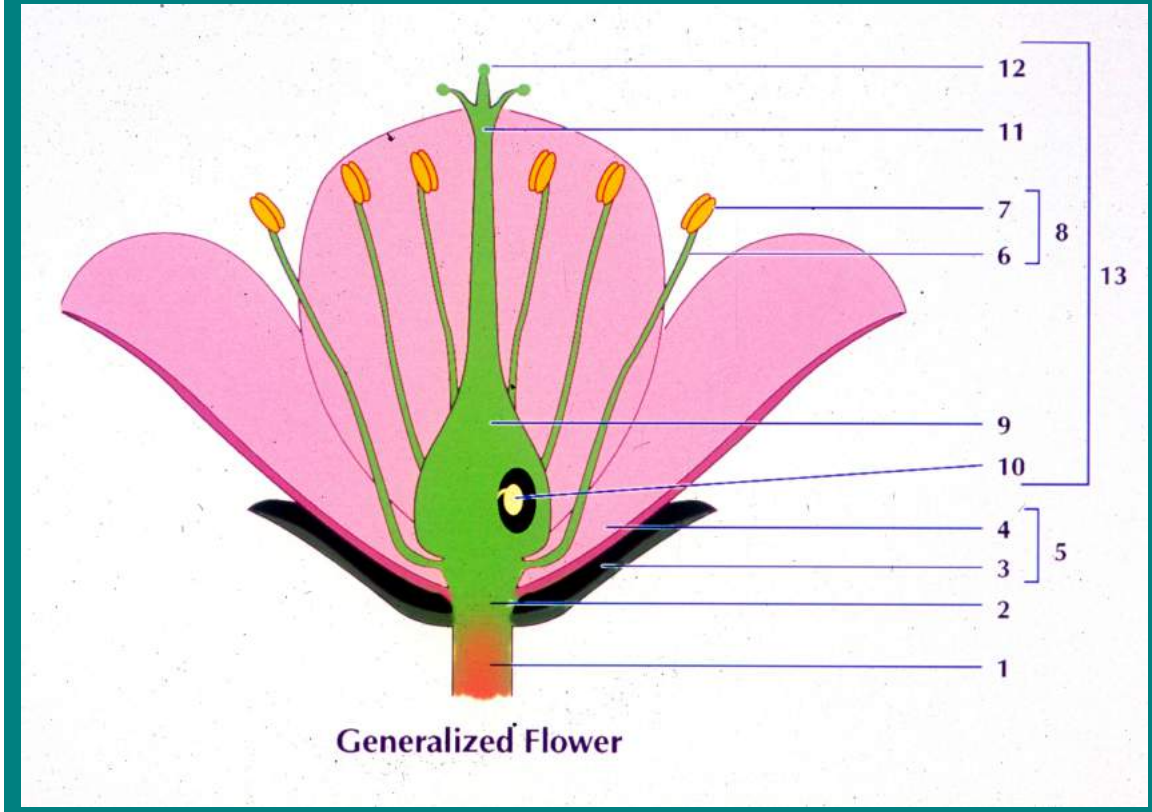
1. Peduncle: floral stalk, the stem supporting the flower; sometimes referred to as the pedicel

The Flower



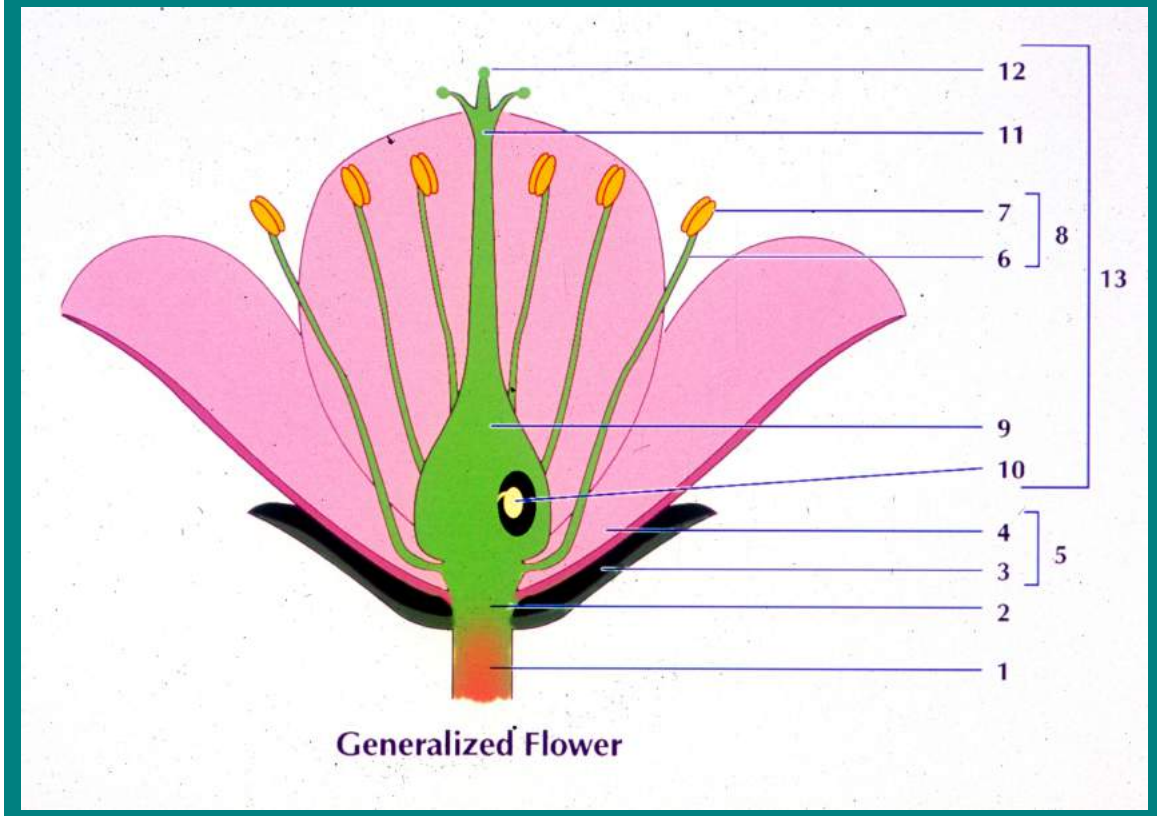
2. Receptacle: modified floral stem or axis from which arise the floral appendages or modified leaves

The Flower



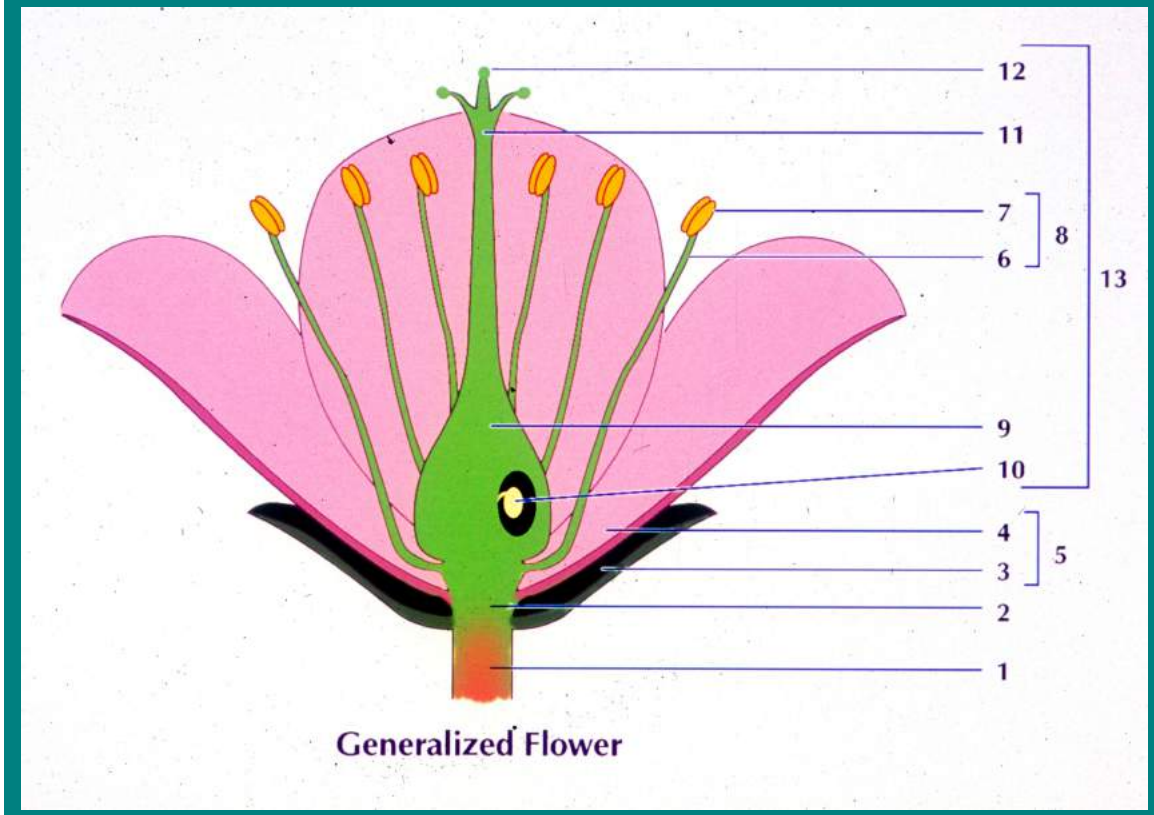
3. Sepal: the outer whorl of leaves, green and protective; collectively called the calyx (CA)

The Flower



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

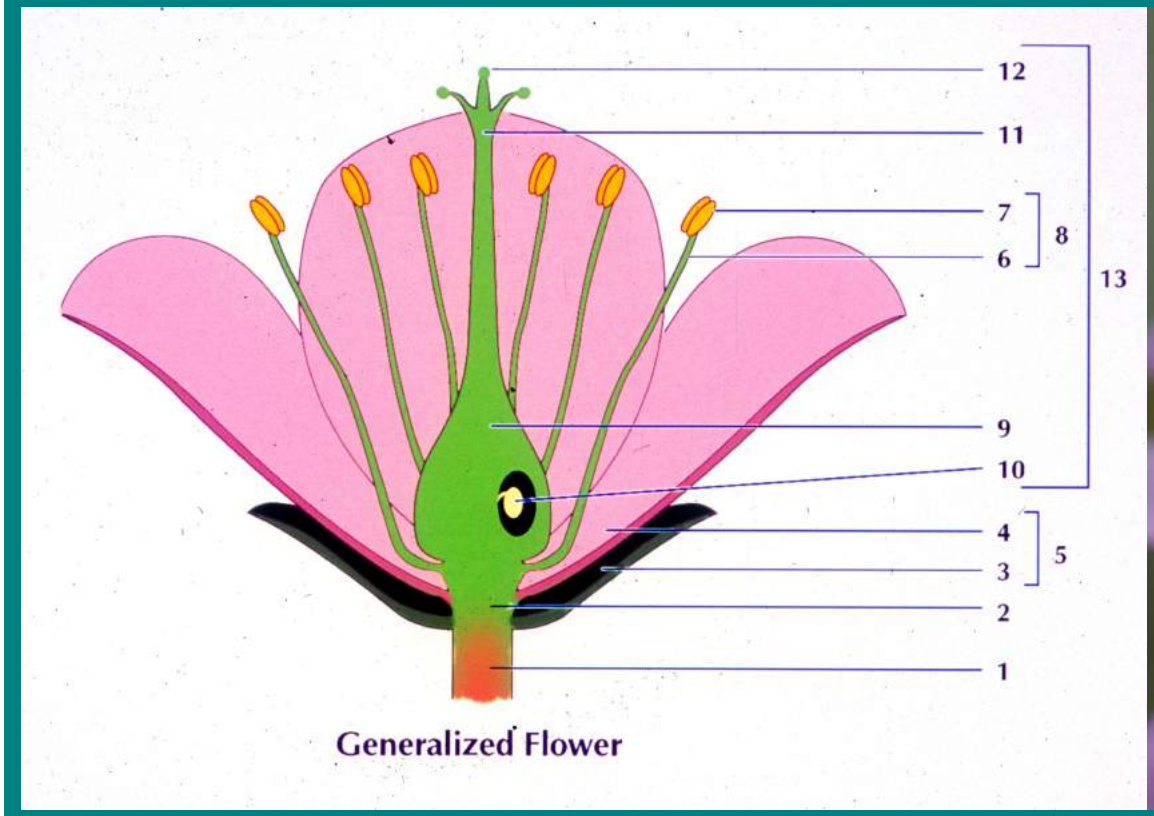
The Flower



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

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

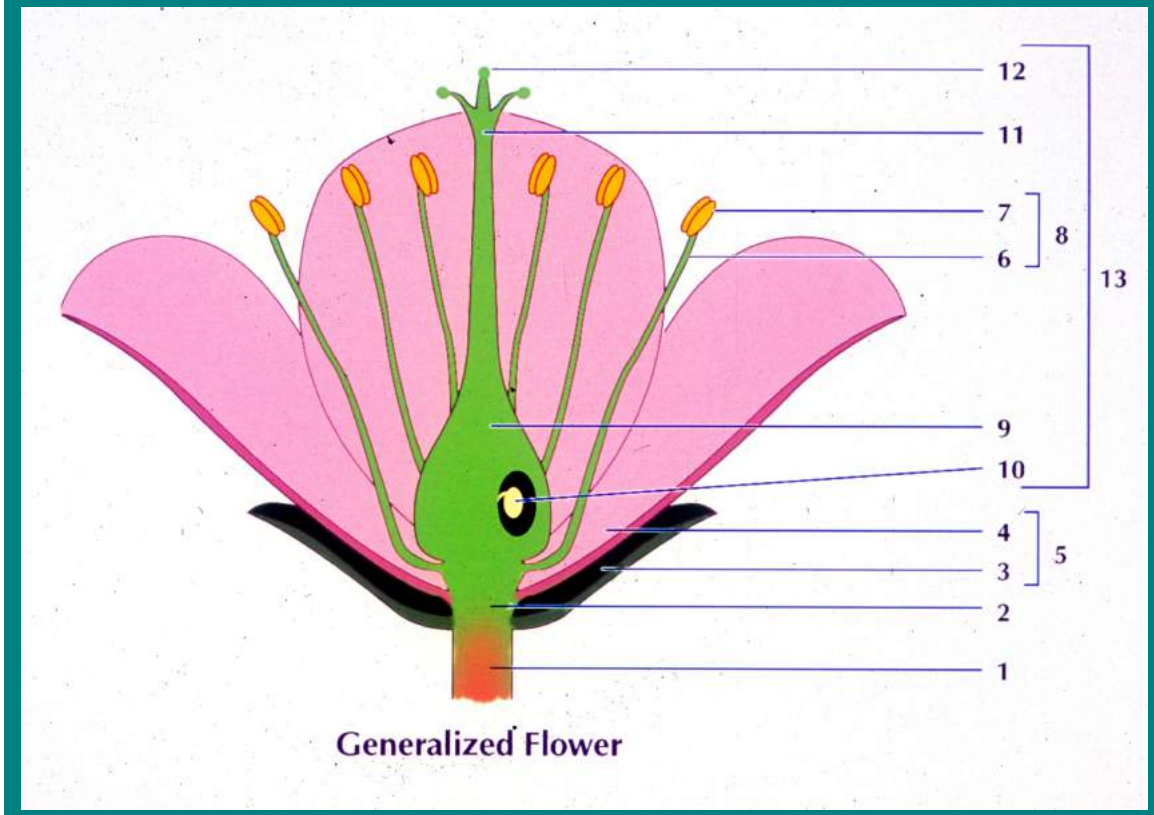
The Flower

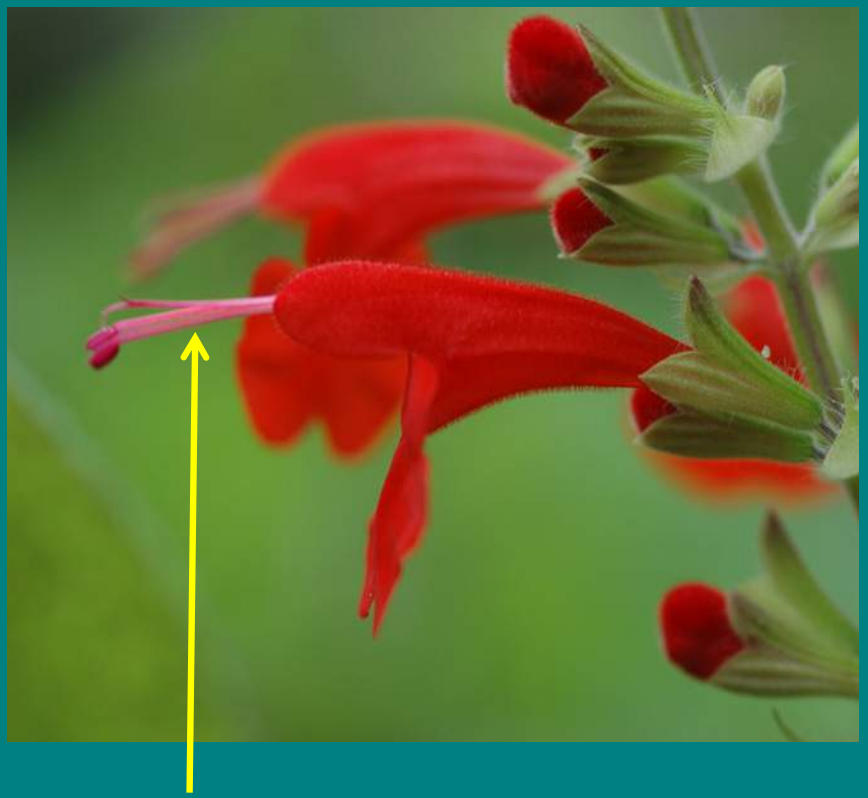


8. Stamen: the male structure of flower comprising filament and anther

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

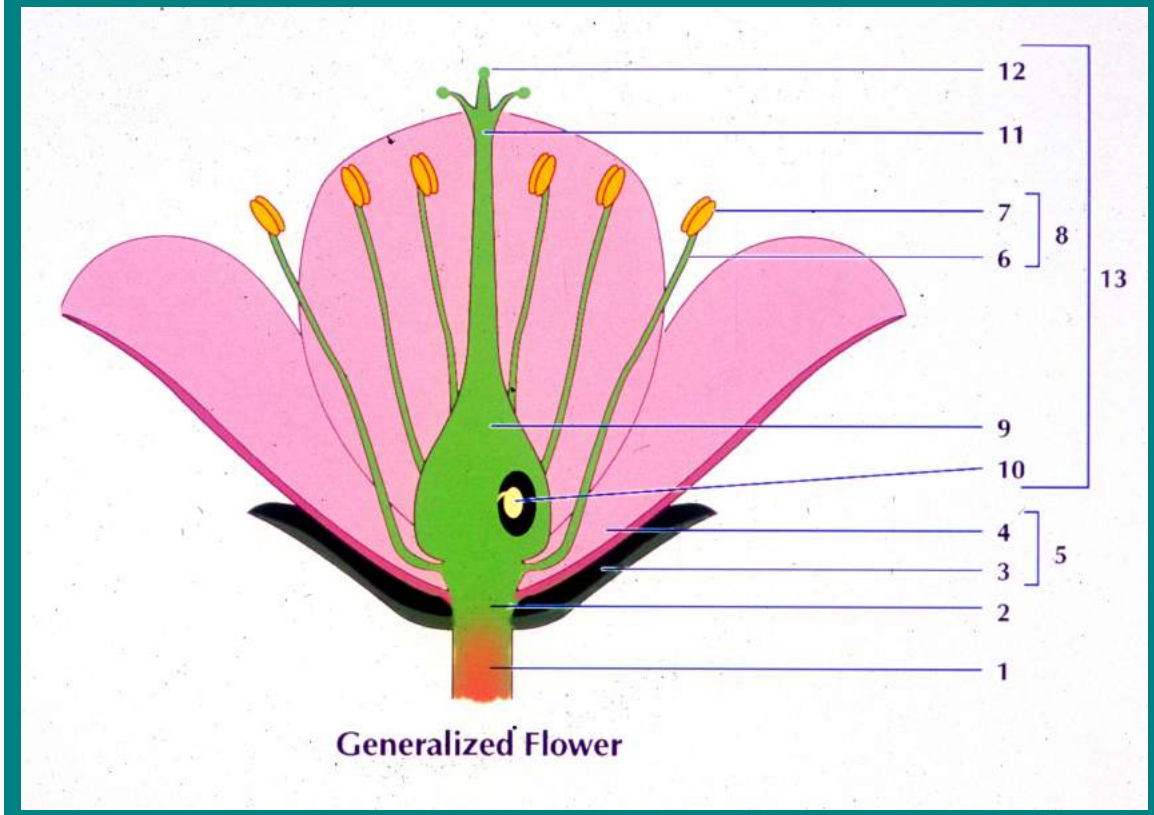
The Flower

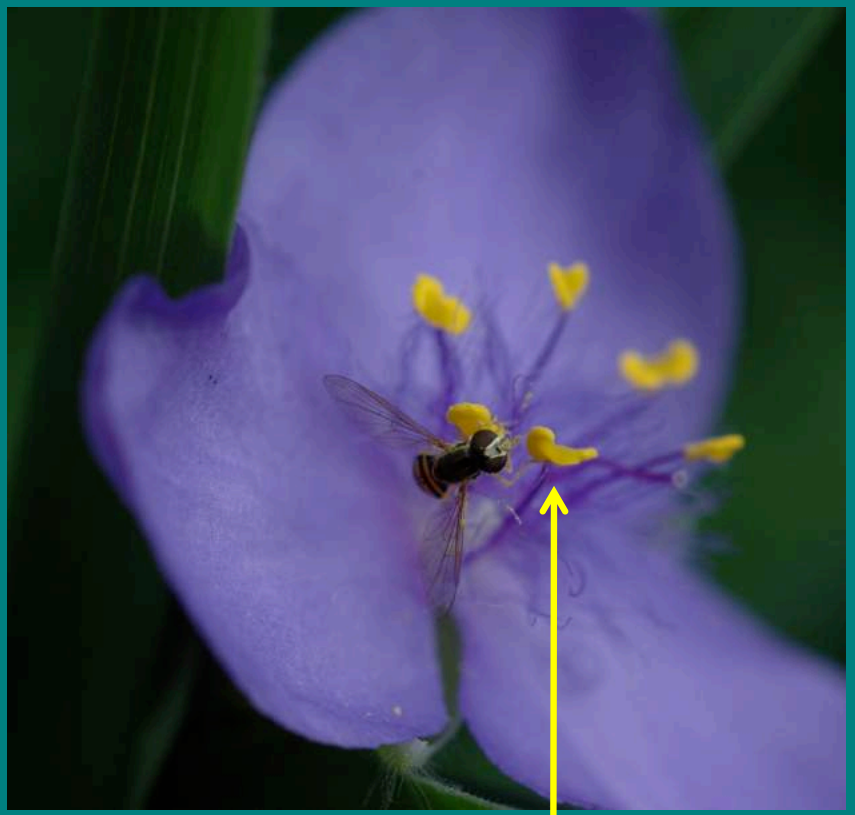




6. Filament: slender stalk of the stamen supporting the anther; permits exsertion of anther with pollen out of flower

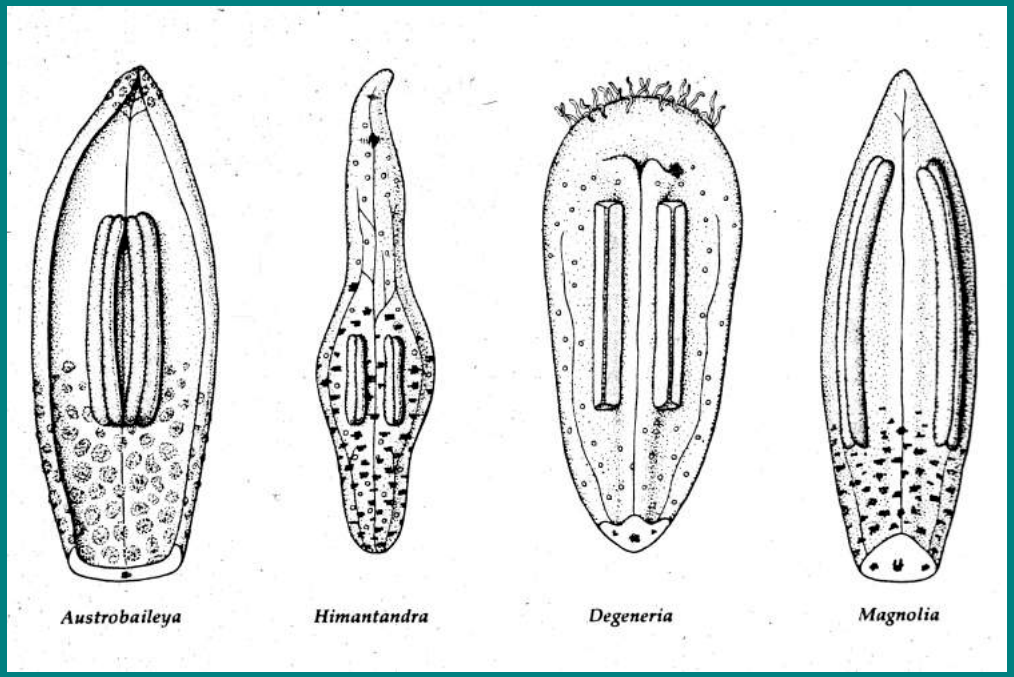
The Flower

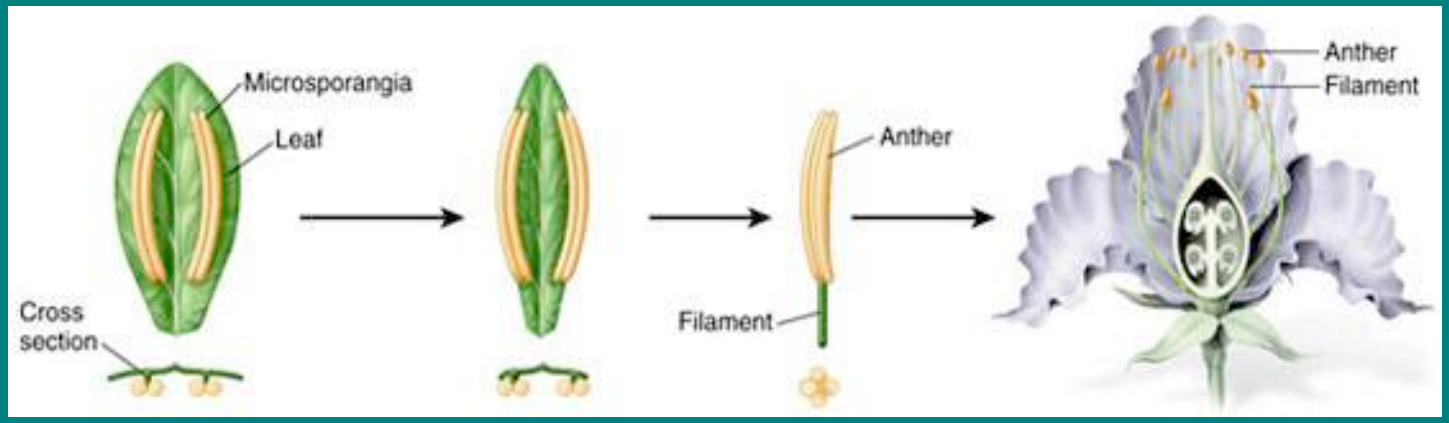




7. Anther: fertile portion of stamen that dehisces to release pollen grains; composed of anther sacs

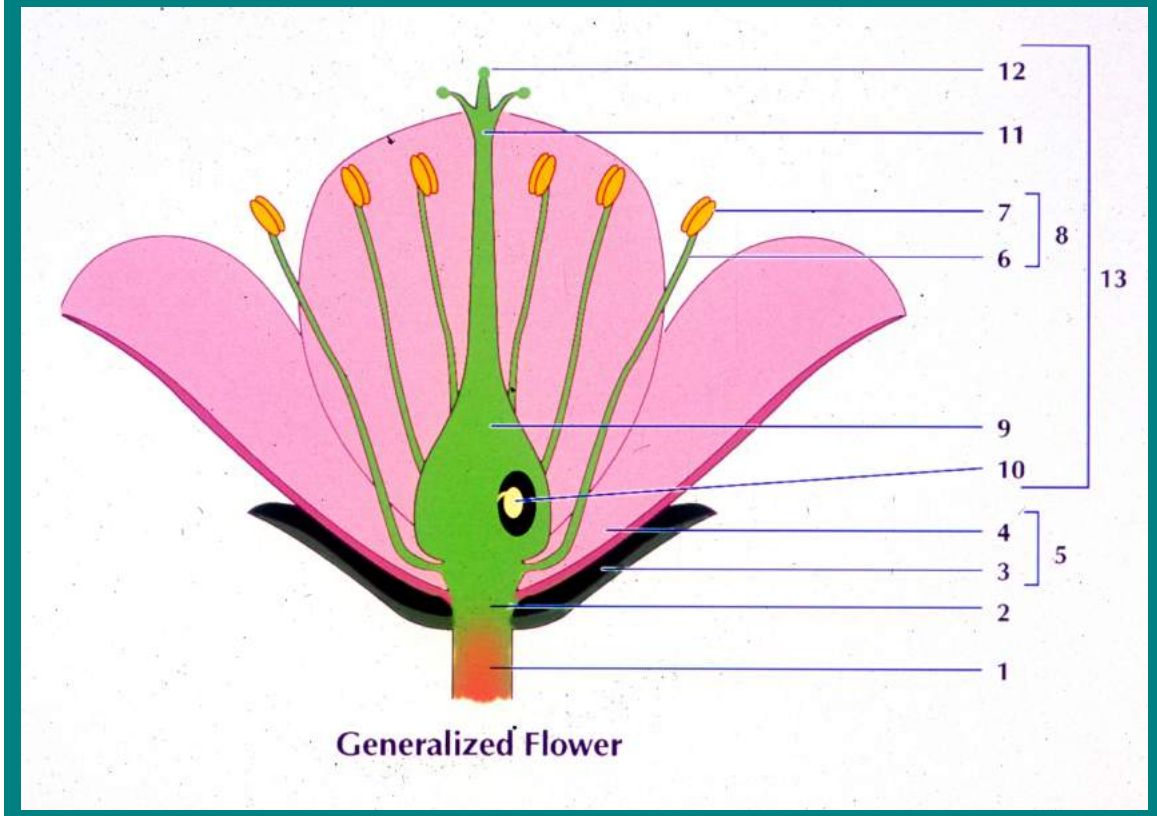
The Flower

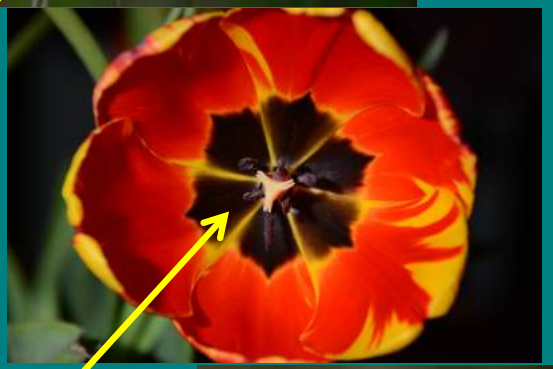




- stamens can be leaf-like in primitive angiosperms!

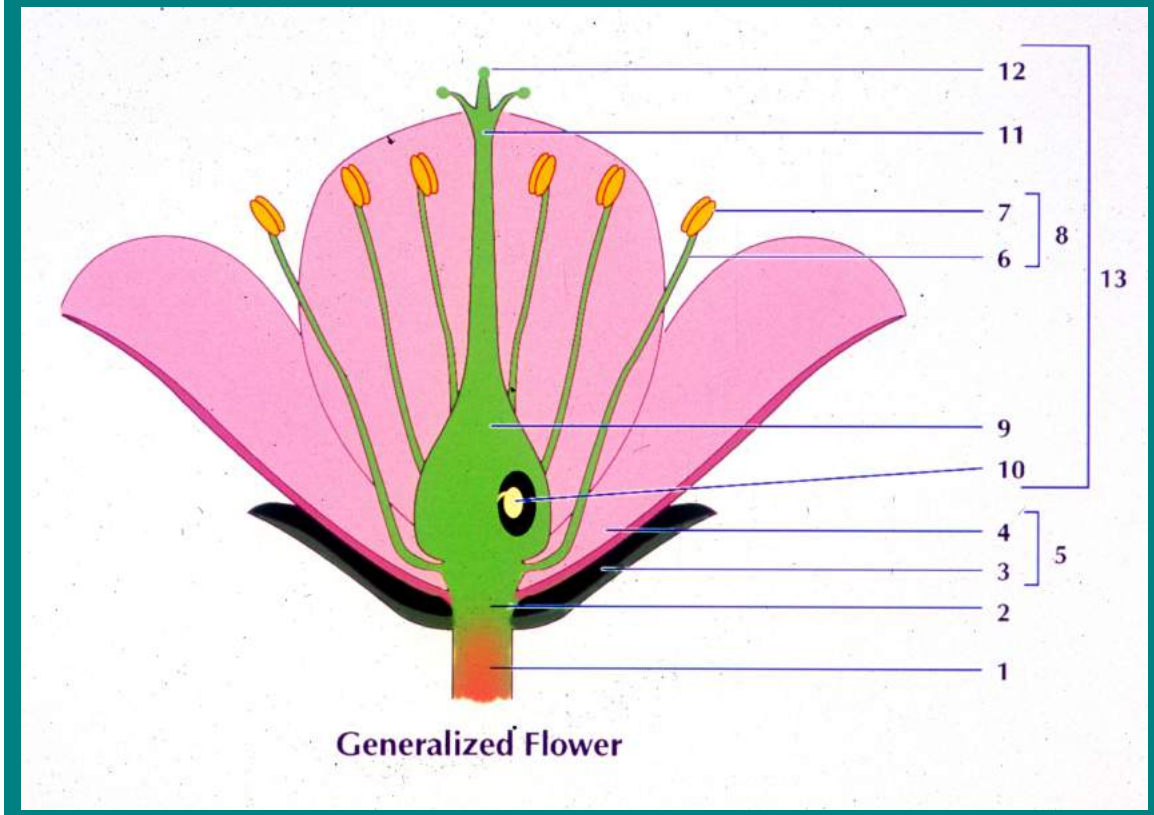
The Flower





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

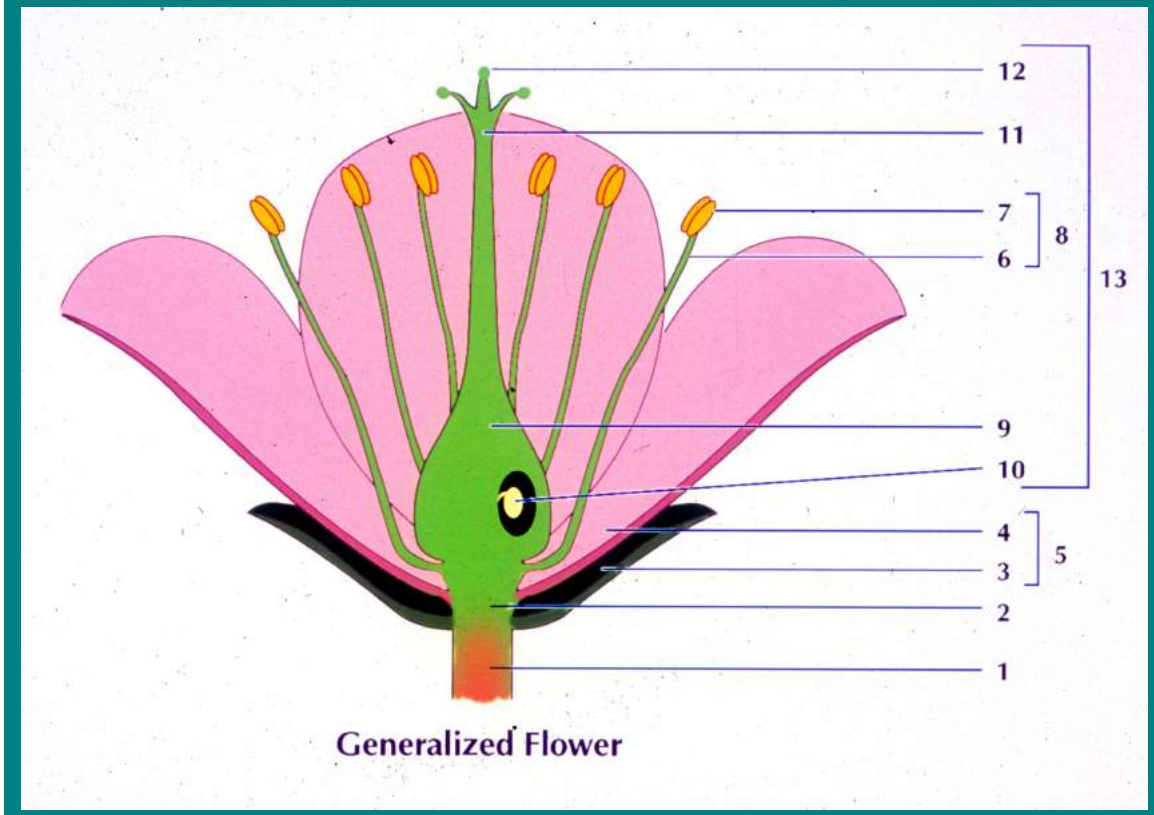
The Flower



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)

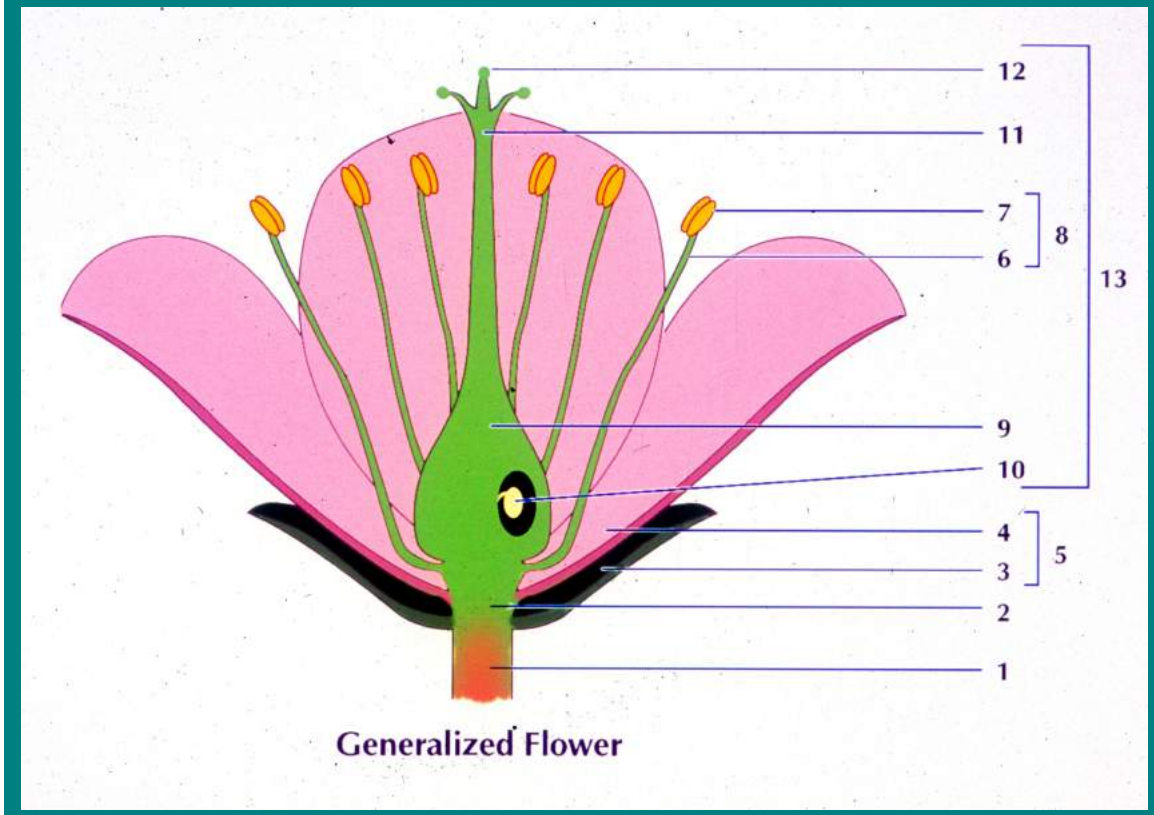
The Flower



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

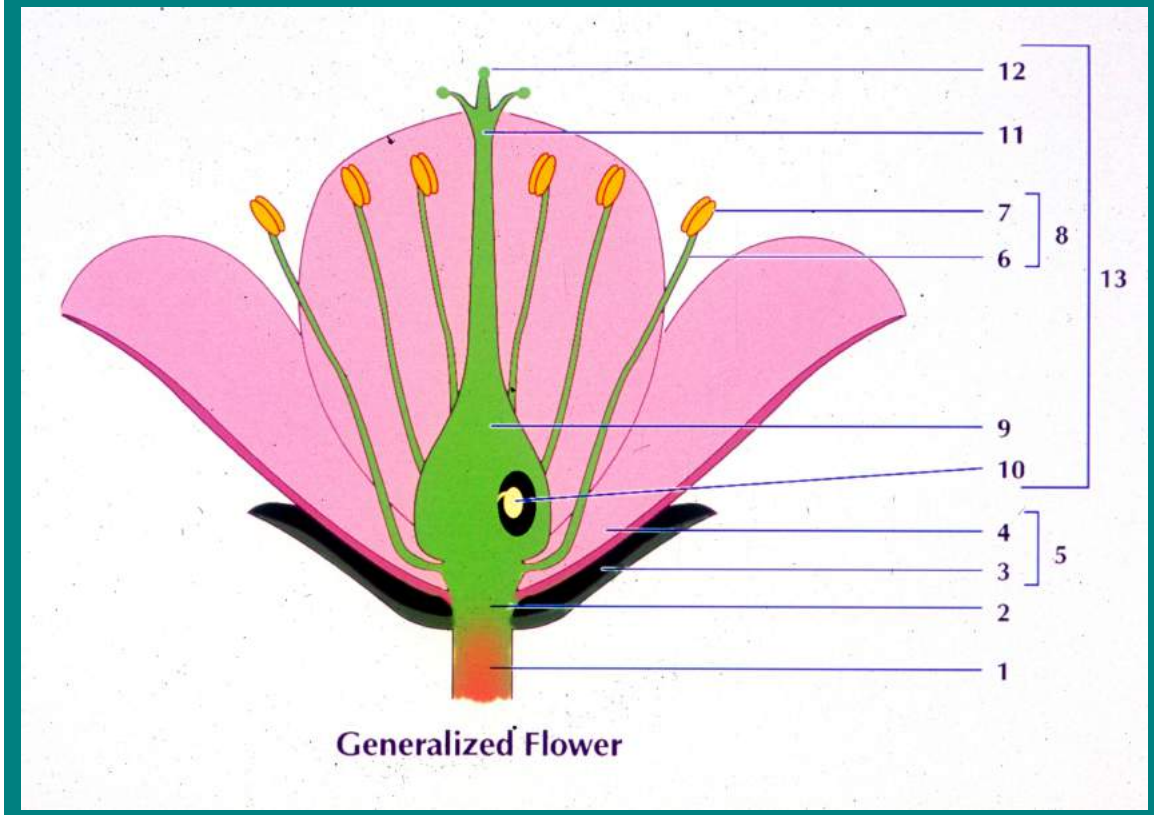
The Flower

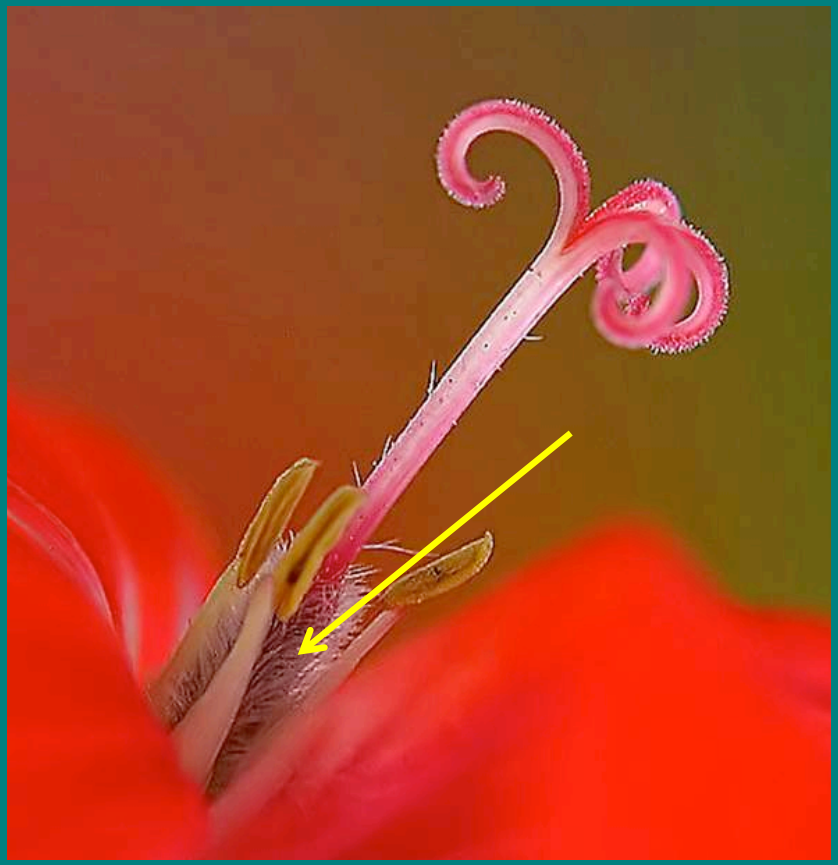


13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

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

The Flower

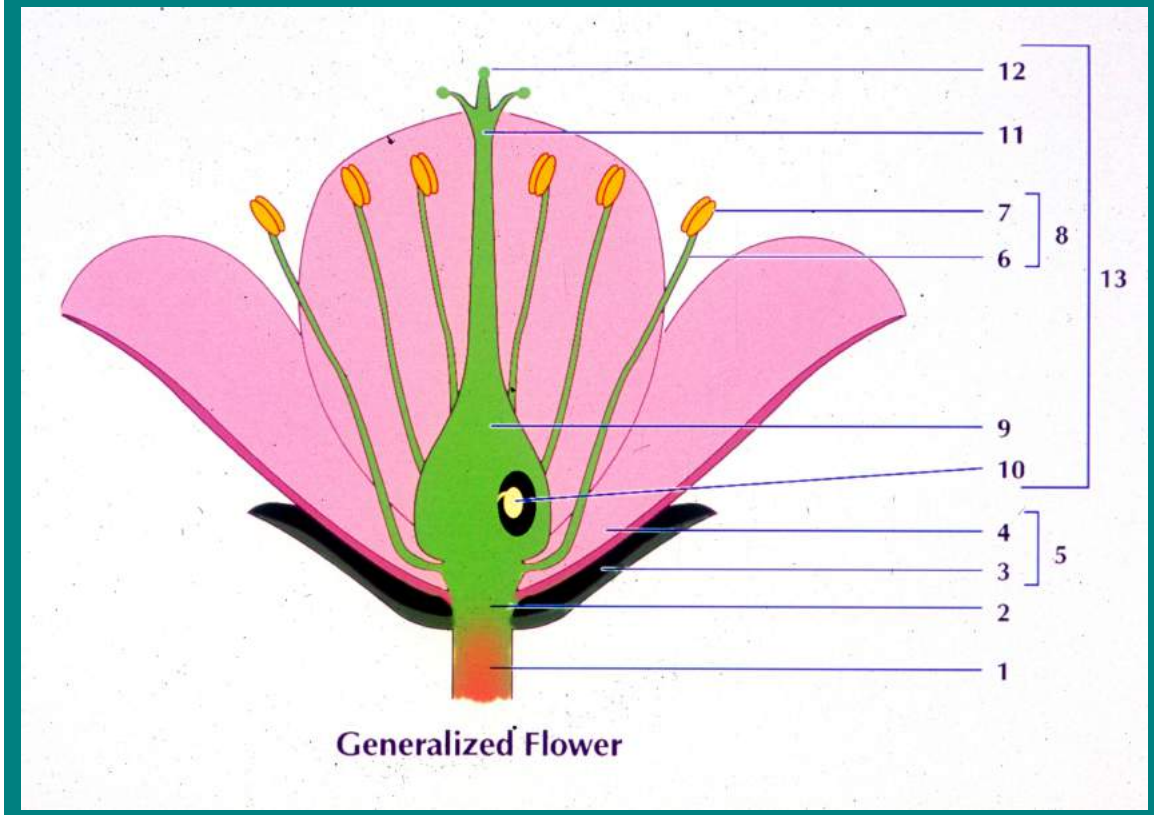




13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

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

The Flower

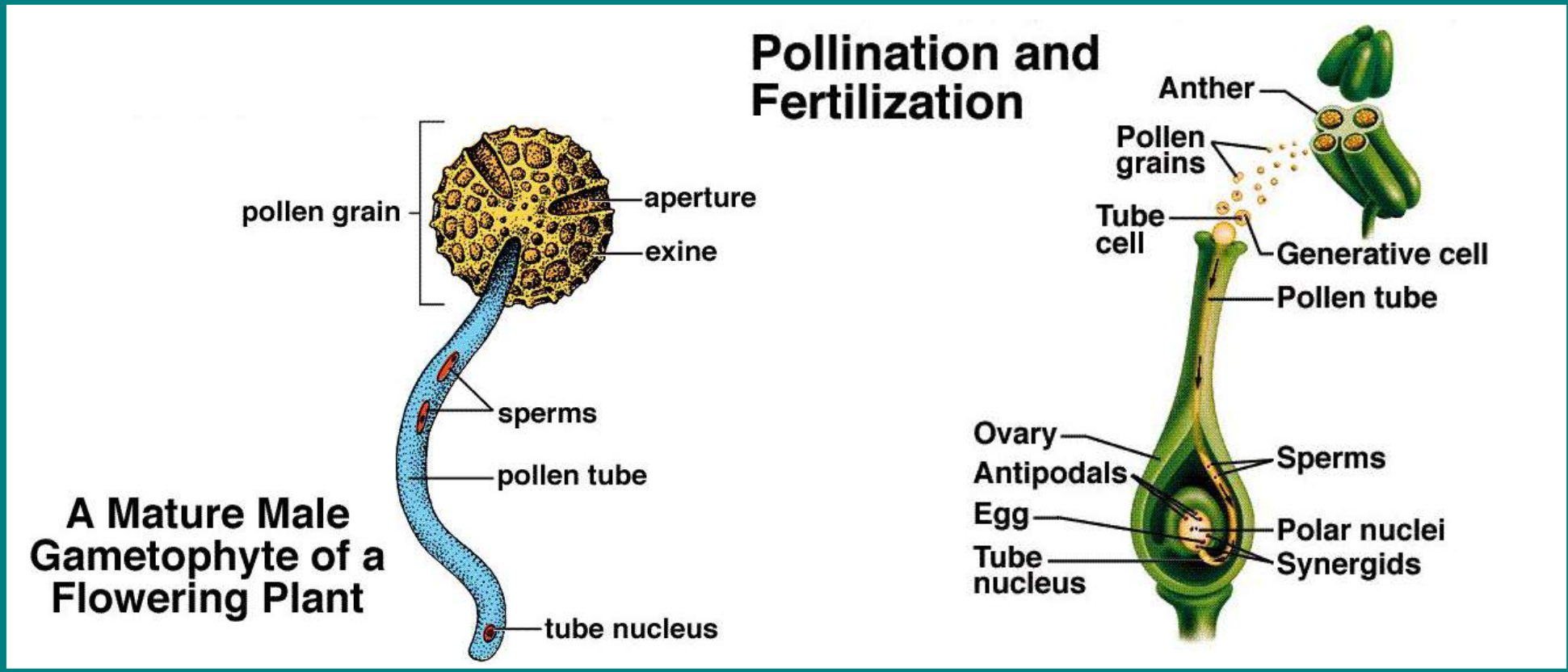


13. Pistil: flask-shaped, female structure comprising three main parts – often referred to as carpel(s)

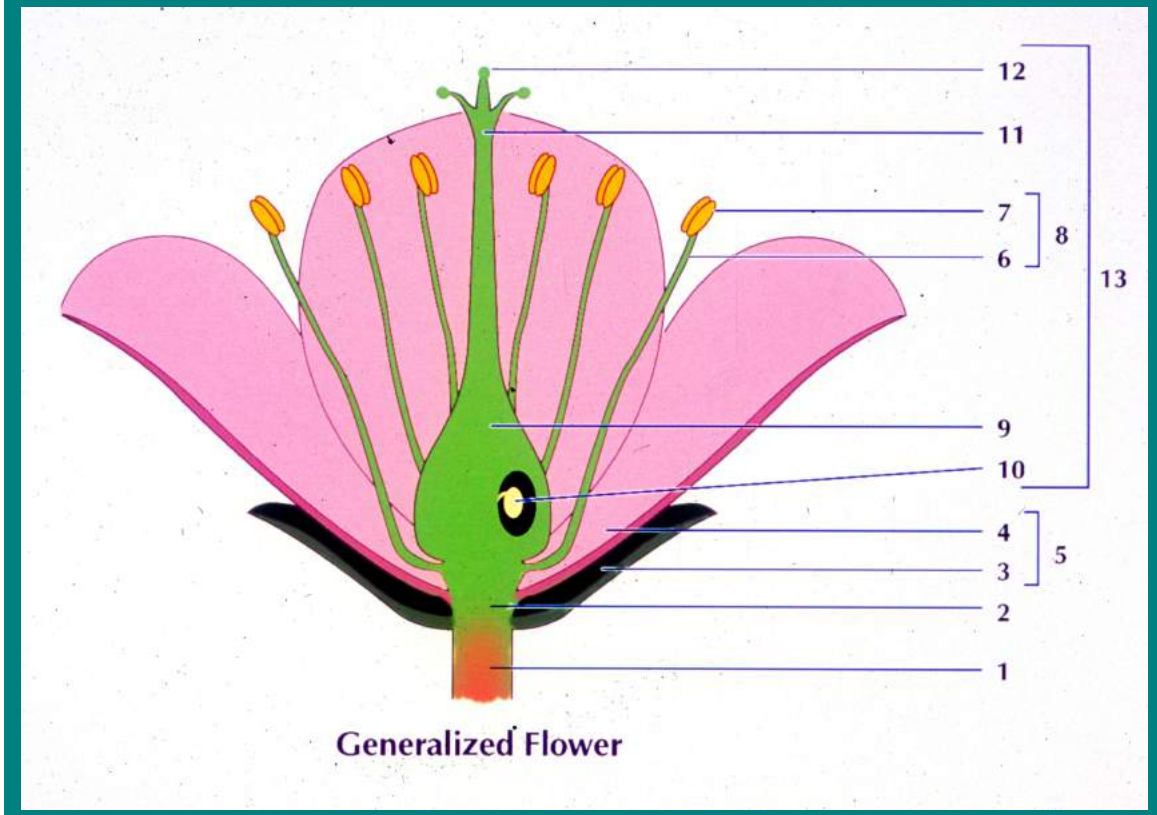
10. Ovules: fertile portions of pistil that contain a female gametophyte (embryo sac); develop into seeds after fertilization

The Flower

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



The Flower



Pistil vs. carpel

How do you know?

3 examples

Carpels not fused

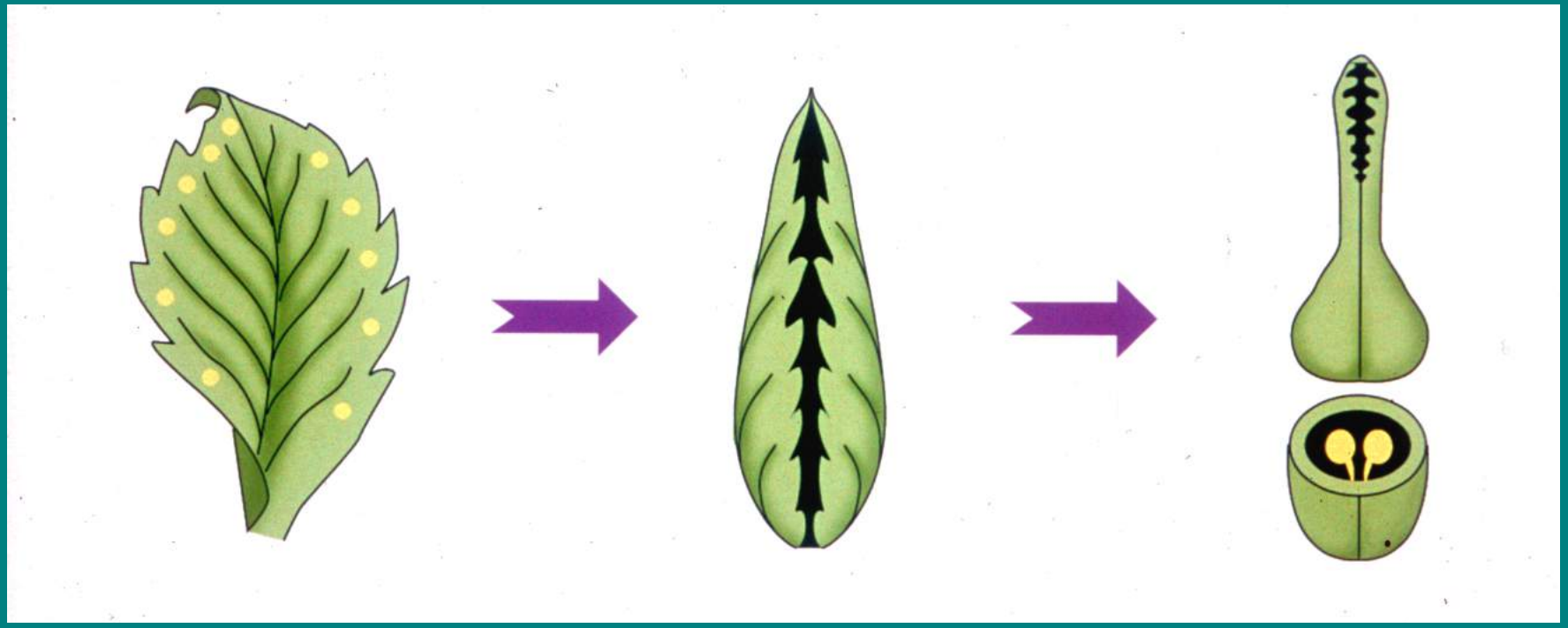
1. Monocarpic
2. Apocarpic

Carpels fused

3. Syncarpic

The Flower

When pistil = carpel



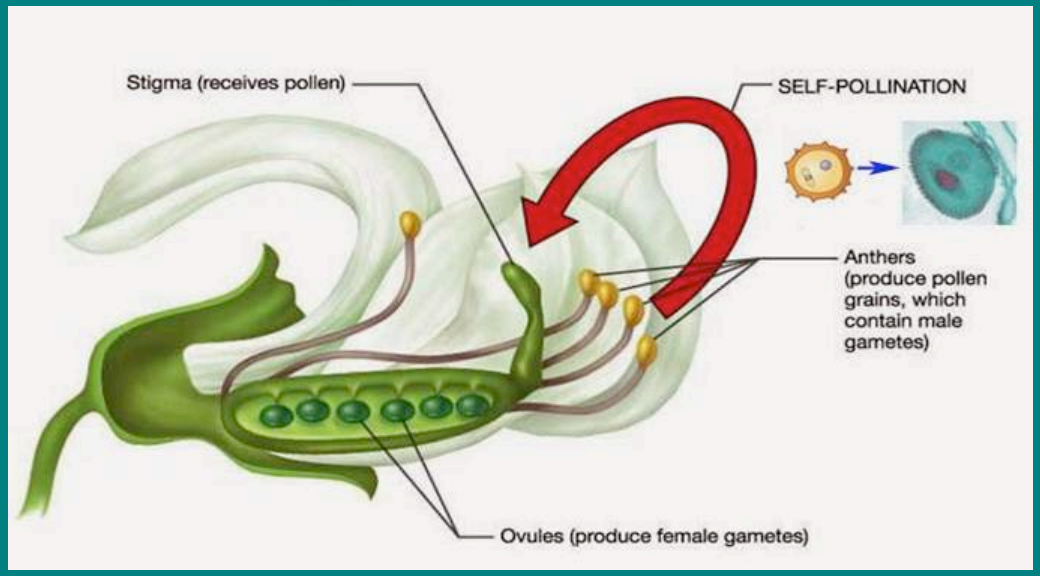
1 floral 'leaf' in gynoecium Folded 'leaf' 1 carpel = 1 pistil

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

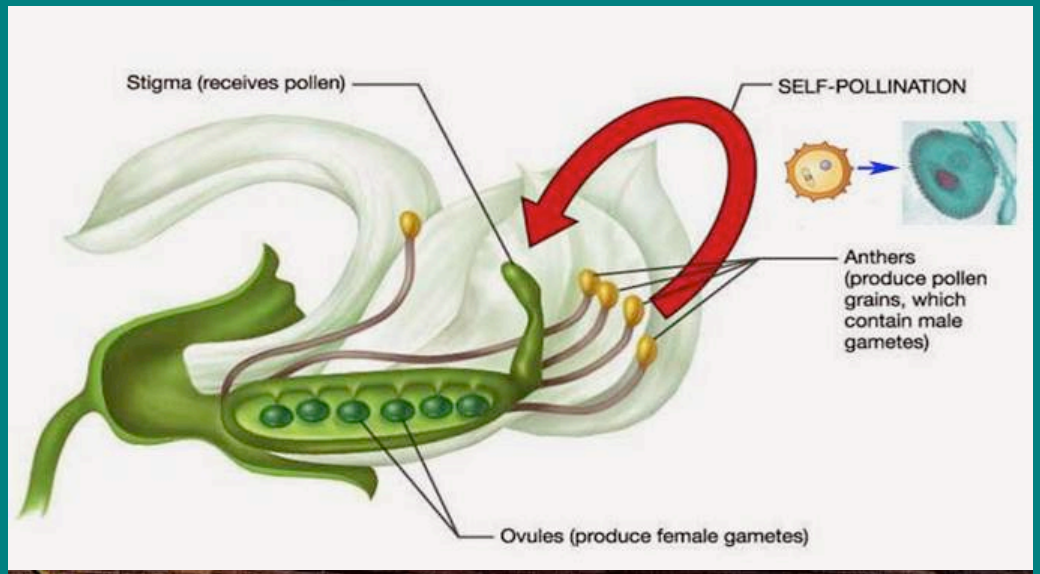
1 carpel = 1 pistil

This gynoecium is monocarpic (one carpel)

The Flower

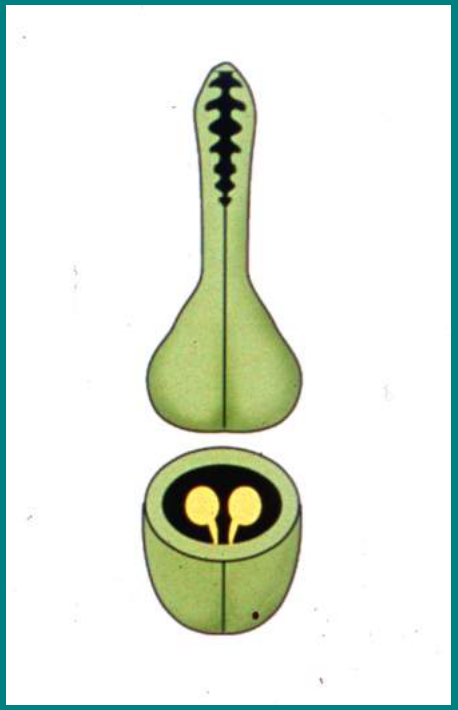
When pistil = carpel

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

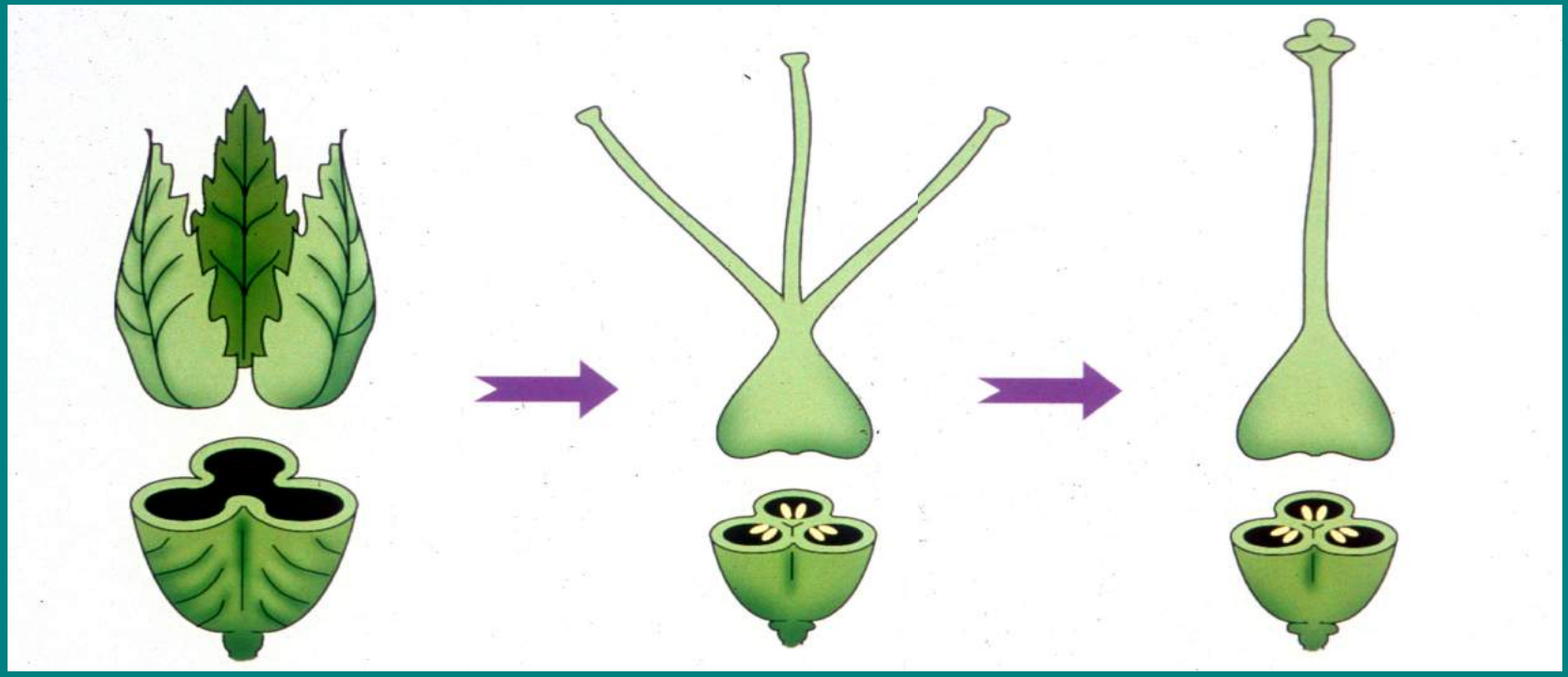
- then the flower has 6 carpels and 6 pistils,

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

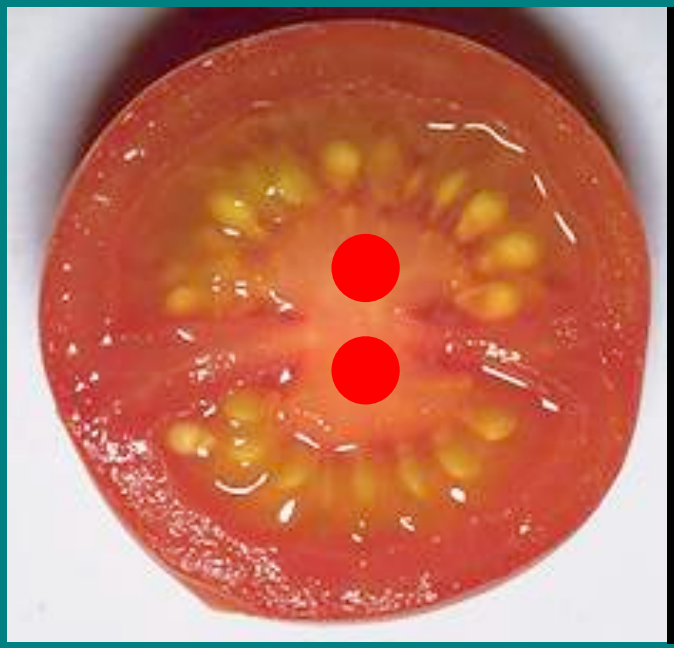
starfruit – 5 carpels

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

The Flower

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



tomato – 2 carpels

passion fruit– 3 carpels

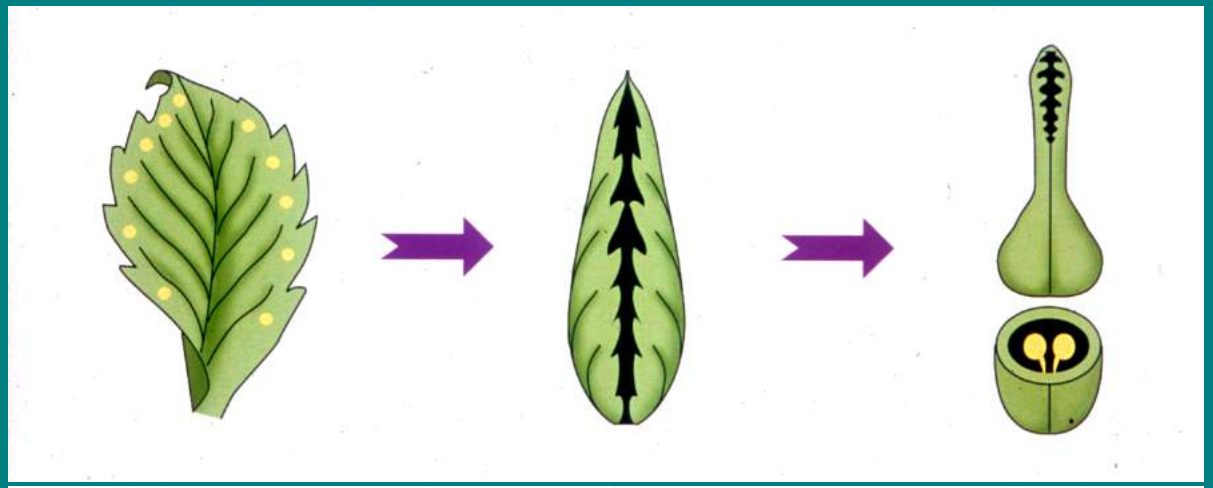
starfruit – 5 carpels

● = placenta tissue

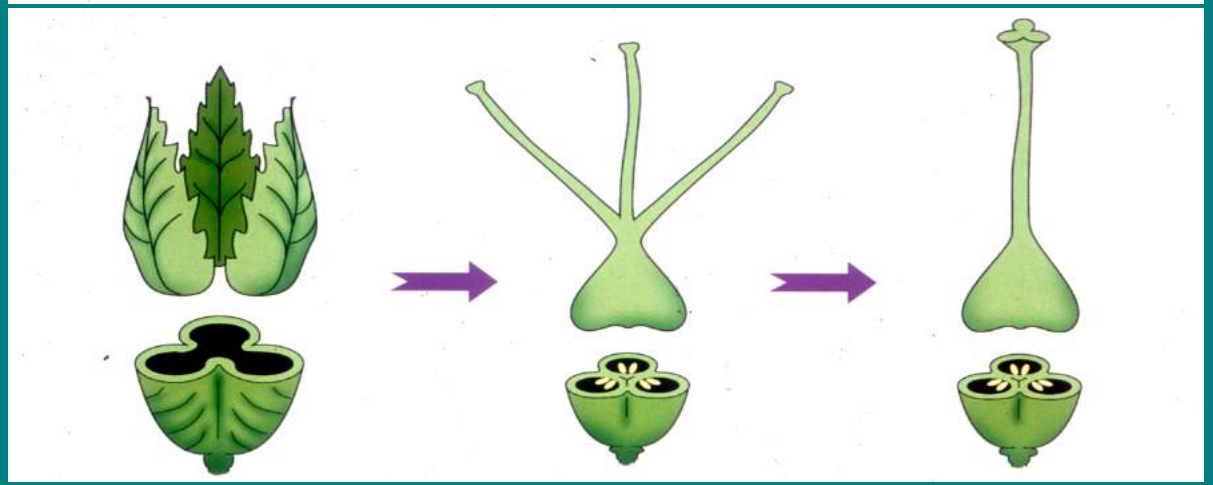
• number of fused carpels is often clear in a cross section of the fruit

The Flower

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



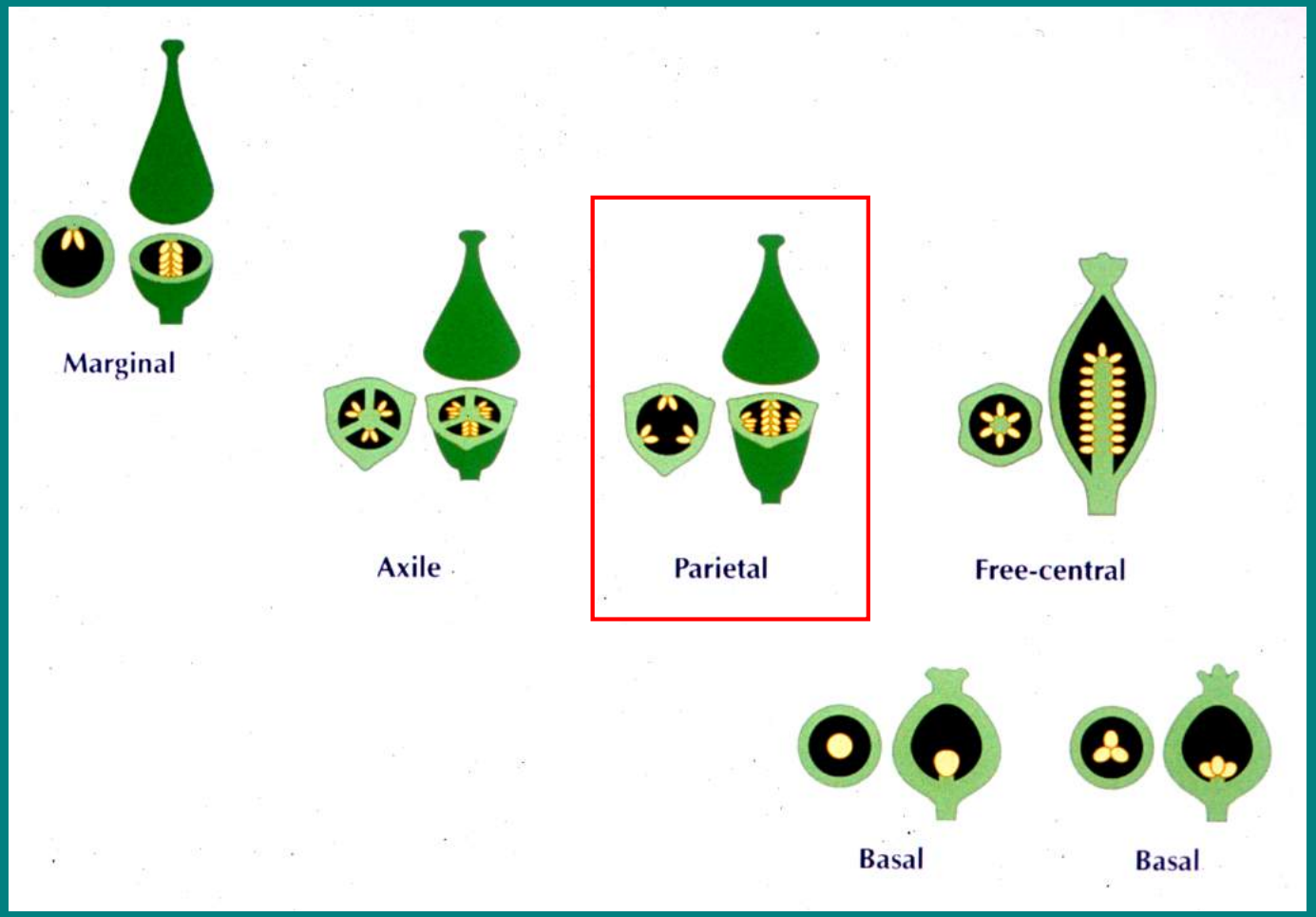
Marginal - found in almost all monocarpic or apocarpic pistils



Axile - found in some syncarpic pistils

The Flower

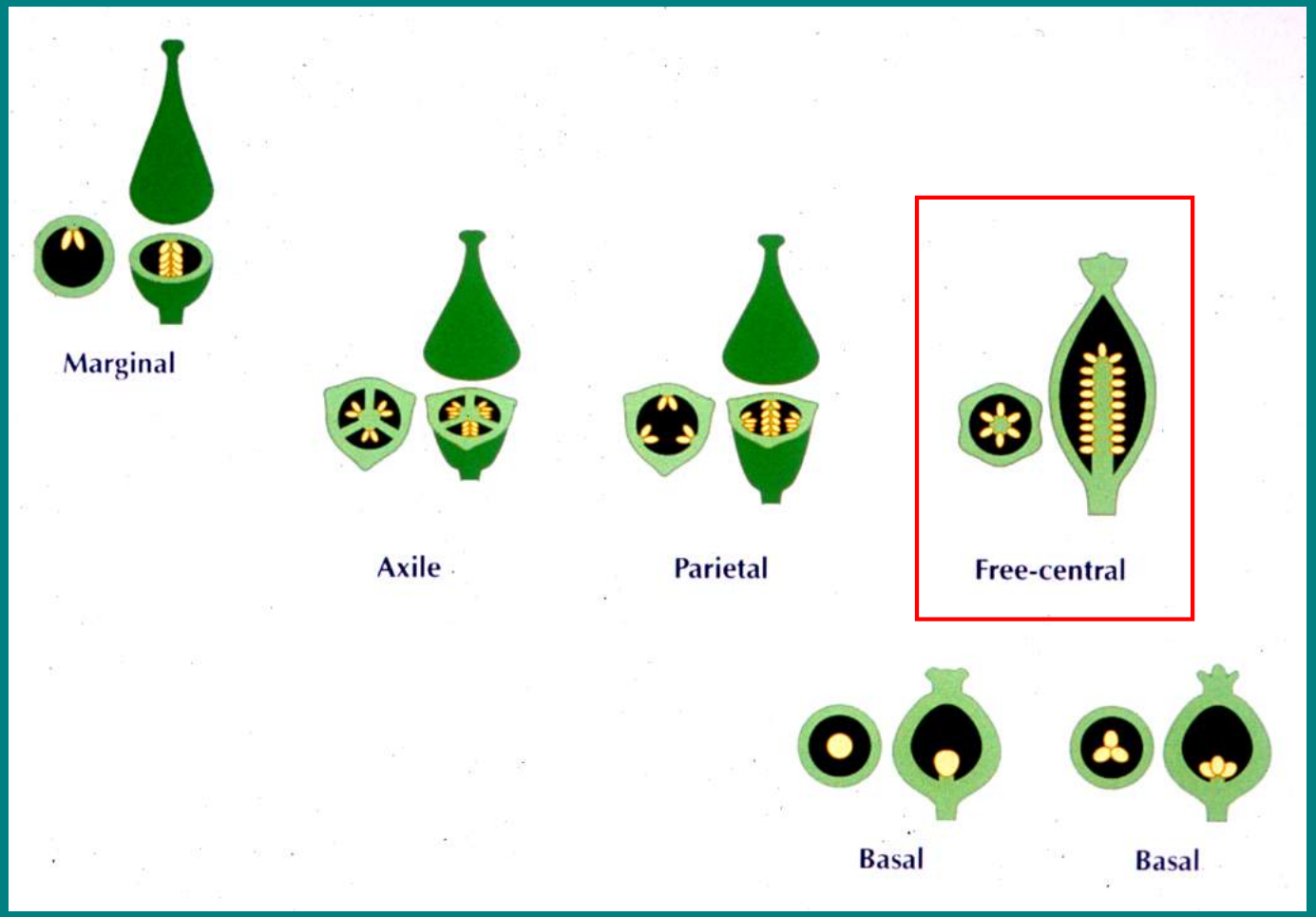
Placentation types - arrangement of ovules, provides hints to the number of carpels



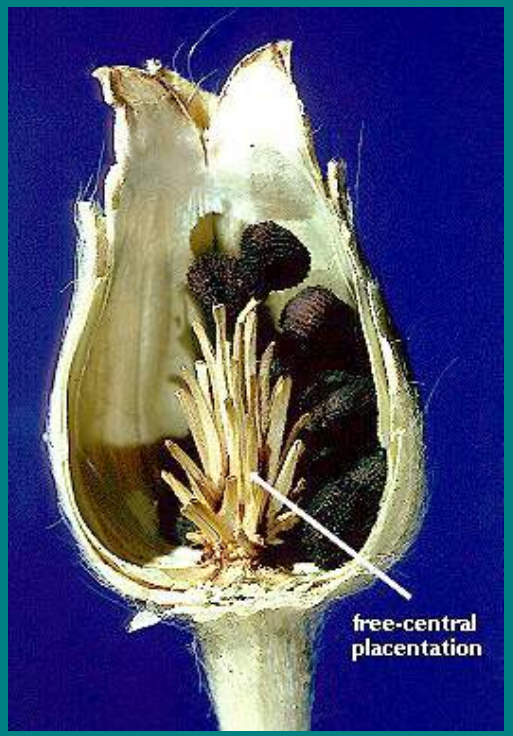
Parietal - found in some syncarpic pistils

The Flower

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

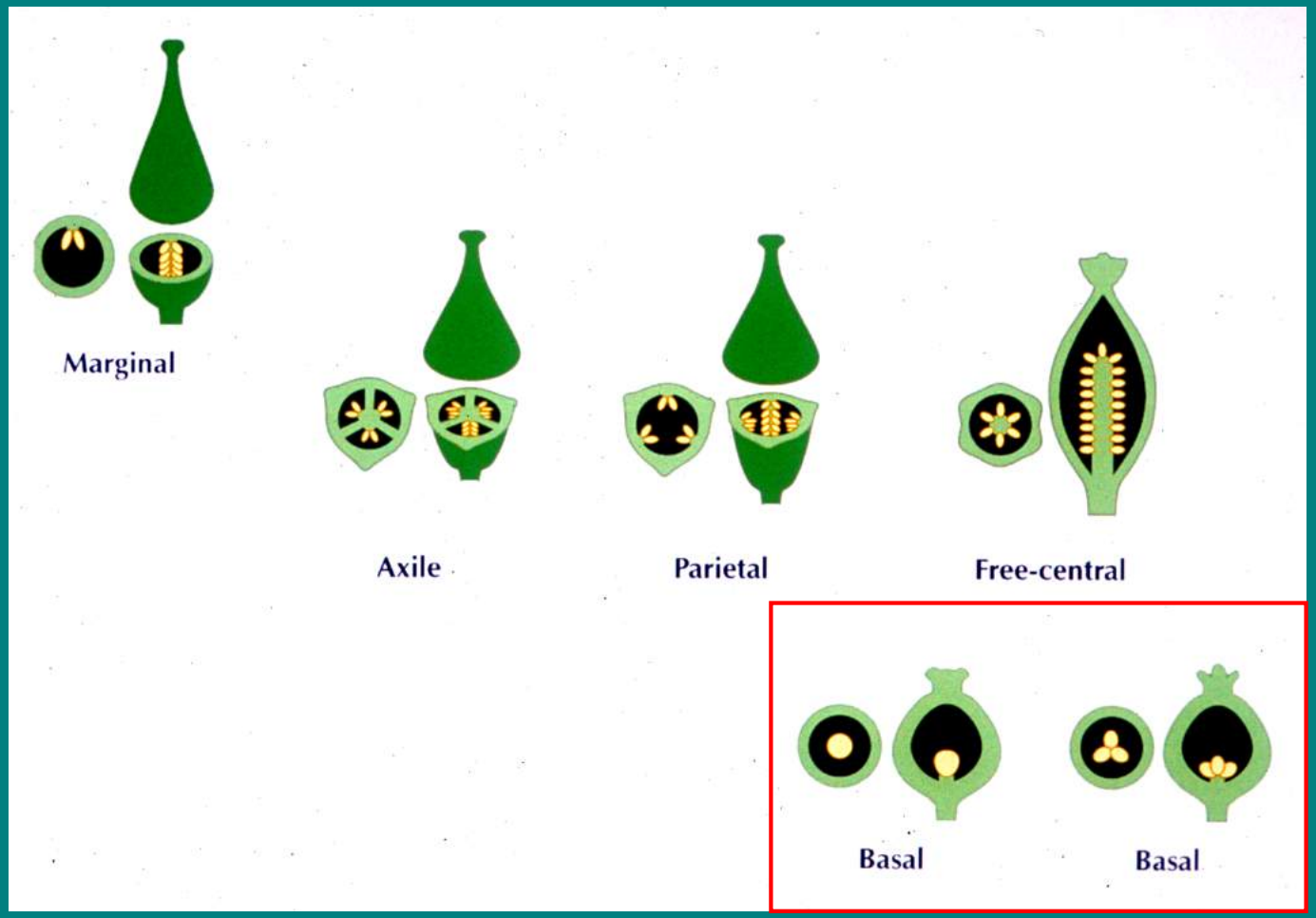


Free-central - found in a few syncarpic pistils



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

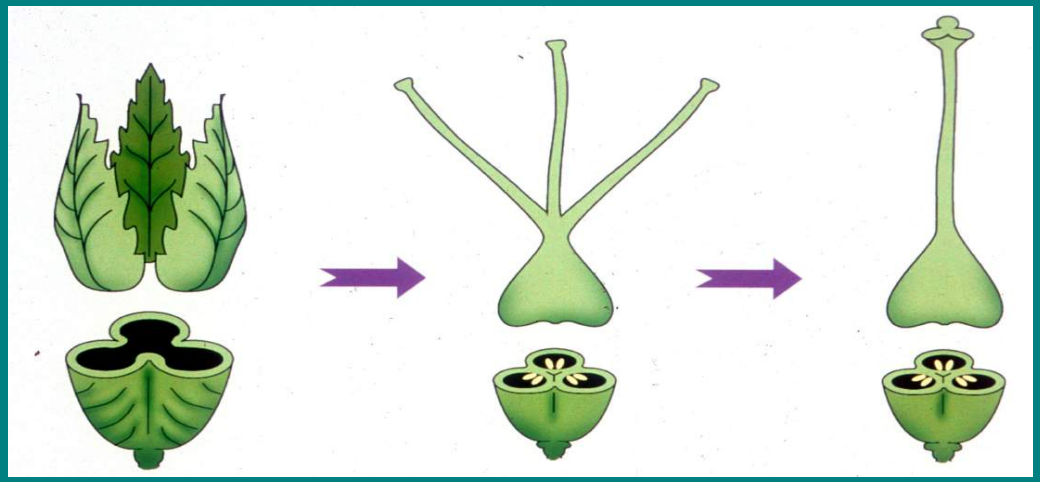
Flowers radially symmetrical

Flowers actinomorphic

Flowers bilaterally symmetrical

Flowers zygomorphic

The Flower



Fusion of carpels → Syncarpic pistil

Connation: fusion of floral parts from the same whorl

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

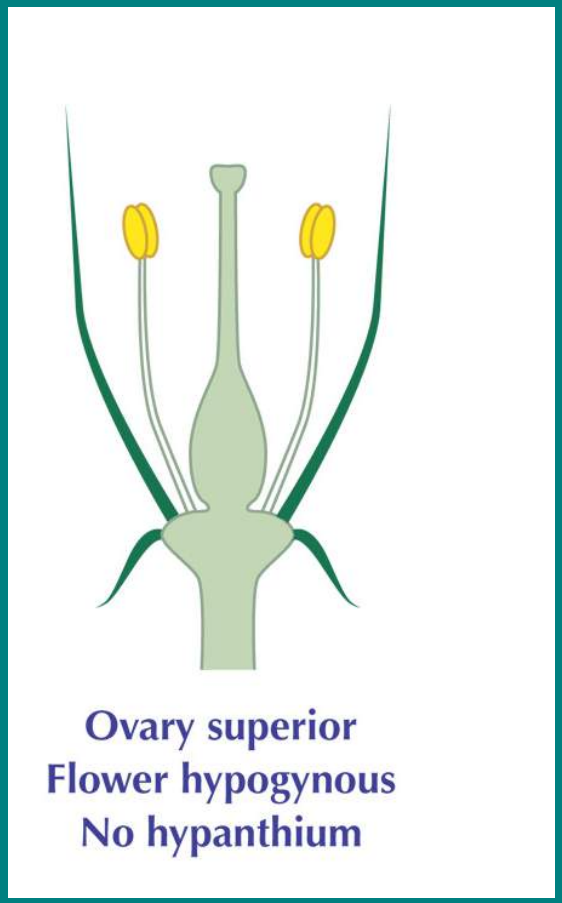
- Complex adnation

Sepals, petals, and stamens fuse to form a hypanthium

The Flower

Adnation: fusion of floral parts from different whorls

e.g., Drimys & sandwort



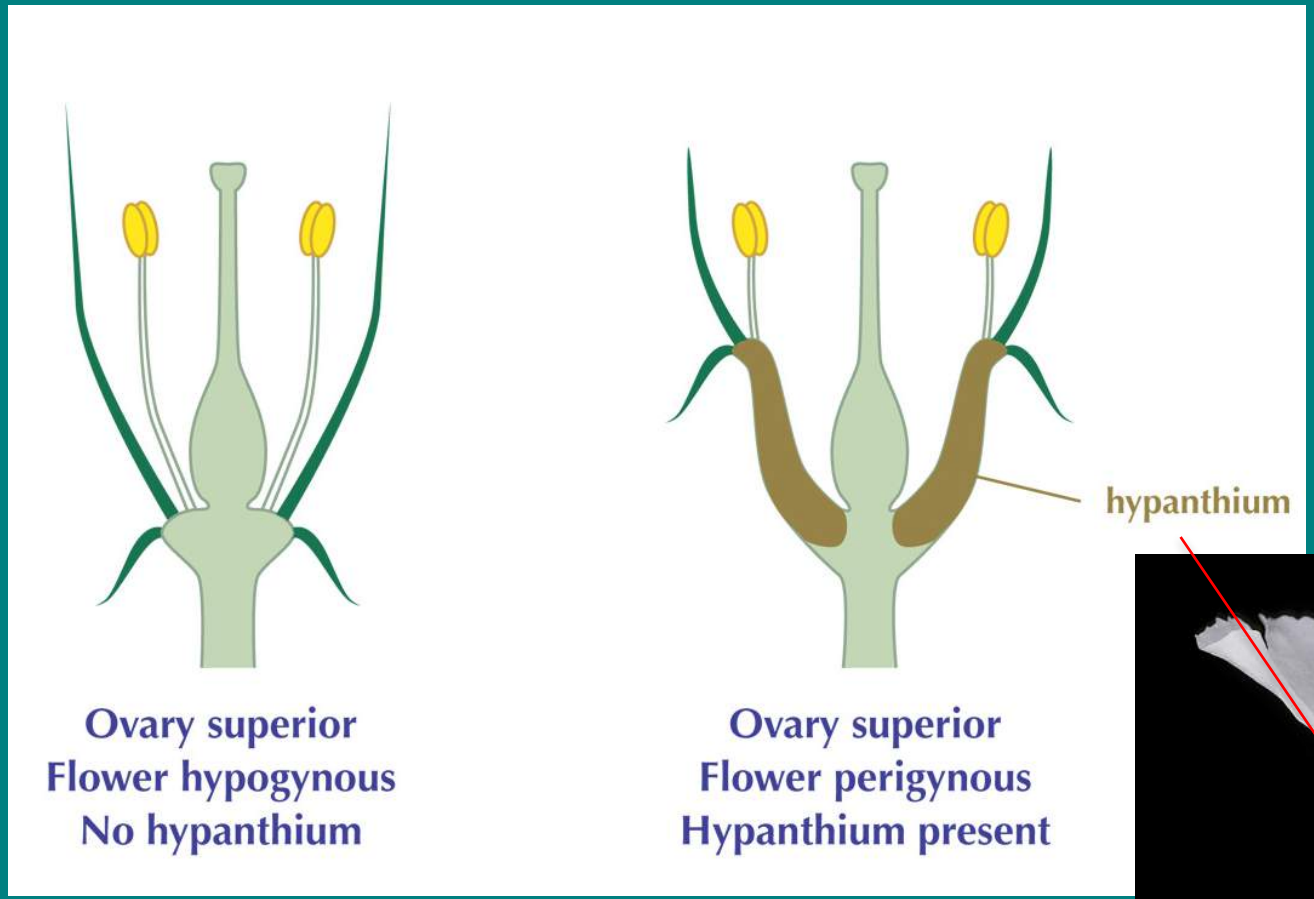
No adnation!

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

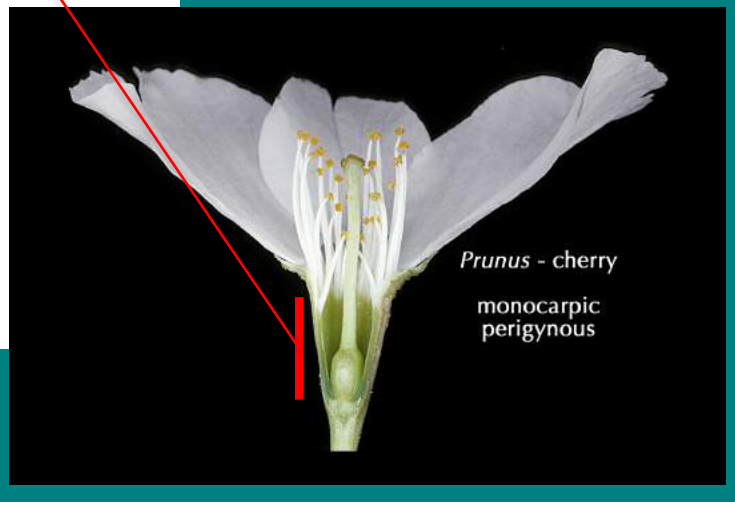
The Flower

e.g., cherry & rose

Adnation: fusion of floral parts from different whorls



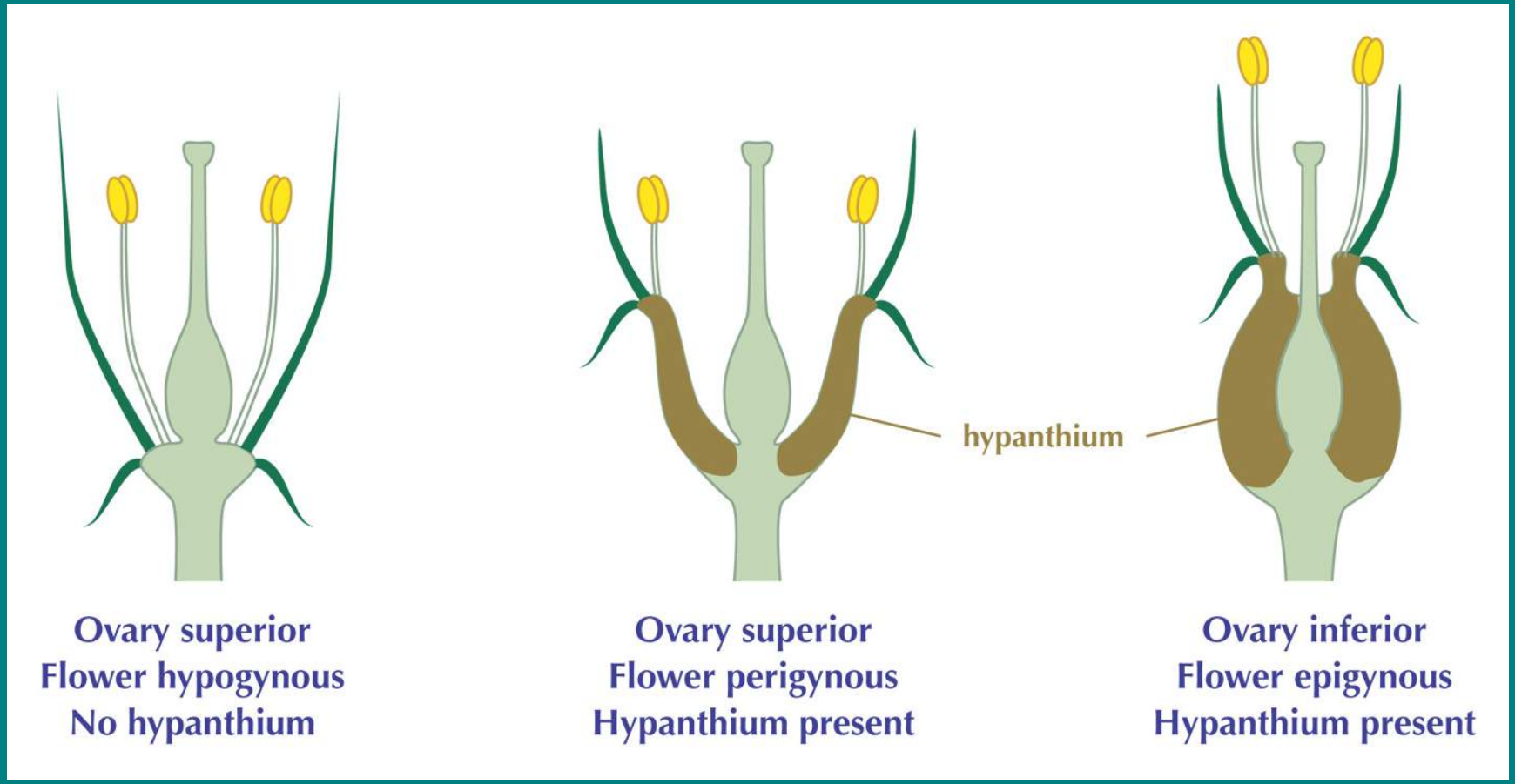
Adnation of calyx, corolla, & stamens = hypanthium



The Flower

e.g., feverwort, honeysuckle, apple

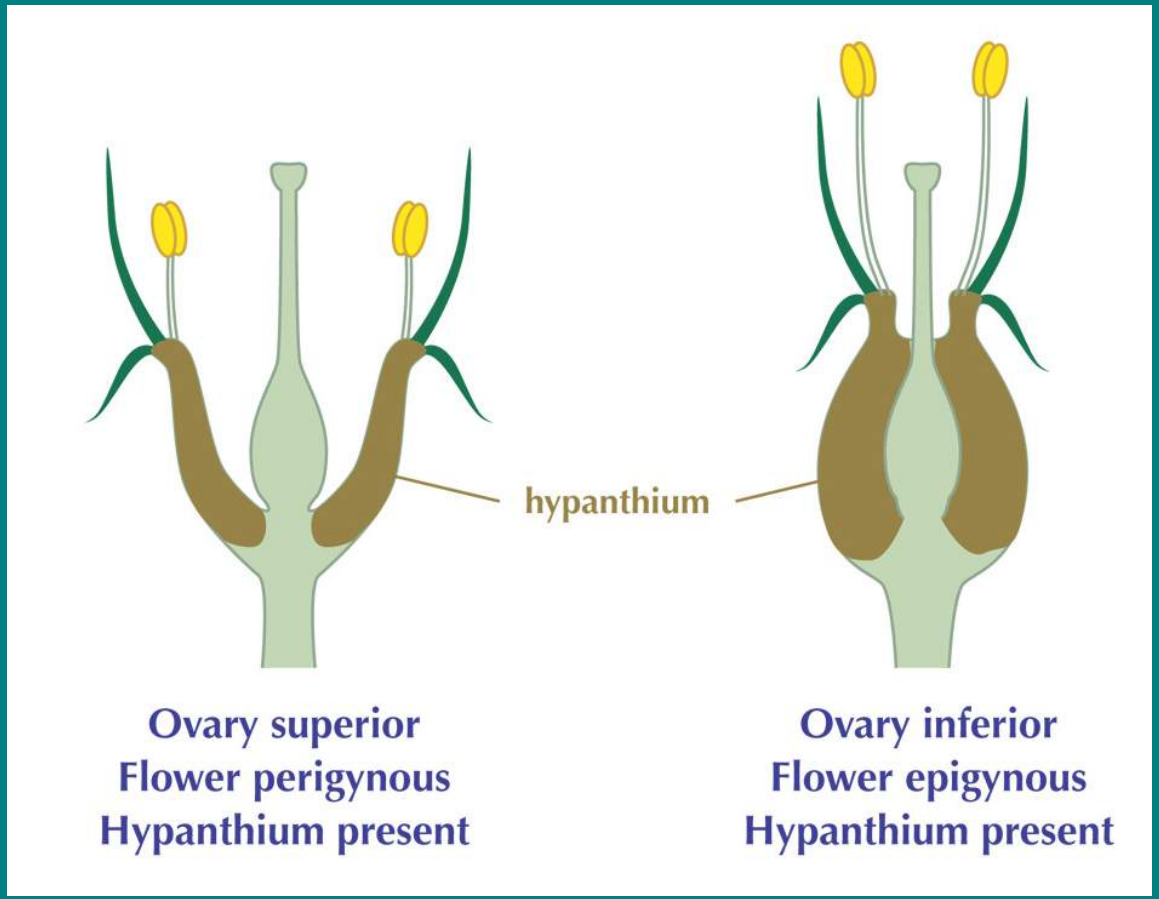
Adnation: fusion of floral parts from different whorls



The Flower

e.g., feverwort, honeysuckle, apple

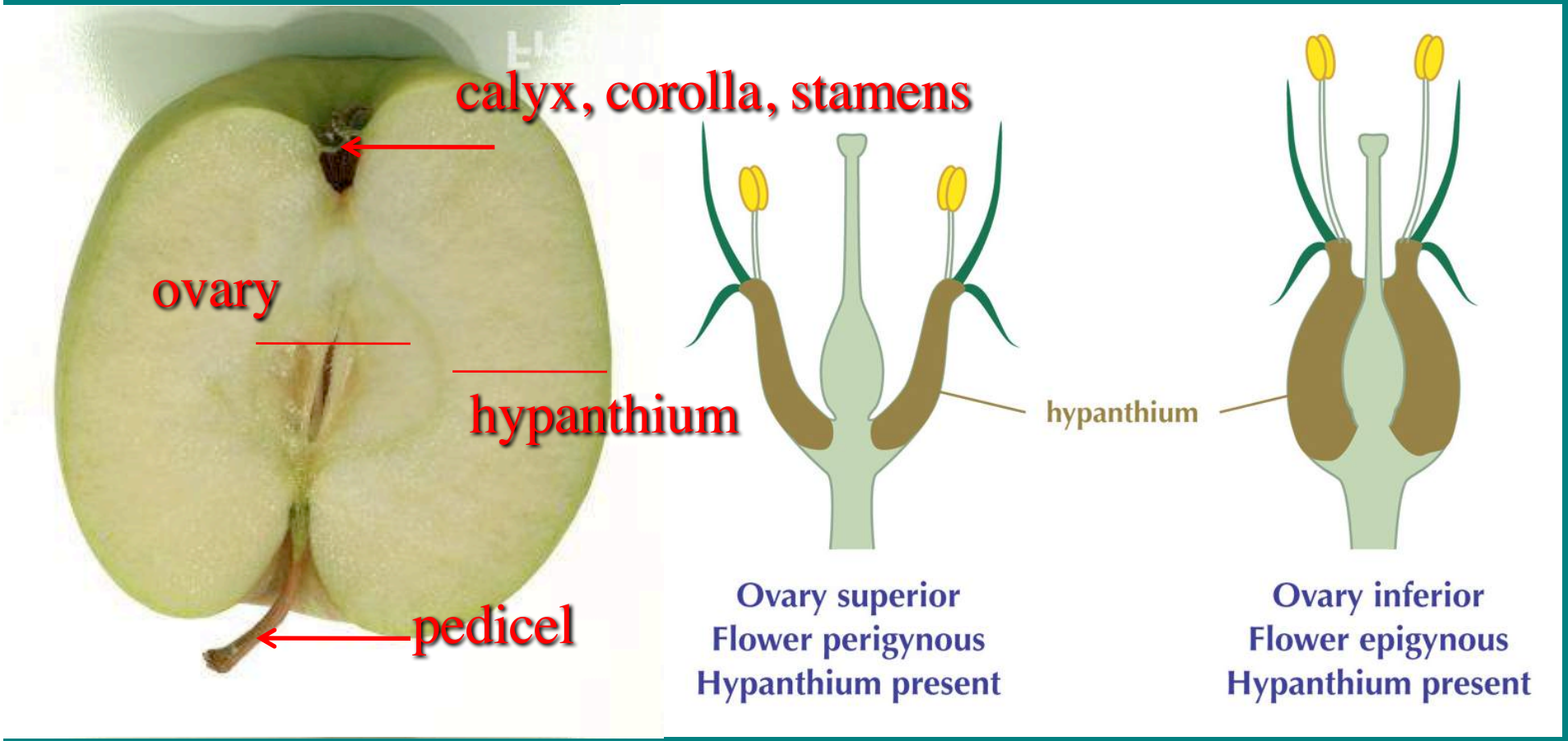
Adnation: fusion of floral parts from different whorls



The Flower

e.g., feverwort, honeysuckle, apple

Adnation: fusion of floral parts from different whorls



The Flower

Floral formula - shorthand notation

CA^4 CO^4 A^8 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

$CA^{4}\ CO^{4}\ A^{8}\ G^{(4)}$

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

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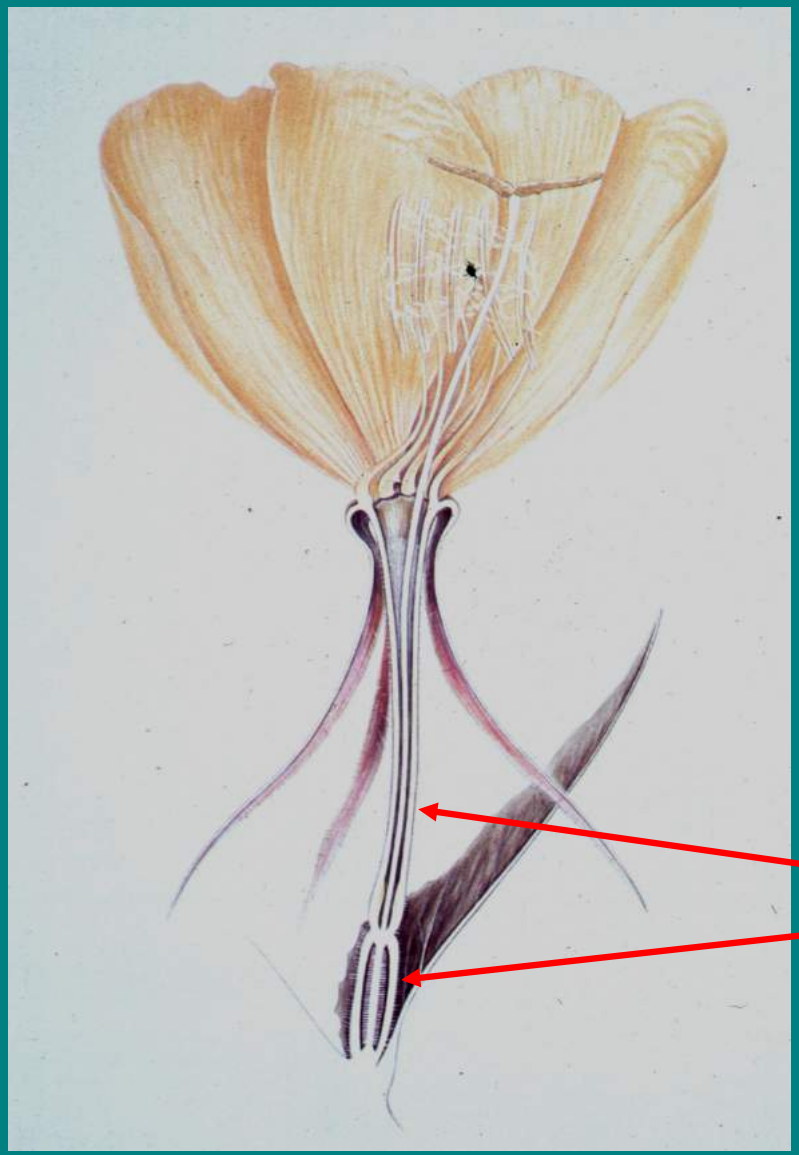
4 petals (**CO**rolla)
8 stamens (**A**ndroecium)
4 carpels (**G**ynoecium)

Carpels fused = 1 pistil

- Ovary inferior

Oenothera biennis
Evening primrose
Onagraceae

The Flower



Floral formula - shorthand notation

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

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)