# HEMUA

**Higher Education Modernization to boost Uzbekistan Agricultural system and promote excellence and regional development**

ERASMUS+ GA number 101179517

# VEGETATIVE and REPRODUCTIVE CYCLE

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# Epigeal structures

Visible above-ground portions of plants which, as a whole, form the aerial apparatus of the tree.

Skeleton (permanent aerial organs)

Canopy (ephemeral organs)

# Hypogeum structures

Root system

# VEGETATIVE and PRODUCTIVE CYCLE

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Biannual

Starts with bud differentiation

Finishes with harvest

Divided into phenological phases

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# TIME LINE

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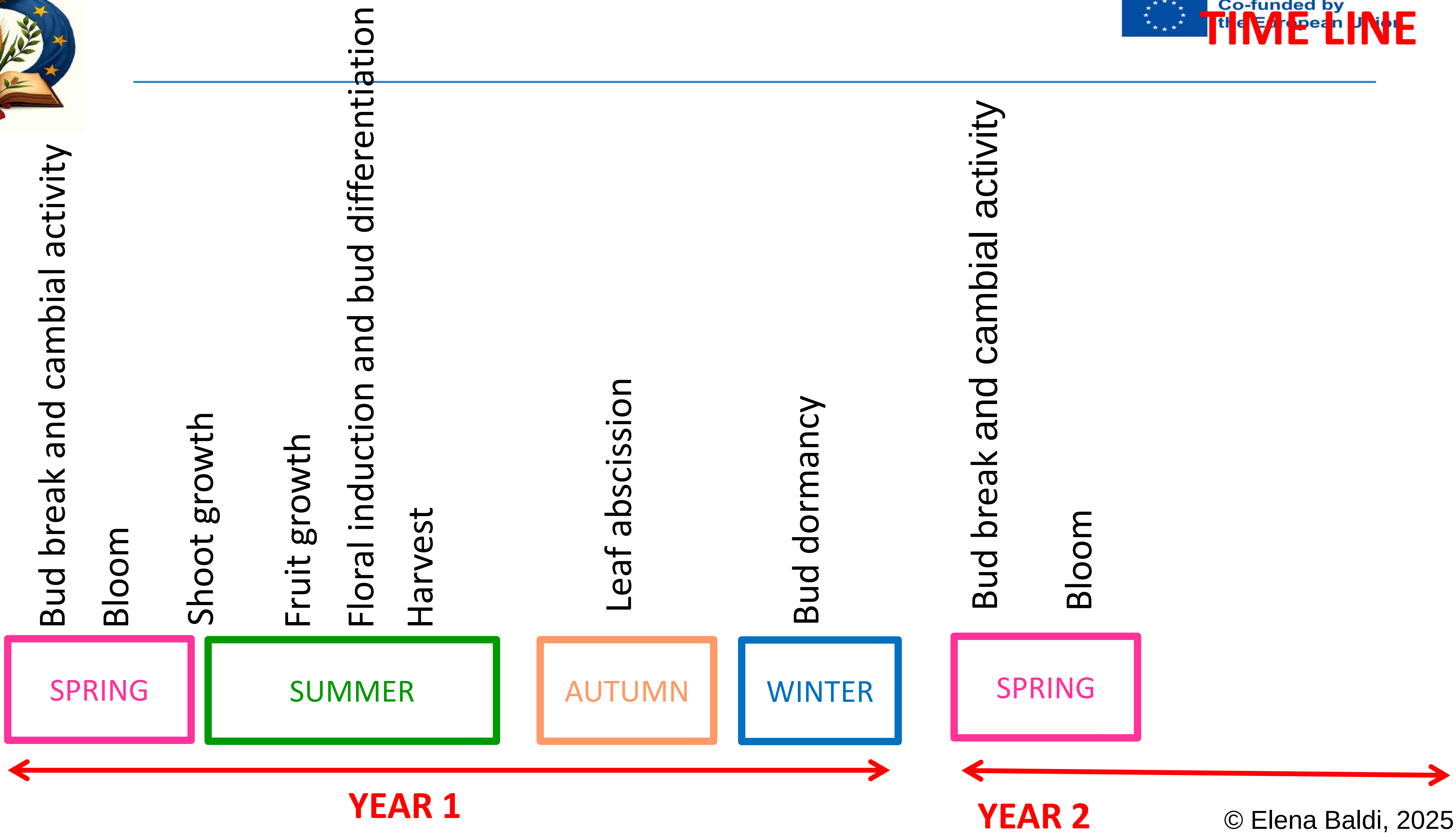

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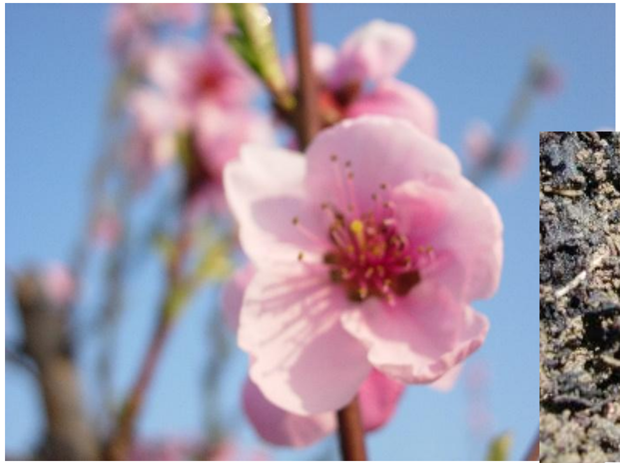


**March – April**

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**April – July**

Shoot growth ends ~ half July


**April – May**

**Fruit growth (May-harvest)**

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October - November

December - February

# APPLE PHENOLOGICAL STAGES

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https://blogs.cornell.edu/jentsch/tree-phenology-dates-and-degree-day-events/

# PEAR PHENOLOGICAL STAGES



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https://blogs.cornell.edu/jentsch/tree-phenology-dates-and-degree-day-events/

# PEACH PHENOLOGICAL STAGES

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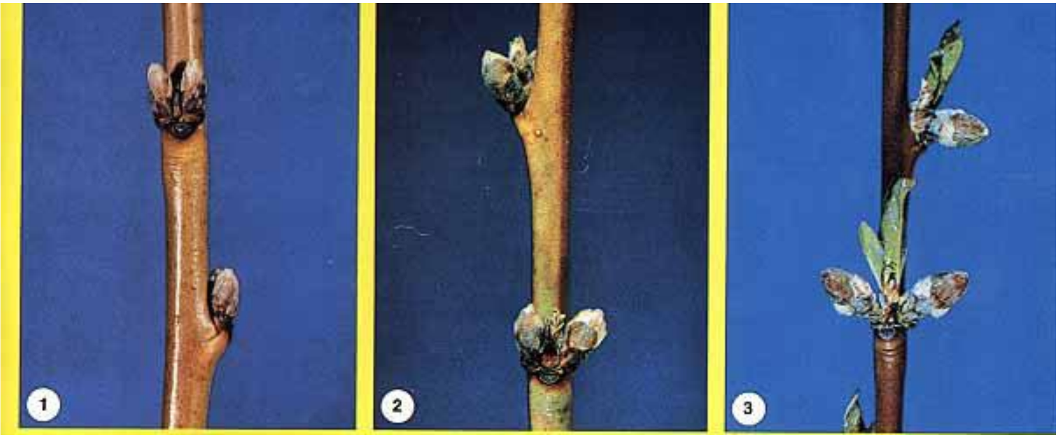
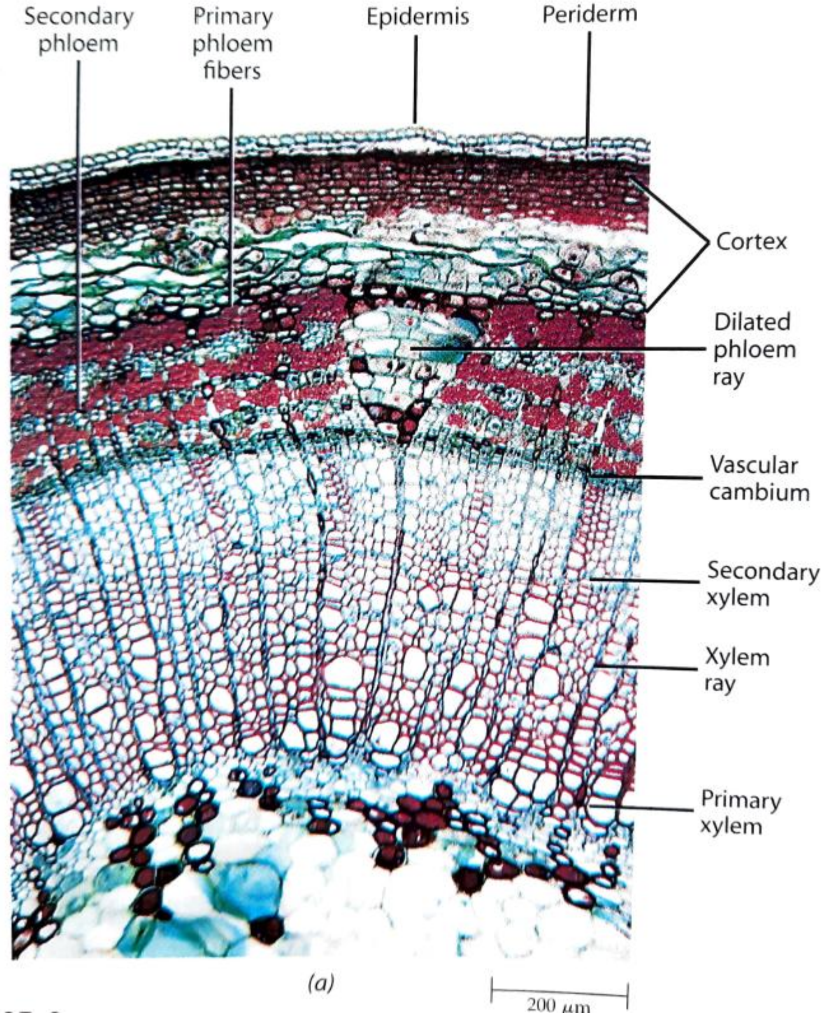




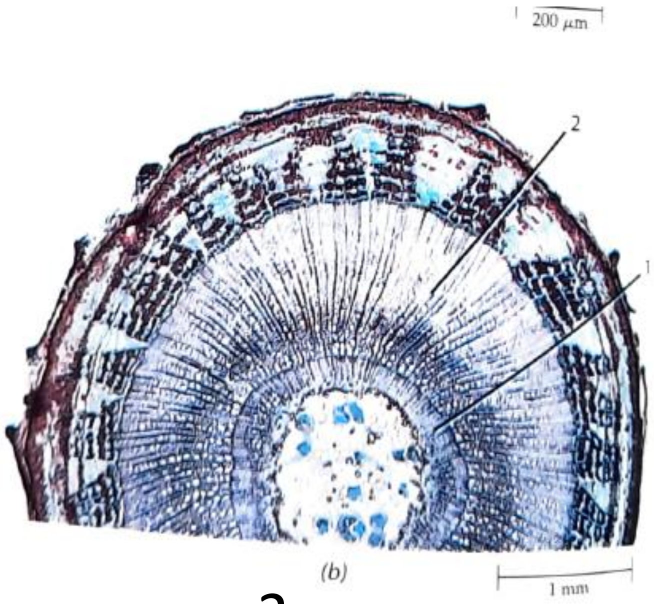

https://blogs.cornell.edu/jentsch/tree-phenology-dates-and-degree-day-events/

# CAMBIAL ACTIVITY

- ✓ Meristematic cells in the cambium start dividing and producing new **phloem** and new **xylem (action of gibberellins/auxin)**
- ✓ Bark easily separates from the trunk
- ✓ Xylem produces larger vessels in spring than in autumn
- ✓ Every year plant produce annual circle

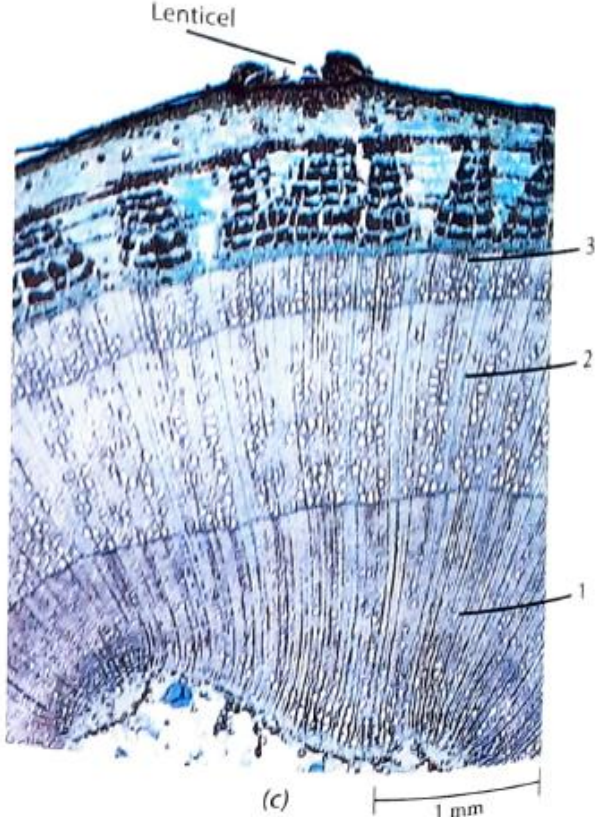



1 year




2 years

3 years




Raven, Evert, Eichhorn Biology of Plants 6th edition

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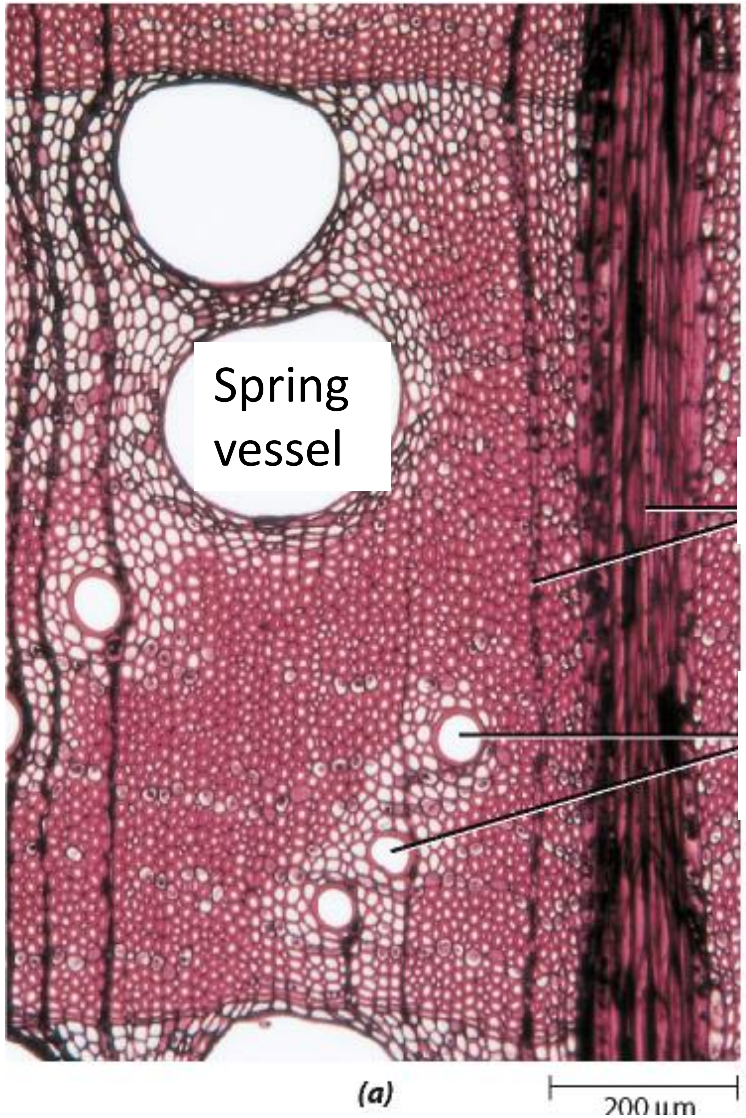
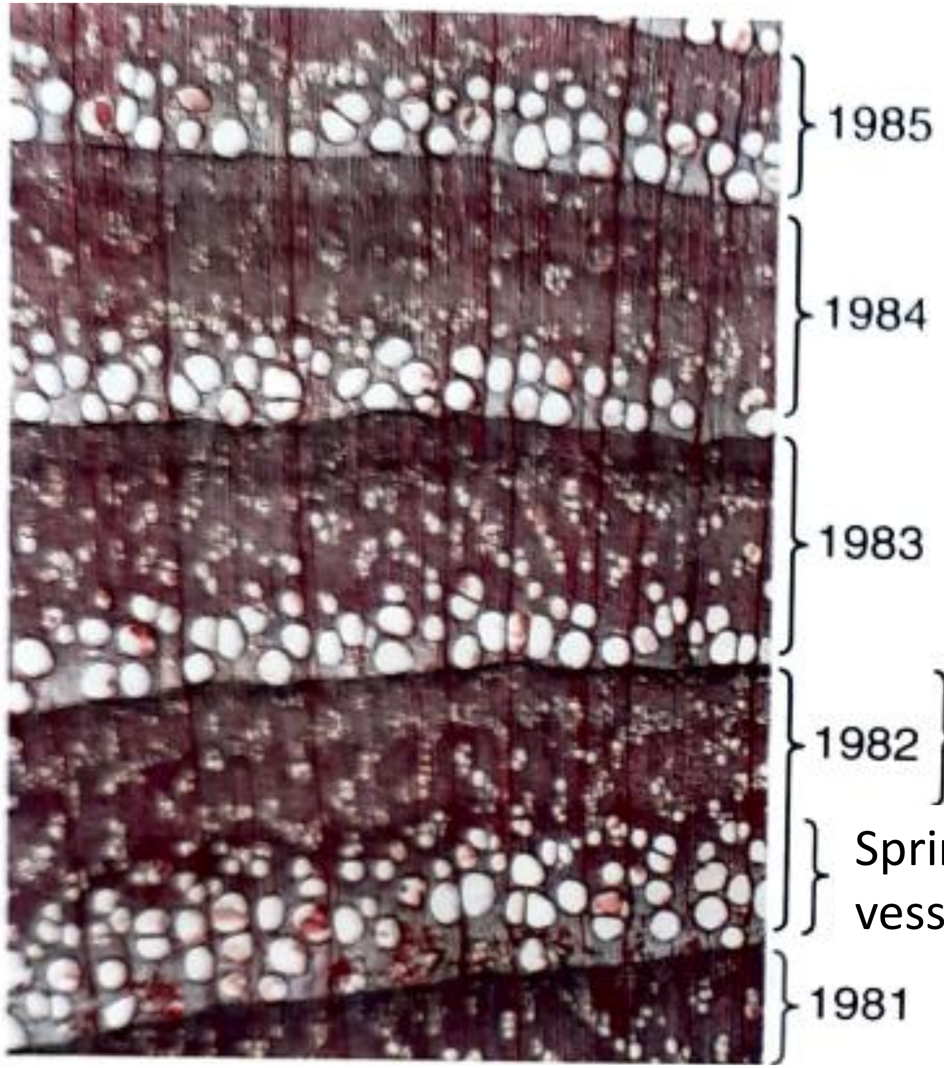
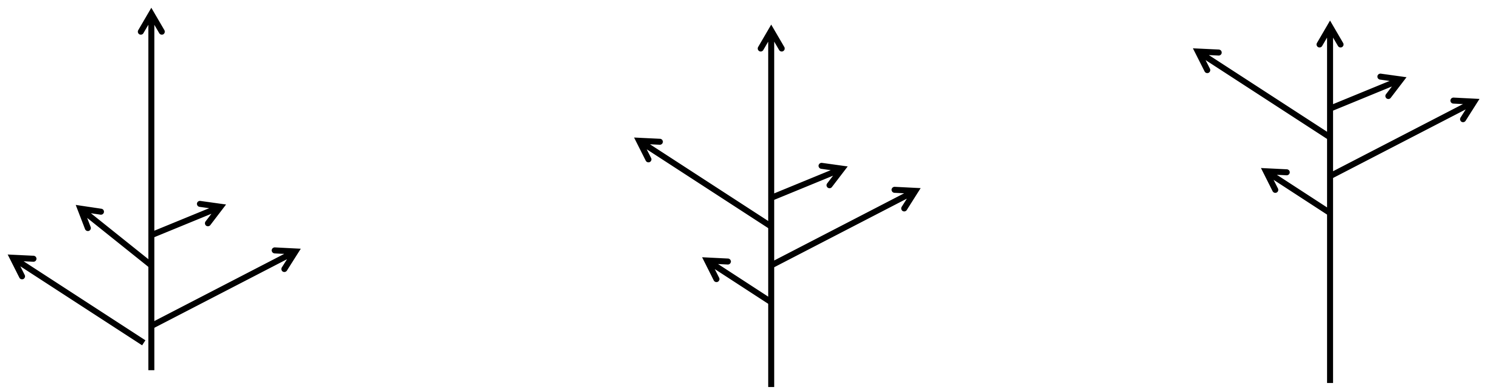


# SPROUTING

- ✓ Starts from apical bud from basal one (**basipetal gradient**)
- ✓ Effect of auxins
- ✓ After first bud break, shoot development depends on vegetative habitus that is different for each species (***acrotonic***, ***mesotonic*** and ***basitonic***)



**ACROTONIC** **MESOTONIC** **BASITONIC**

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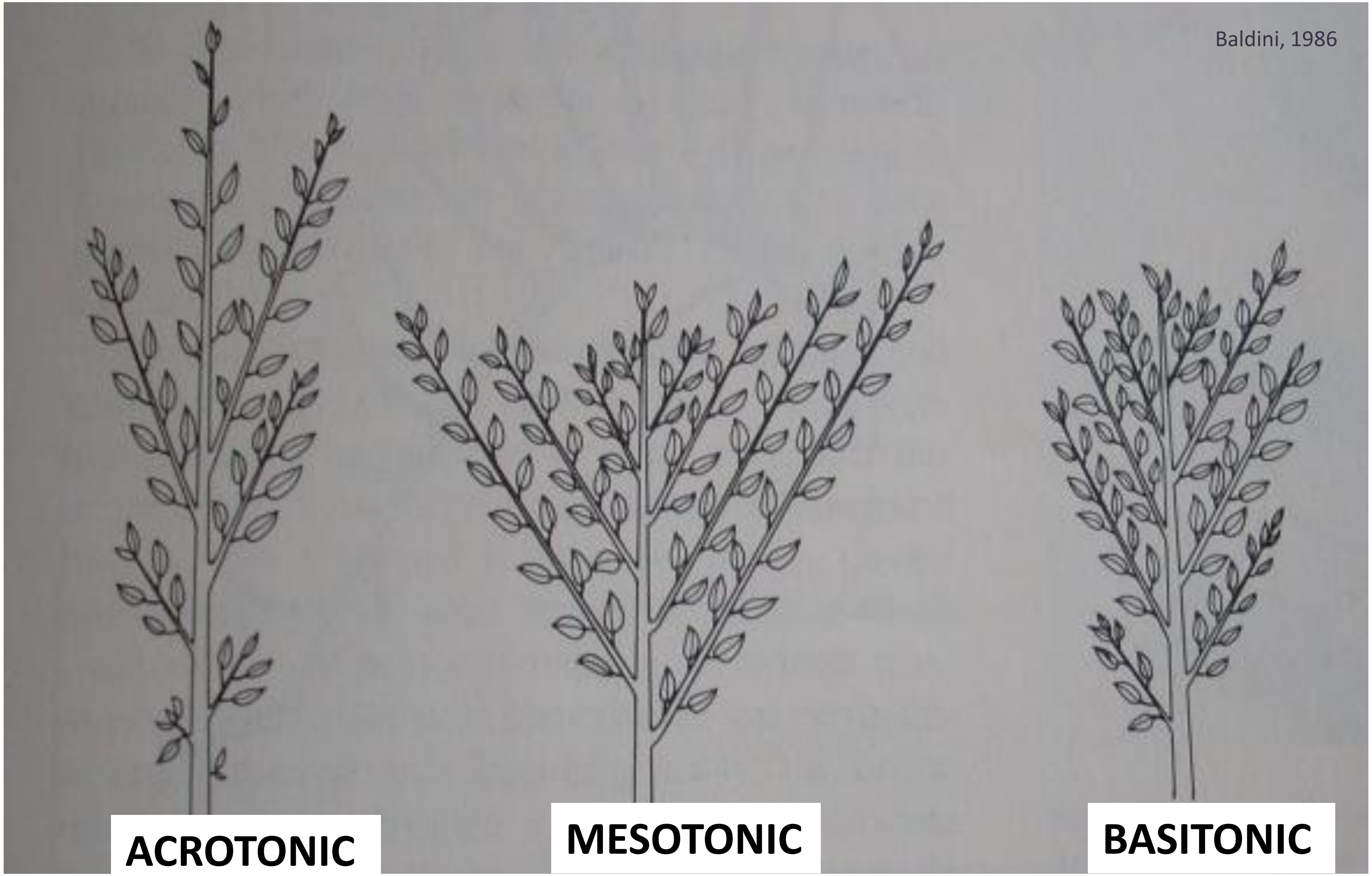
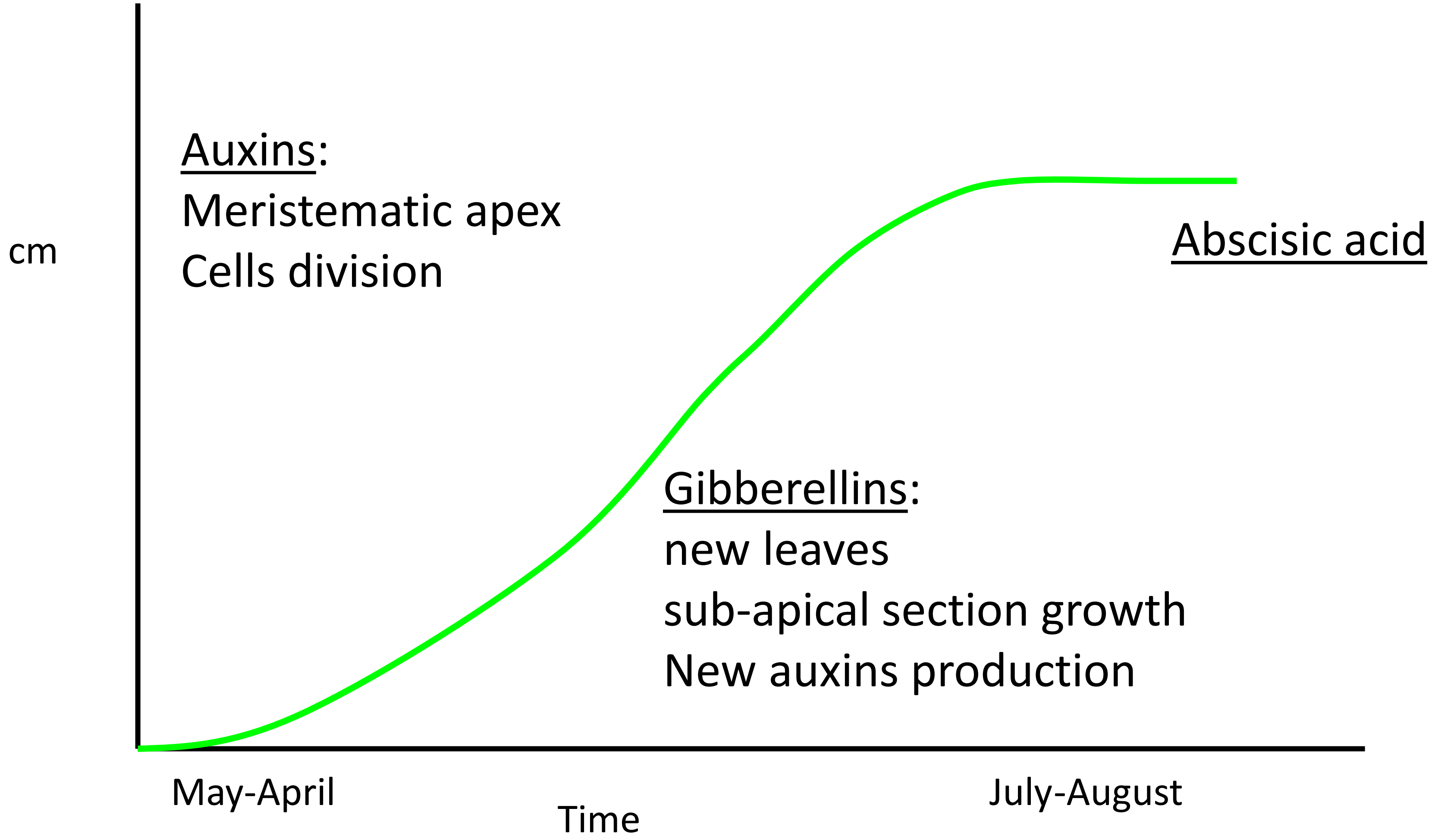


- ✓ First phase of bud burst with reserves
- ✓ Auxin and gibberellins stimulate shoot growth; cytokinin hinder it



# APICAL DOMINANCE (ecto dormancy)

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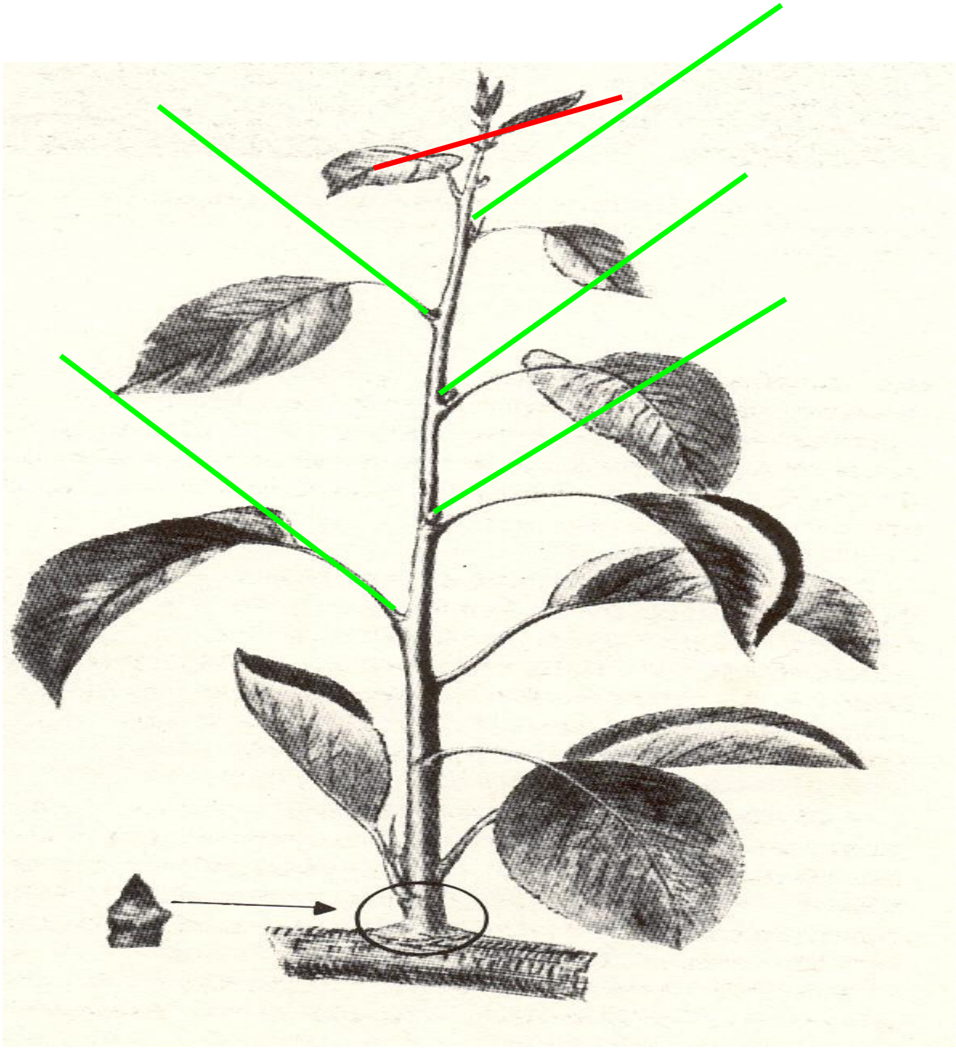


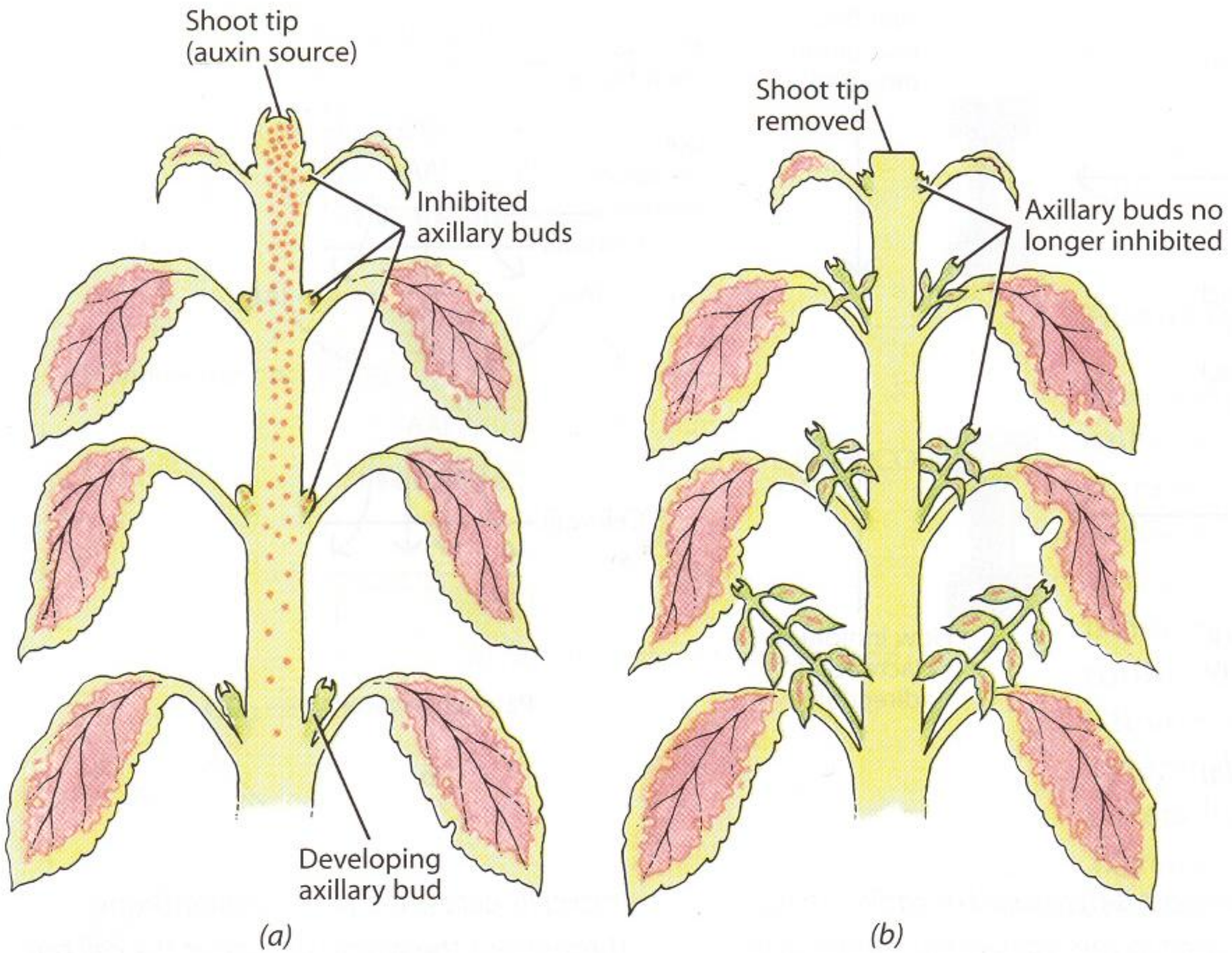
**Auxins** attract carbohydrates

Removal of apical meristem leads to the formation of lateral shoots

**Cytokinin** blocks apical dominance

Peach and grape do not have AP; produce feathers

Baldini, 1986




Raven, Evert, Eichorn, 2003

# FLOWER INDUCTION

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Acquisition of the reproductive potential by the newly formed buds; it is the beginning of the fruiting cycle

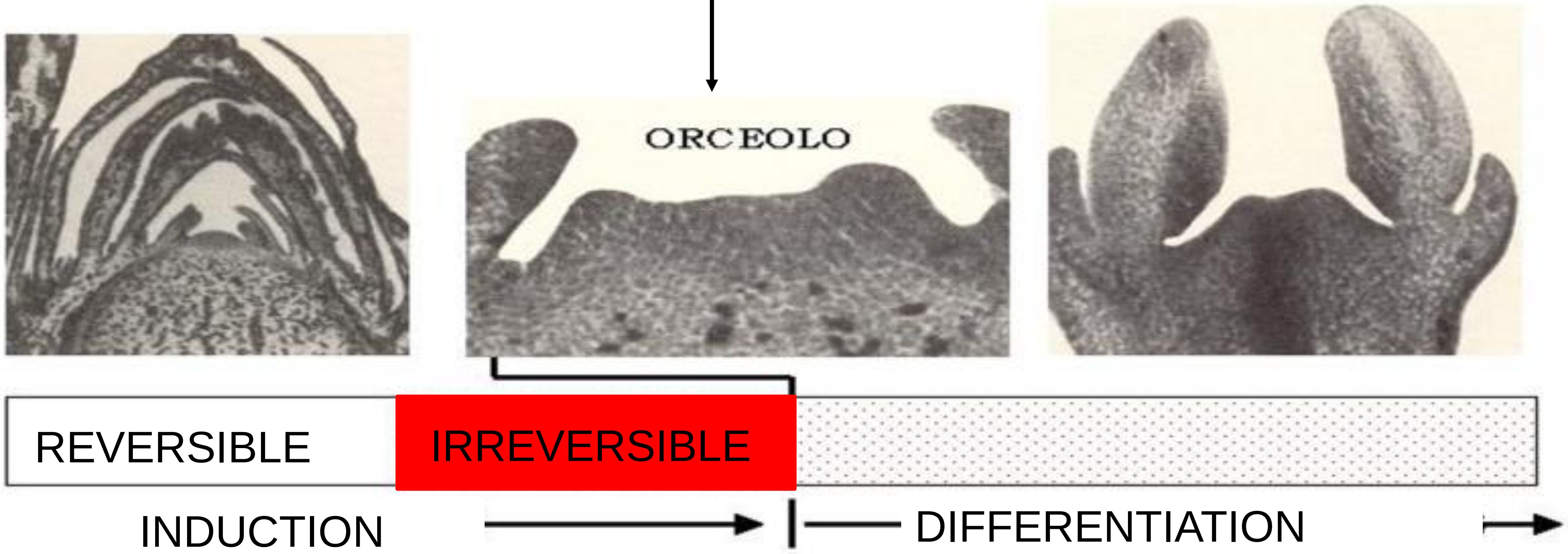
It follows bud differentiation and could also last all winter season

Two separate phases: 1st stage reversible and 2nd stage irreversible

Favourable inductive condition (inside or outside plants) lead to the formation of flower buds.

The programme evolution of the bud ca not be changed.

**Morphological signal** of the transition from vegetative to reproductive bud → enlargement of the meristematic apex (intense mitotic activity in the central apex cells). This lead to the gradual formation of the primordia floral verticils.



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The differentiation process starts in summer, and continues slowly also during winter rest and completes before bloom.

Flower induction is usually placed at the end of intense shoot growth (6-9 weeks after full bloom) and precedes by 4-5 weeks the beginning of morphological differentiation.

# FACTORS INFLUENCING FLORAL INDUCTION





- ✓ Presence of fruits → negative influence due to competition for carbohydrates
- ✓ Light → floral induction is strongly inhibited in the canopy where light is below 30%
- ✓ Presence of leaves → positive
- ✓ Hormones → some (auxins, cytokines, ethylene and polyamine) have positive effect; others (gibberellins negative)
- ✓ C/N → high ration between C and N stimulated the evolution of flower buds; a low induced the formation of vegetative buds

# COMPETITION BETWEEN FRUITS AND SHOOTS

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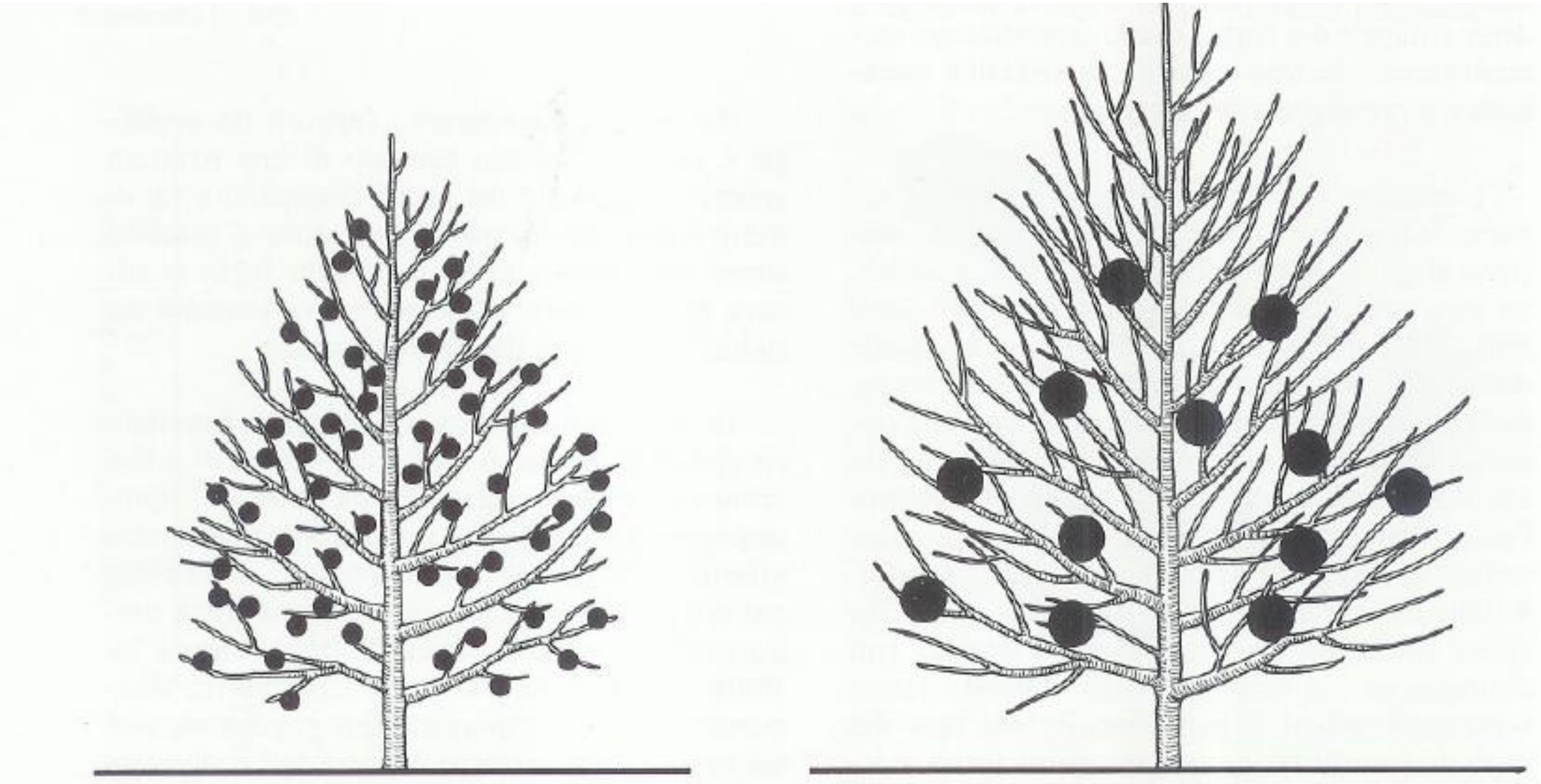
- ✓ Alternate bearing
- ✓ Fruit thinning
- ✓ Alternate years of high yield and low yield



Baldini, 1986

# PHYSIOLOGICAL EQUILIBRIUM

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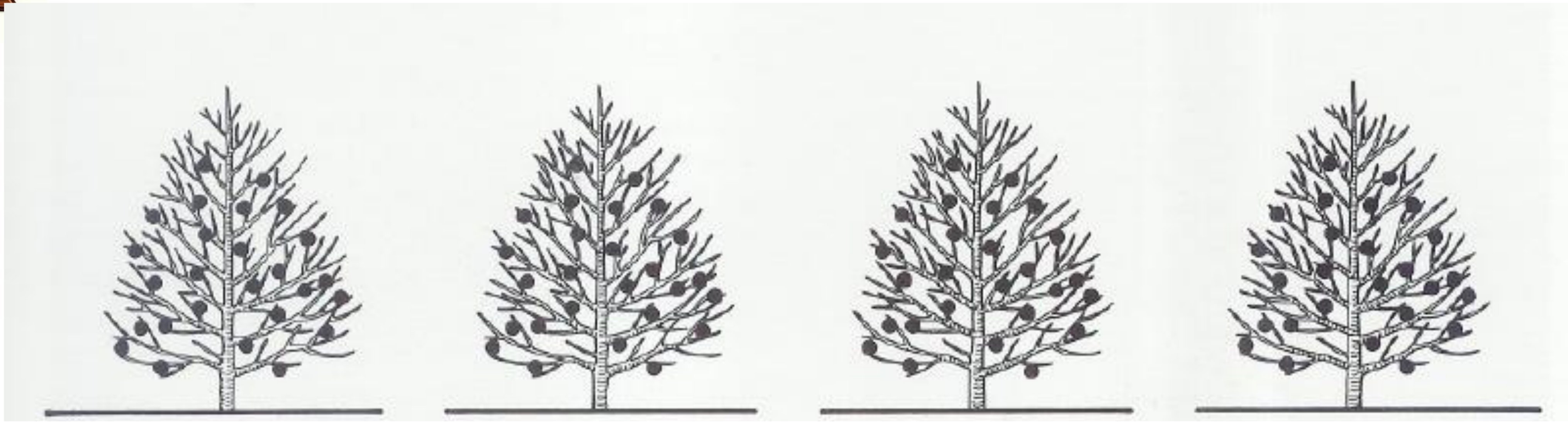
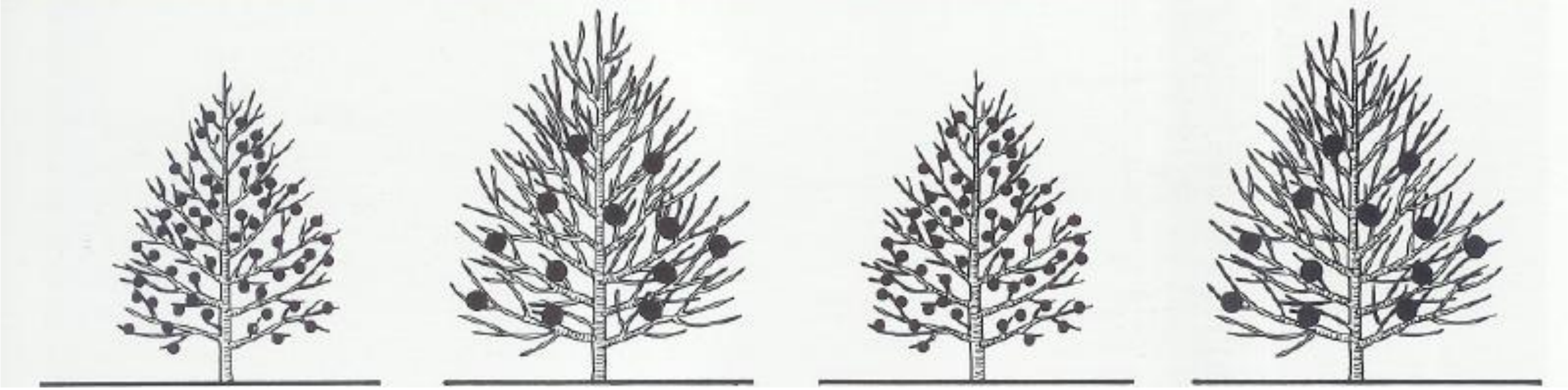


# ALTERNATE BEARING



Baldini, 1986

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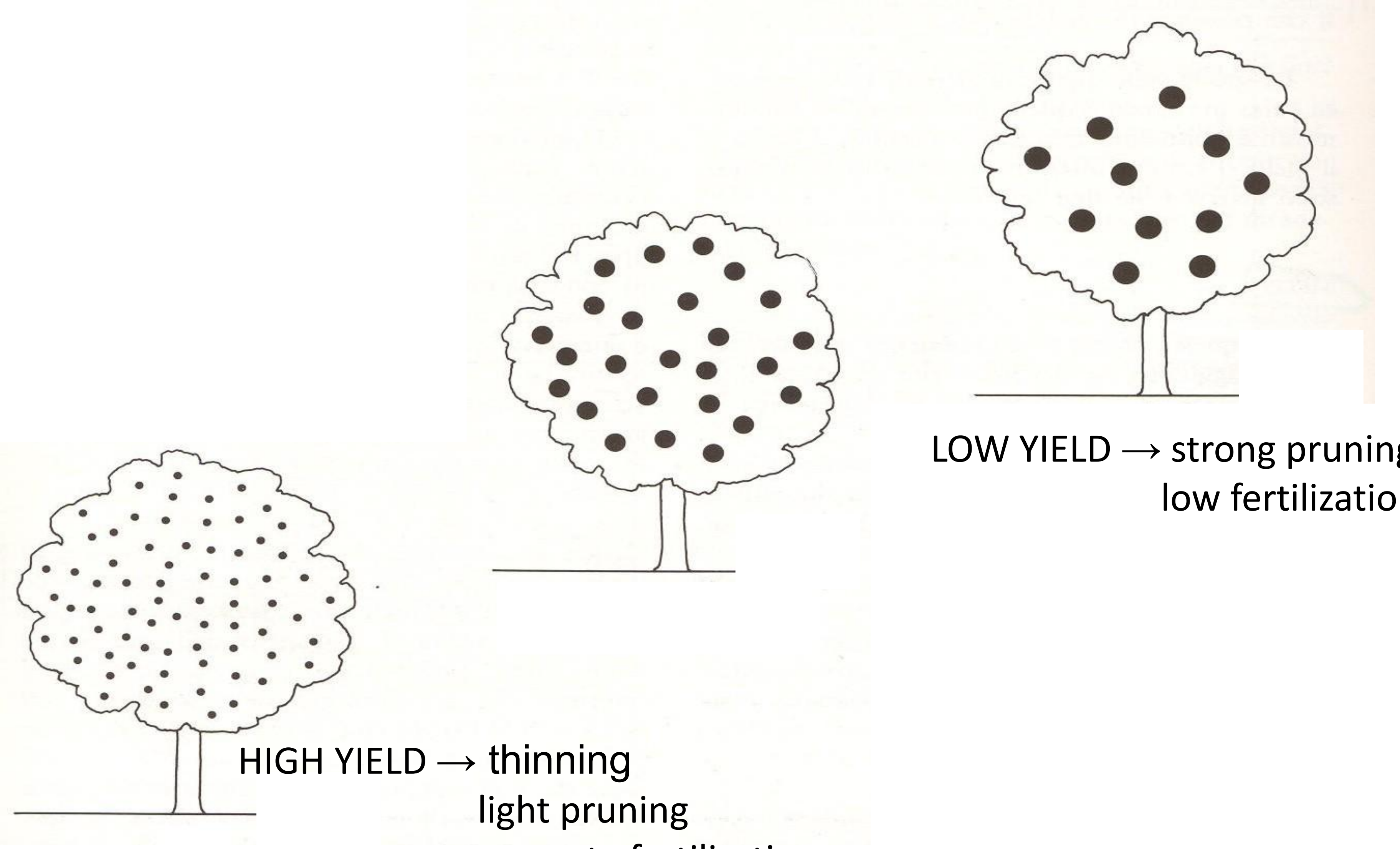

LOW YIELD → strong pruning
low fertilization

HIGH YIELD → thinning
light pruning
accurate fertilization

# THINNING

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- ✓ To reduce alternate bearing and uniformize crop load
- ✓ Can be done controlling **buds**, **flowers** and/or **fruitlet** numbers

Winter pruning (mainly kiwifruit and grape) taking into account plant density, % bud formation and fertility of the orchard.

Chemical on blossom (substances with caustic action, e.g. ammonium thiosulfate); mechanically (Darwing machine), manual https://www.youtube.com/watch?v=kujf7F8PC80

Manual or chemical

MANUAL FRUIT THINNING → requires good expertise to remove the smallest fruitlets and favour the correct distribution on different types of branches (presence of light, distance between fruits, leaves/fruit ratio)

CHEMICAL FRUIT THINNING → use mainly for apples since the success of this approach depends on flower hierarchy within the corymb.

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## Vegetative Growth

### DORMANCY

| | Ecodormancy | Ectodormancy | Endodormancy |
|---|---|---|---|
| | Regulated by ***environmental*** factors | Regulated by ***physiological*** factors outside the affected structure | Regulated by ***physiological*** factors inside the affected structure |
| EXAMPLES | Temperature extremes<br>Nutrient deficiency<br>Water stress | Apical dominance<br>Photoperiodic responses | Chilling responses<br>Photoperiodic responses |

**FIGURE 3.4.** Dormancy: A simple, descriptive terminology applied to regulatory factors and examples of plant dormancy. From Lang et al. (1987) *Hortscience* **22,** 371–377.

Pallardy 2008. Physiology of woody plants

# ENDODORMANCY

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- ✓ Buds have a threshold above which they can sprout
- ✓ The threshold can be overcome with exposure to low temperature
- ✓ Chilling requirements
- ✓ **Chilling unit** → depends on temperature and can be longer than 1 hour if the temperature is not optimal
- ✓ Three models used to define chilling requirements: Utah, dynamic and linear

# LINEAR MODEL

- ✓ Chilling requirement is satisfied in a linear way when temperature is between 0°C and 7°C
- ✓ Outside this range cold is not accumulated
- ✓ This model do not consider the negative effect of high winter temperature
- ✓ It is not clear when calculation for chilling units starts

# UTAH MODEL

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- ✓ Takes into consideration negative effect of high winter temperature
- ✓ Chilling units accumulate between 1.5°C and 12.5°C
- ✓ Outside the range there is no/negative effect

**Table 9.2.** Chill unit (CU) values for 1 h exposure to different temperatures (after Richardson *et al.*, 1974).

| Temperature (°C) | Chill unit value |
|---|---|
| <=1.4 | 0 |
| 1.5–2.4 | 0.5 |
| 2.5–9.1 | 1 |
| 9.2–12.4 | 0.5 |
| 12.5–14.9 | 0 |
| 15–18 | –0.5 |
| >18 | –1 |

***Durner, 2013***

# DYNAMIC MODEL

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- ✓ The degree of dormancy completion depends on the level of certain dormancy factors that accumulated in buds with a **two-step** process
- ✓ Considers chilling portions (CP)
- ✓ Once on CP is satisfied this is irreversibly accumulated
- ✓ 1 CP = 28 hours at + 6°C; if temperature is not efficient (<4 or > 6°C) 1 > 28 h
- ✓ Cold accumulation starts at 75% of leaves abscission

# ECODORMANCY

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- ✓ Imposed by external factors (temperature, light, water availability)
- ✓ Buds, even if have satisfied their chilling units, remain in quiescence
- ✓ When heat units are satisfied bud burst

# Growing degree hours (GDH)
# Growing degree days (GDD)

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- ✓ A single unit of GDH corresponds to one hour at temperature that exceed the thermal threshold by 1 degree at which there is the reactivation of plants metabolic processes (cambial activity, bud break, bud differentiation)
- ✓ The value is = 4.5°C for all species but grape and late-flowering species where the values is 10°C
- ✓ GDH accumulation is linear until 25°C
- ✓ Some more complex models (asymetric curvilinear - ASYMCUR) take into consideration biological effect above 25°C

# Chilling units and GDH of some species

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| Species | Cultivars | CU | GDH |
|---|---|---|---|
| *Apple* | Red Delicious | 1,234 | 6,172 |
| *Apricot* | Tilton | 720 | 3,533 |
| *Cherry* | Bing | 880 | 5,328 |
| *Cherry* | Montmorency | 924 | 5,380 |
| *Peach* | Elberta | 800 | 4,239 |
| *Peach* | Redhaven | 870 | 4,174 |
| *Pear* | Bartlett | 1,210 | 5,044 |
| *Plum* | Italian Prune | 788 | 10,230 |

Sansavini et al. 2019. Principles of modern fruit Sciences

# PLANT HORMONES

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PROMOTORS

**Auxin**: bud burst, cell division and elongation (shoot and root apex, seed and fruits)

**Gibberellin**: revoke bud dormancy, cell elongation (shoot and elongation roots)

**Cytokinin**: revoke bud dormancy, root apex synthesis and translocation to leaves

# PLANT HORMONES

INHIBITORS

**Abscisic acid (ABA)**: bud dormancy, leaves abscission, fruit drop

**Ethilene:** fruit ripening, abiotic and biotic stress (fruits and roots)

| HORMONE | Celle division speed | Cell elongation speed | Direction of cell elongation |
| --- | --- | --- | --- |
| Auxin | + | + | Longitudinal |
| Cytokinin | + | Almost no effect | none |
| Ethylene | + o - | + o - | Lateral |
| Abscisic acid | - | - | None |
| Gibberellin | + | + | Longitudinal |