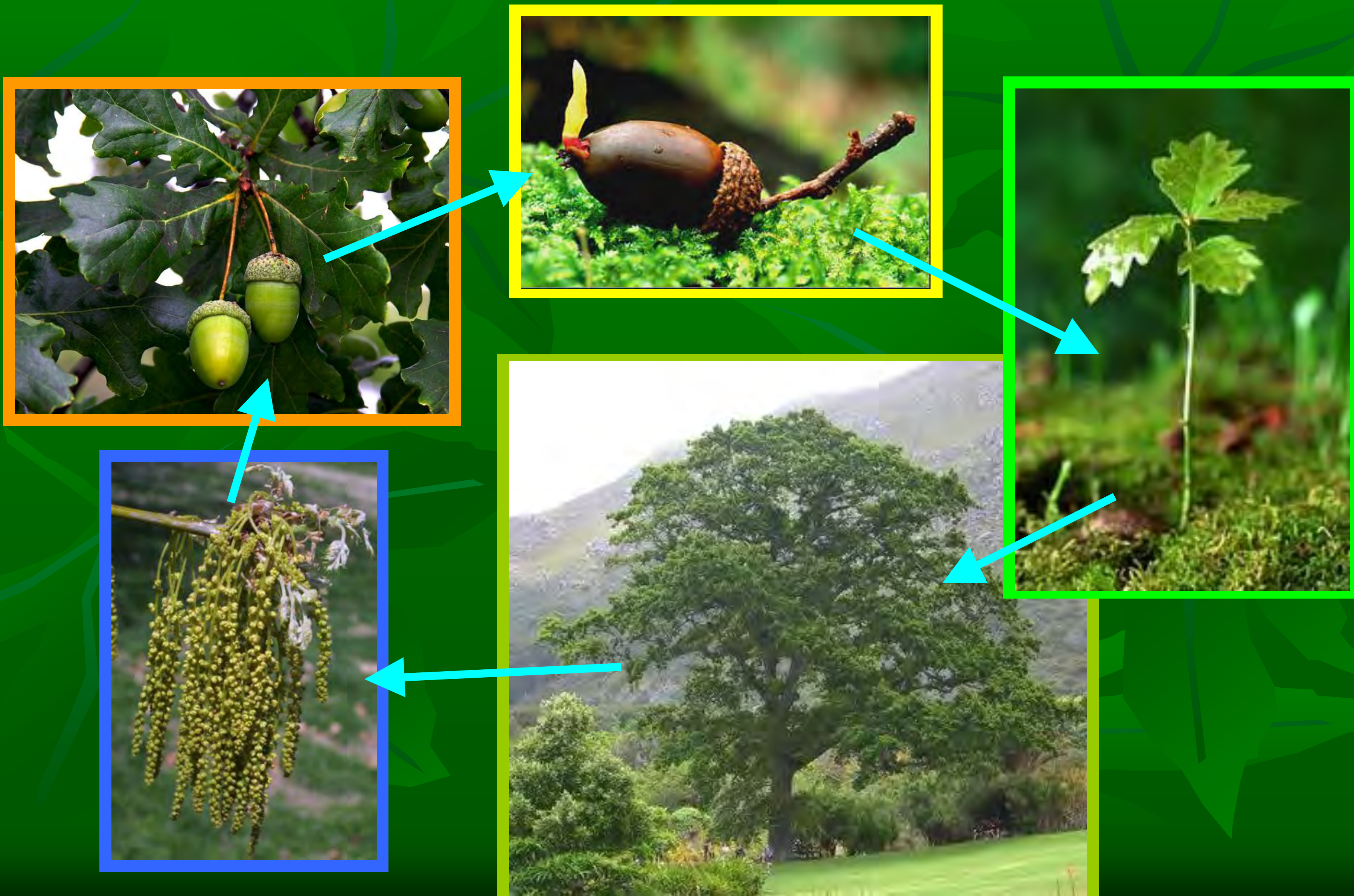
Growth and development of Trees

- Objectives:
- 1. To study the morphological and physiological processes that occur for a temperate deciduous tree during the annual cycle, and the whole life cycle.
- 2. To use this information to make informed management decisions.

Life and Annual Cycle

- Life
  - Germination
  - Juvenility/Maturity
  - Old age
- Annual
  - Dormancy
  - Growth
    - Vegetative
    - Reproductive

Example of Oak Life Cycle



Juvenility

- Plants are non-reproductive for several years, even if given correct environmental conditions
  - Length varies with species (1-45 yrs)
  - Also may have different characteristics:

    a. Leaf shape (lobed vs. not lobed)

    b. Ease of rooting

    c. Stem anatomy (cambial growth)

    d. Presence of thorns (ex. Honey locust)

    e. Production of pigment

Example: English Ivy

Juvenile:
grows along ground
lobed leaves

Mature:
grows upright
leaves are not lobed

Juvenility

- Length of time related to vegetative stature
  - Longer juvenile period generally results in a larger plant
- Transition zone
  - Zone between juvenile and adult tissue
- Rejuvenation
  - Cut back and let re-grow

Juvenile and Adult Tissues can be grafted together

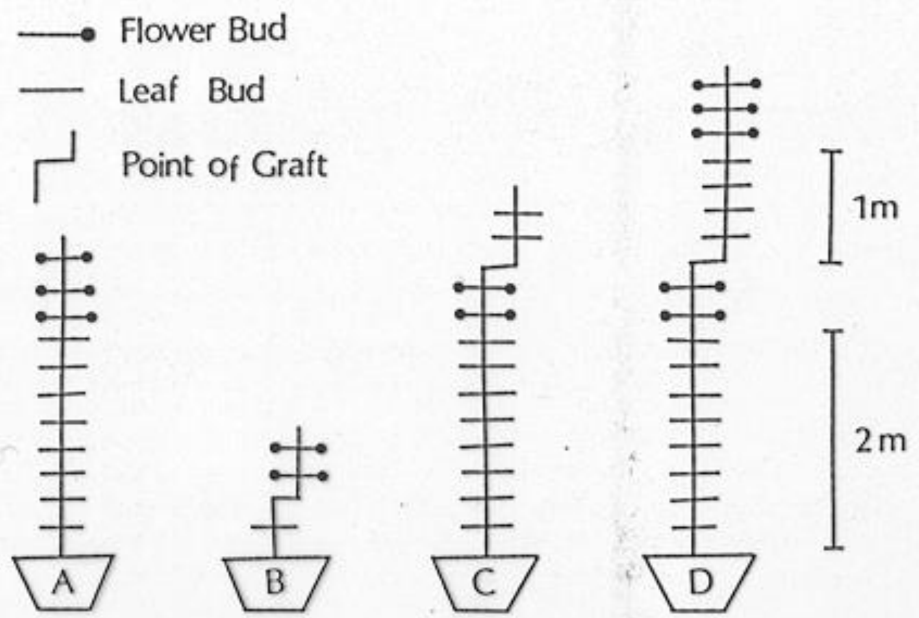


Figure 4.1 Transferring flowering in the juvenile and adult phase of *Malus hupehensis*: A, ungrafted plant; B, adult phase grafted on juvenile plant; C, juvenile plant grafted on adult plant; D, 1-m-high juvenile plant grafted on adult plant. In every case, growing point was transferred and the indicated portion above the g[illegible] grew on the nurse plant.

There is no Transition Zone between Juvenile and Adult Tissue on a Grafted Plant

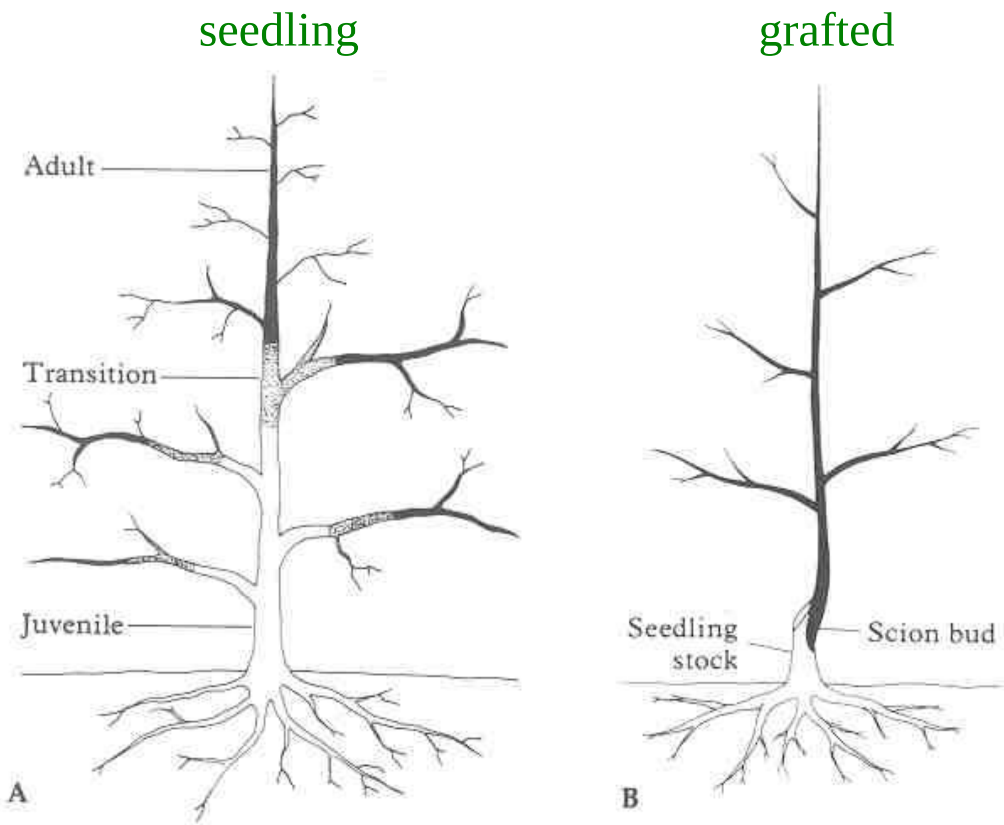
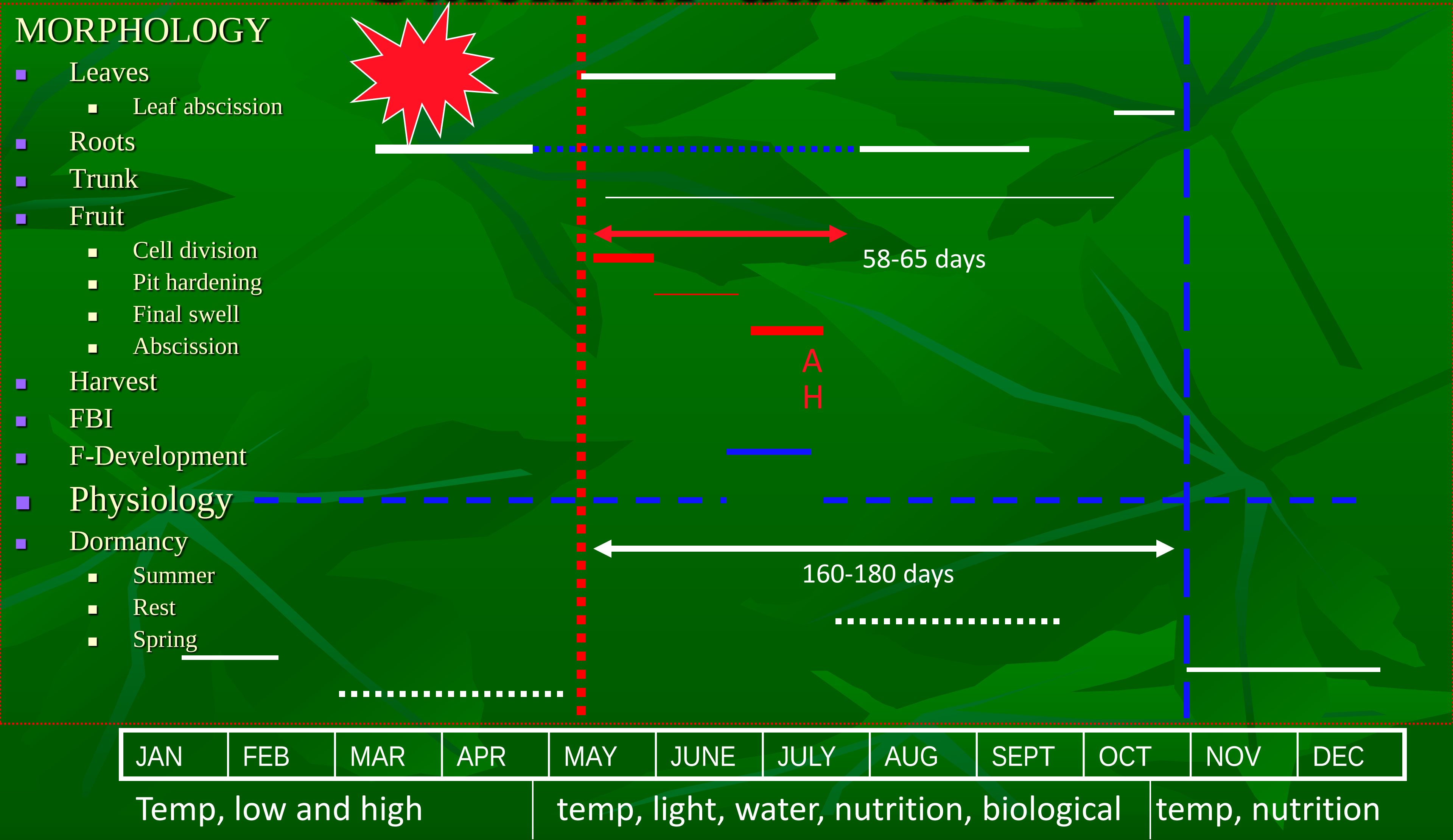


Figure 8-1. (A) The seedling tree has a juvenile zone at the crown and lower region of the tree, a transition zone in the mid-region, and an adult zone at the top and periphery. **(B)** The grafted or budded nursery tree, however, is entirely adult above the bud union.

Seasonal Cycles

CHERRY ANNUAL CYCLE
Calendar date basis



Types of Dormancy

- Ecodormancy
  - Environmental factors
- Paradormancy (ectodormancy)
  - Physiological factors outside the plant
- Endodormancy
  - Physiological factors within the plant (shoot apex)
- The transition into and out of a dormant state is gradual (quiescence or predormancy)

Dormancy Definitions

DORMANCY

	Ecodormancy	Ecto dormancy Paradormancy	Endodormancy
	Regulated by ***environmental*** factors	Regulated by ***physiological*** factors outside the affected structure	Regulated by ***physiological*** factors inside the affected structure
EXAMPLES	Temperature extremes Nutrient deficiency Water stress	Apical dominance Photoperiodic responses	Chilling responses Photoperiodic responses

FIGURE 3.1. Simple, descriptive terminology applied to regulatory factors and examples of plant dormancy. From Lang *et al.* (1987). *HortScience* 22, 371–377).

Example of how a Plant may Experience Different Types of Dormancy throughout a Season

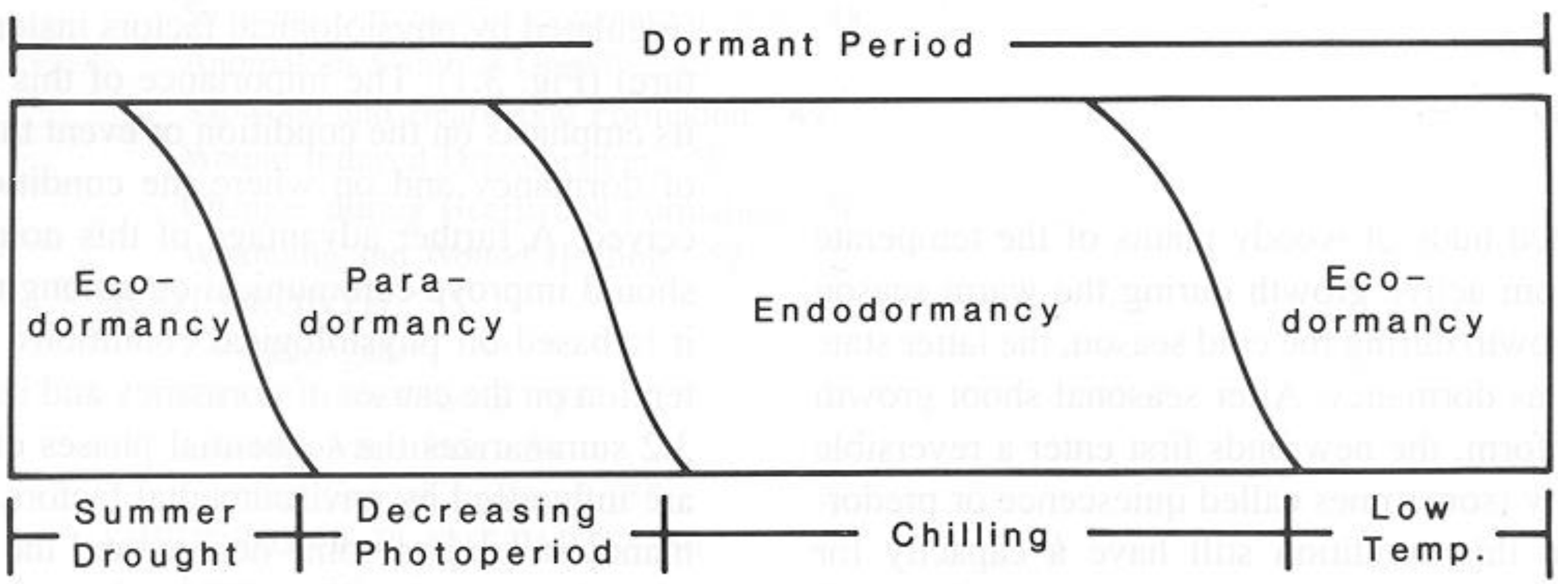
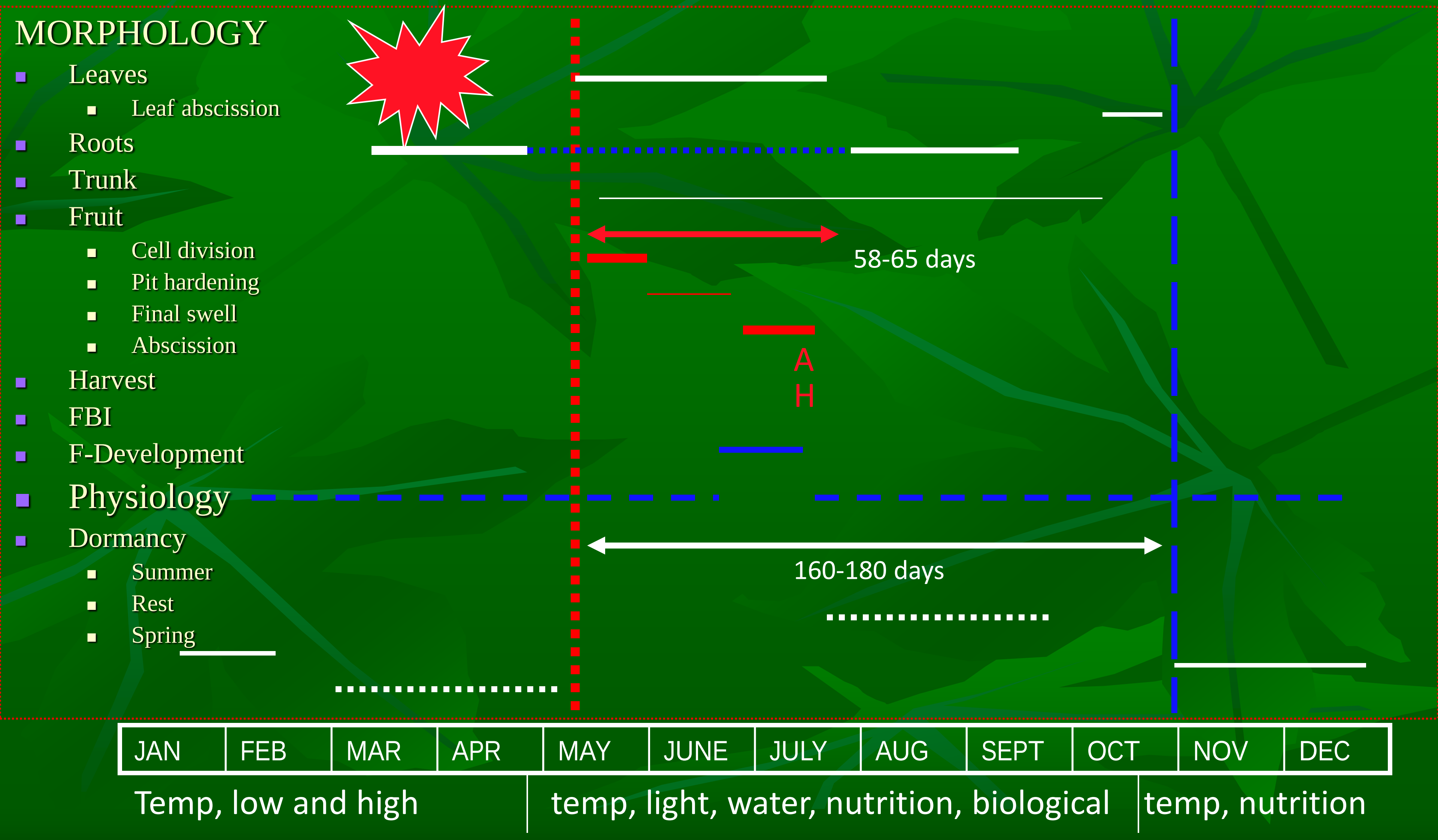
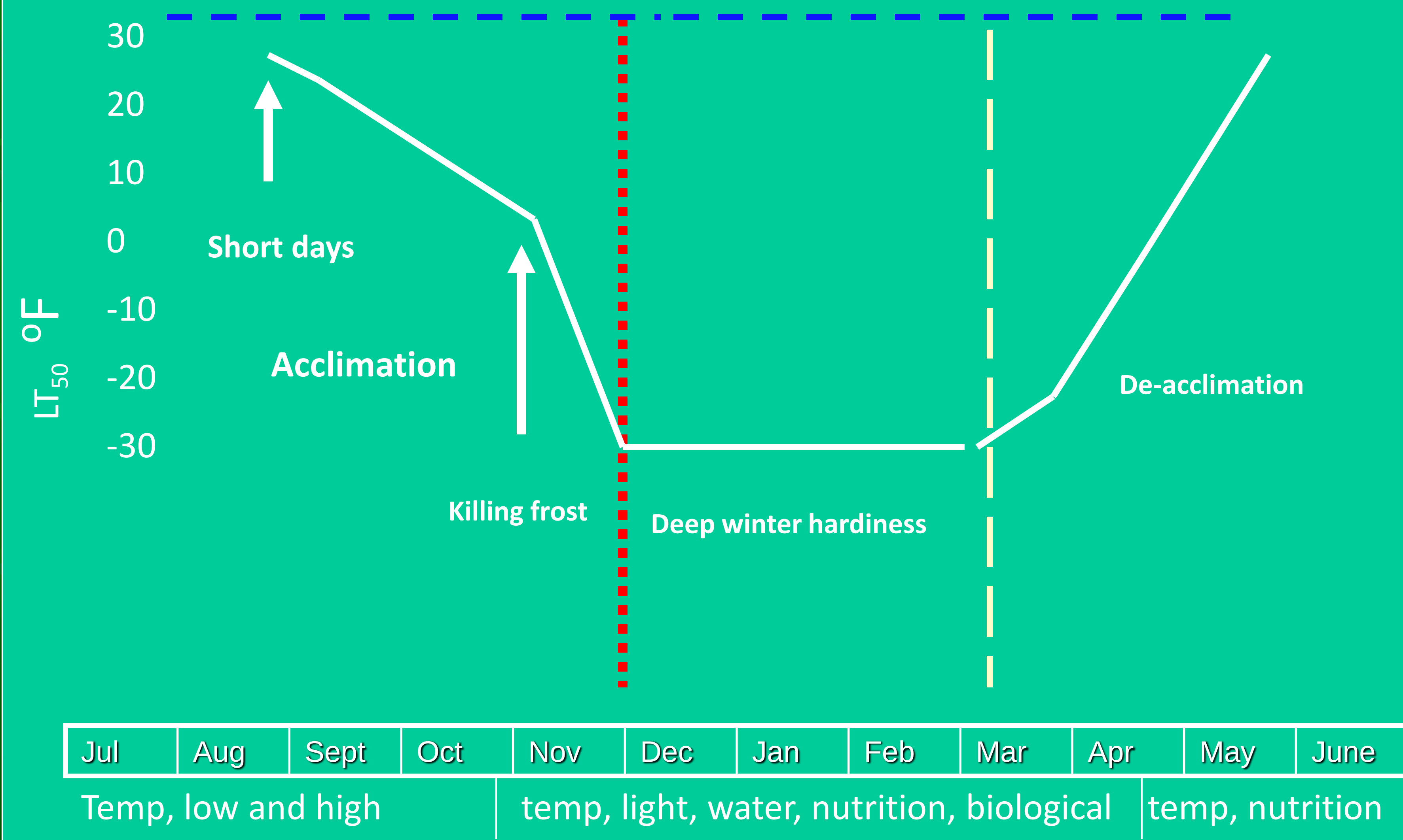


FIGURE 3.2. Relative contribution of the various types of dormancy during a hypothetical dormant period for an apical bud. From Lang *et al.* (1987). *HortScience* **22**, 371–377.

CHERRY ANNUAL CYCLE



Cold Hardiness in Montmorency



Breaking dormancy! Chilling Requirement

- Definition:
  - # of hours of temp between 0-10° C required to break endodormancy (regulated by physiological factors inside the affected structure)
  - How? Inhibitors, promotors?
- Advantages?
- Disadvantages?

Chilling Requirements

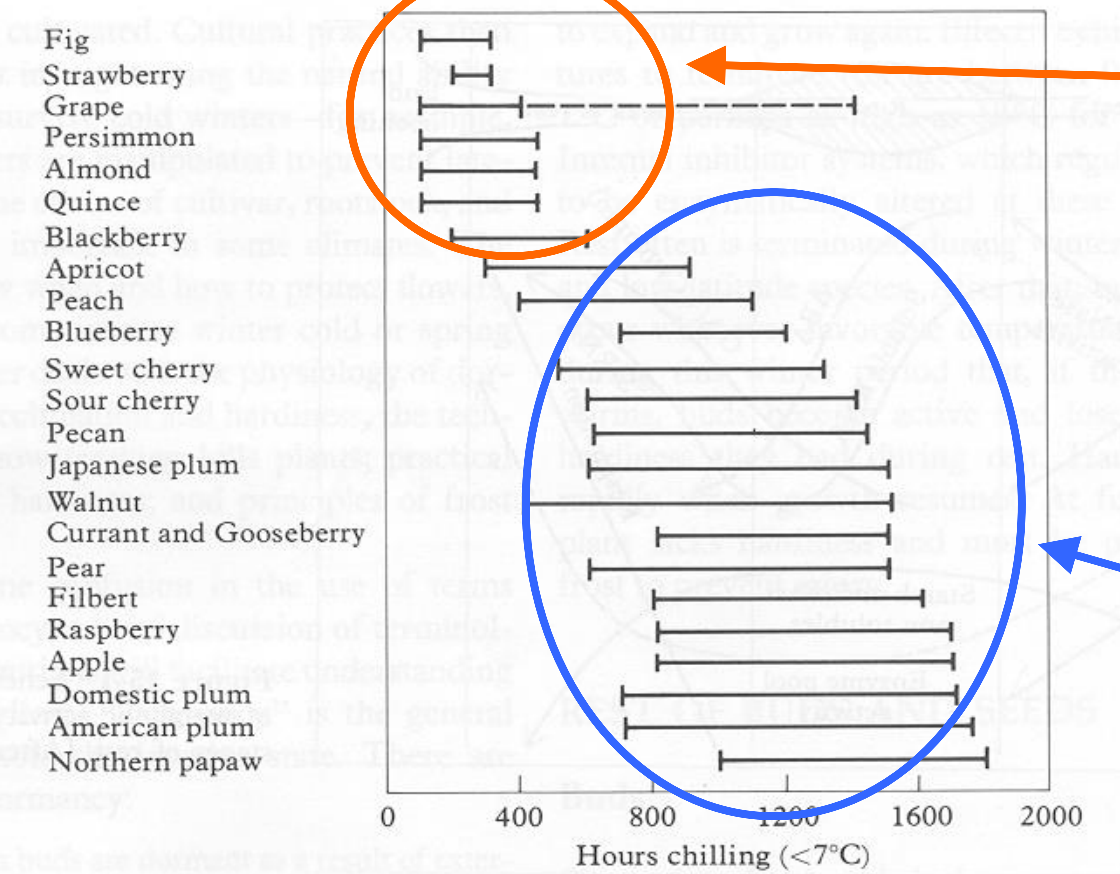


Figure 15-3 Approximate chilling requirements to break winter rest for fruit and nut species. The ranges shown for each species indicate the differences between low- and high-chilling cultivars within the species. Grape will grow with very little chilling but will begin growth much faster after long chilling. [Partially based on data of Chandler, Kimball, Philp, Tufts, and Weldon, 1937]

Low-chilling

+ Longer productive season

- more susceptible to late frost damage

High-chilling

+ protected against late frost

- Shorter growing season

Then in Spring…

- Heat Units: quantitative term used to describe the accumulation of heat used to break ectodormancy (also called growing degree days)
- Traditional method of calculation using max, min.
- Degree Days calculation:

(Max+Min)/2 - base temp = degree days

example: (70+50)/2 - 50 = 10 degree days

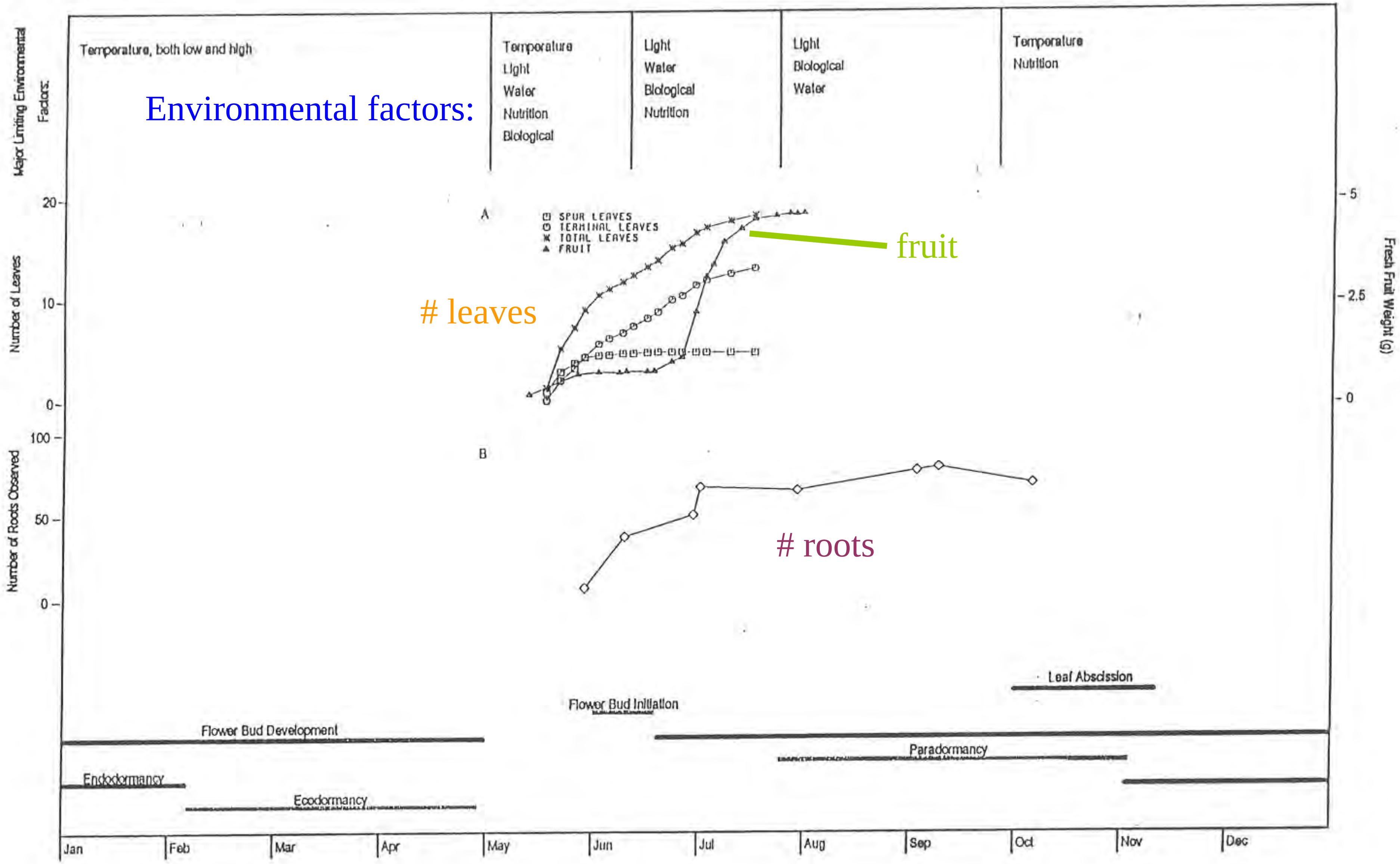
used to: predict bud break, harvest date, bloom date, vegetative growth, insect and disease growth (IPM)

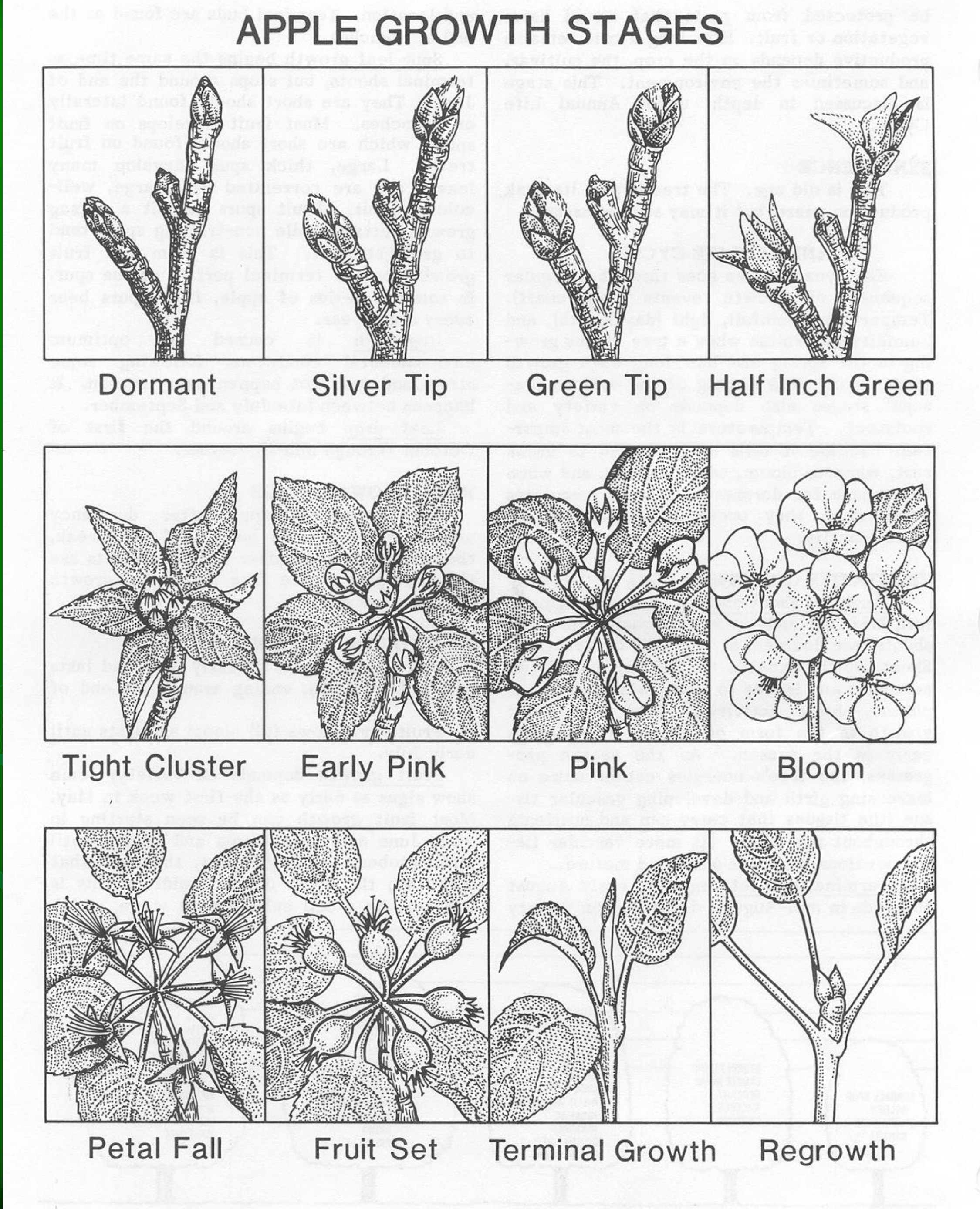
Degree days

- Other methods of calculation
- Baskerville emin method. Uses sine function for change in temperature.
- Different DD bases: examples
  - 40, 42, 45, 50 degrees F.
  - Can vary with the stage of development

Phenology

- Study of timing of natural events
  - Ex. bud break in spring
  - Related to GDD

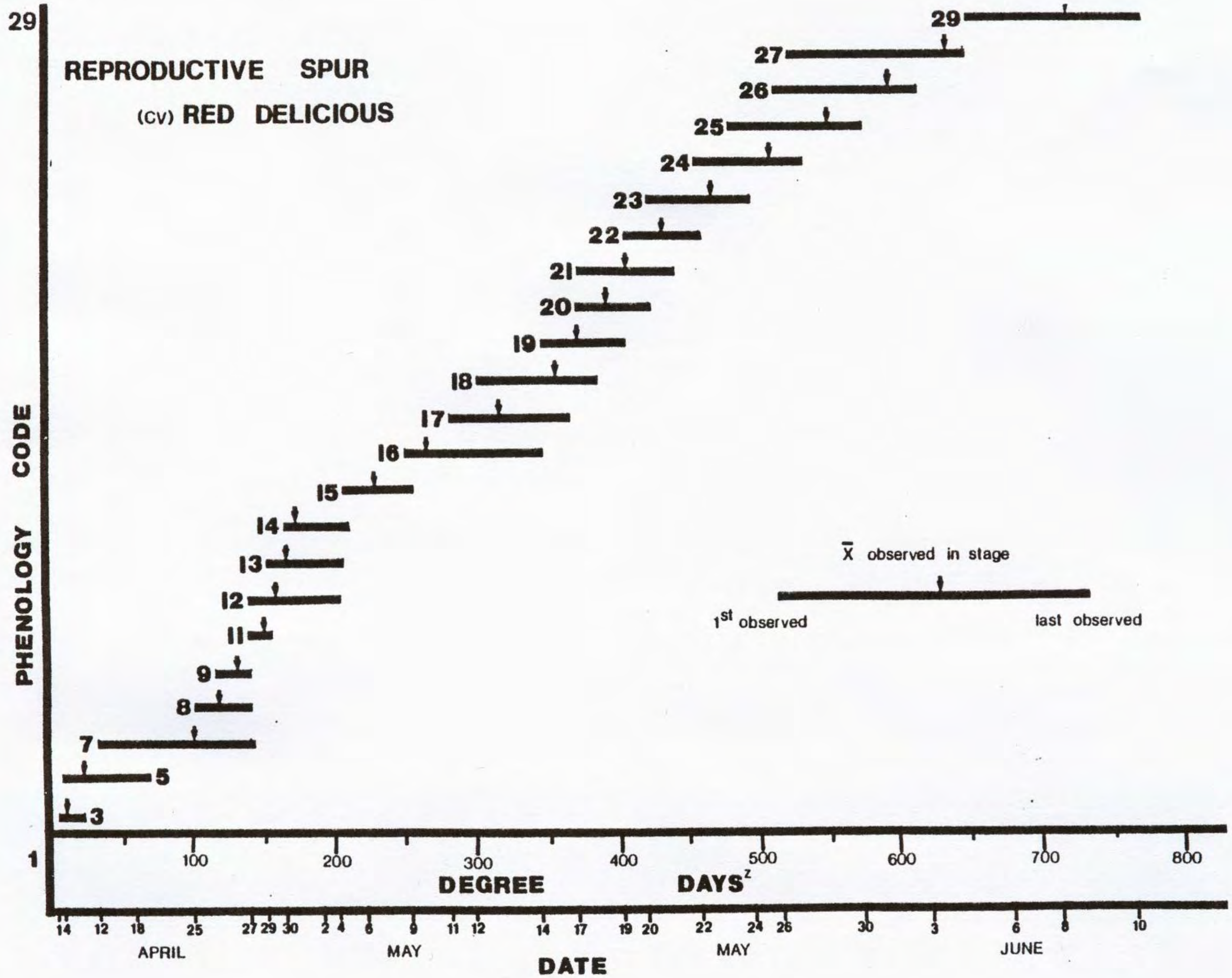

Environmental factors:
Major Limiting Environmental Factors:
Temperature, both low and high
Temperature
Light
Water
Nutrition
Biological
Light
Water
Biological
Nutrition
Light
Biological
Water
Temperature
Nutrition
A
SPUR LEAVES
TERMINAL LEAVES
TOTAL LEAVES
FRUIT
fruit
leaves
Number of Leaves
Fresh Fruit Weight (g)
B
Number of Roots Observed
roots
Leaf Abscission
Flower Bud Initiation
Flower Bud Development
Paradormancy
Endodormancy
Ecodormancy
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec



Stages are not
At equal DD
intervals

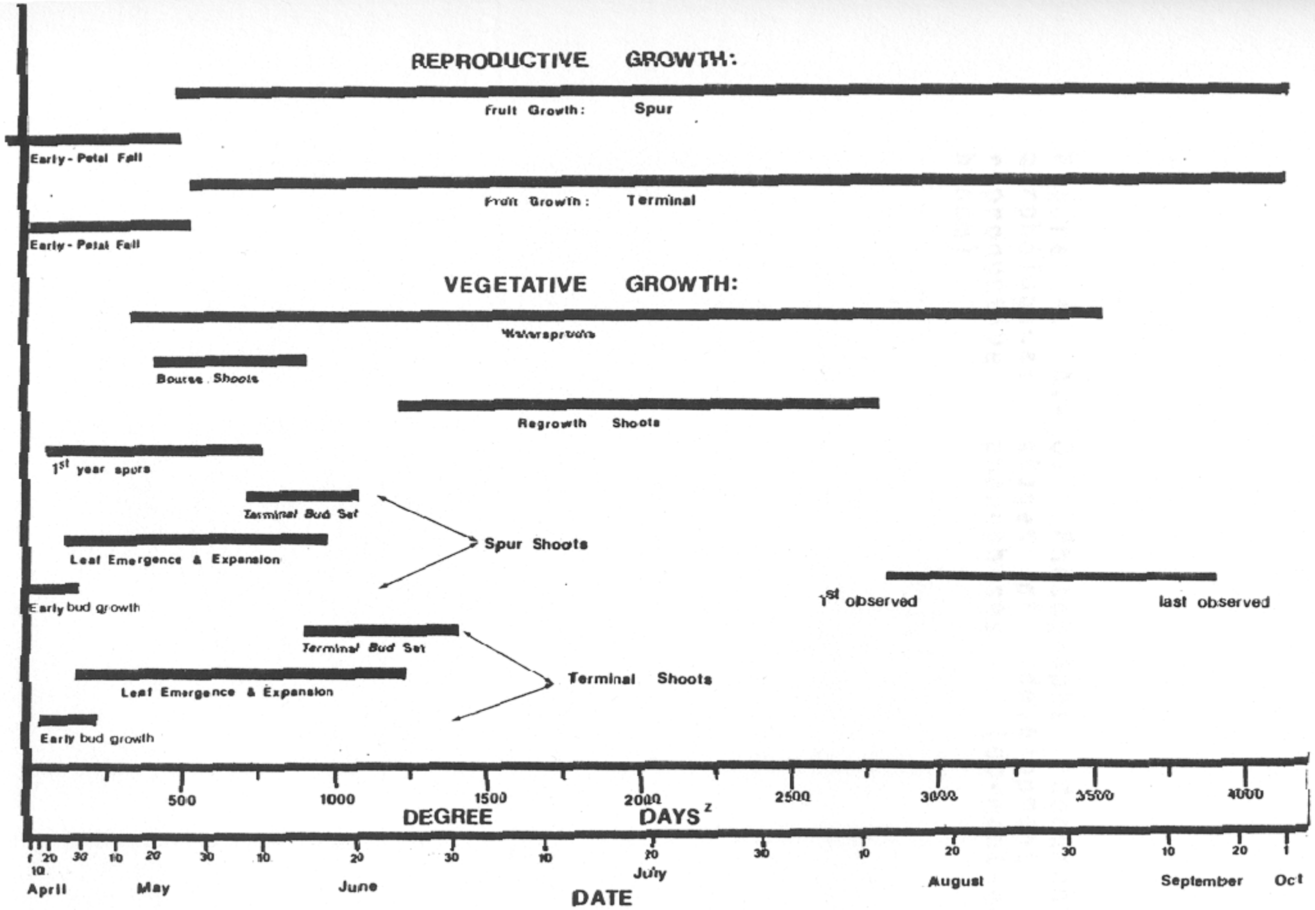
Developmental stages

- Calendar date is not predictible, because development is driven by temperature.
- Therefore prediction is best based on temperature dates as a currency.
- Stages of development are not equally spaced based on either calendar date or temperature units.



z Degree-day accumulation calculated at Base 40 °F using the Baskerville and Emin method (4). Start date for degree-day accumulation: April 1. Orchard site: HRC, 1983.

Different Parts of Plants Require Different Number of Growing Degree Days



z Degree-day accumulation calculated at Base 40°F using the Baskerville and Emin method (4). Start date for degree-day accumulation: April 1. Orchard site: HRC, 1983.

KNOW THIS GRAPH

Vegetative growth: Roots

- Governed by temperature, water, and oxygen
- 4-6° C min; 20-25 optimum; 30-35 max
- Temperature threshold is lower than for shoots
- In competition with shoots for resources

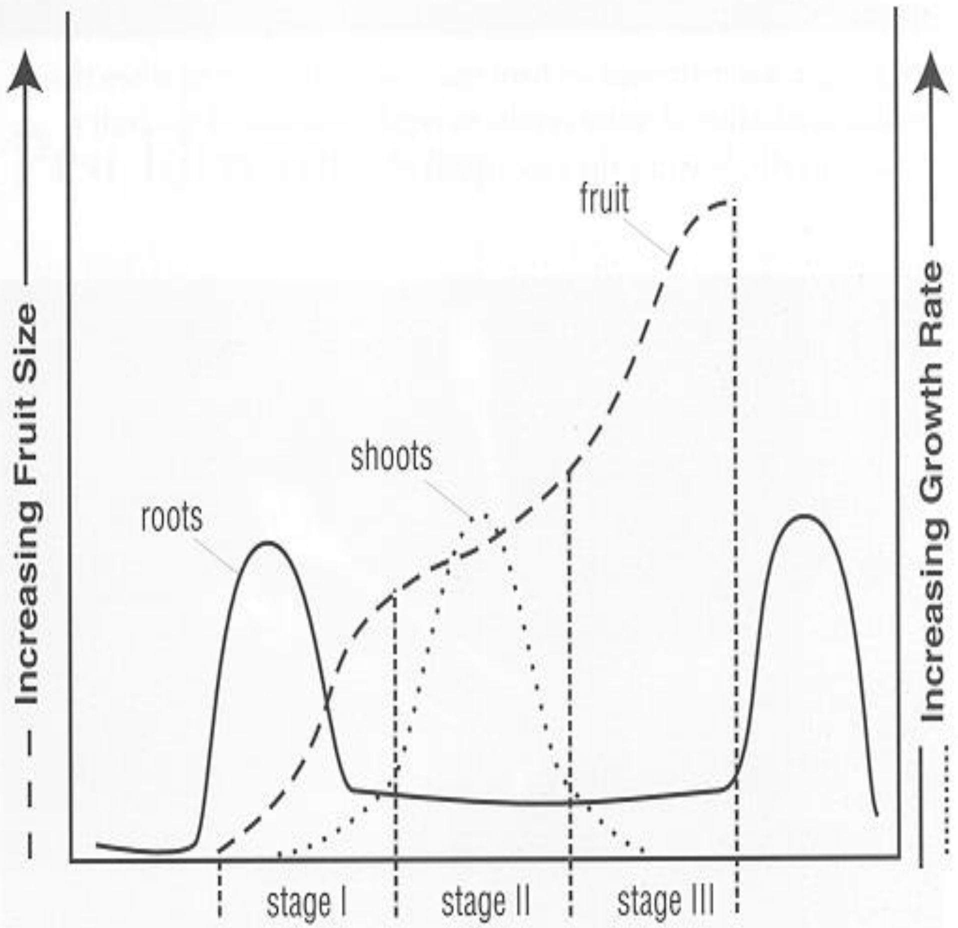


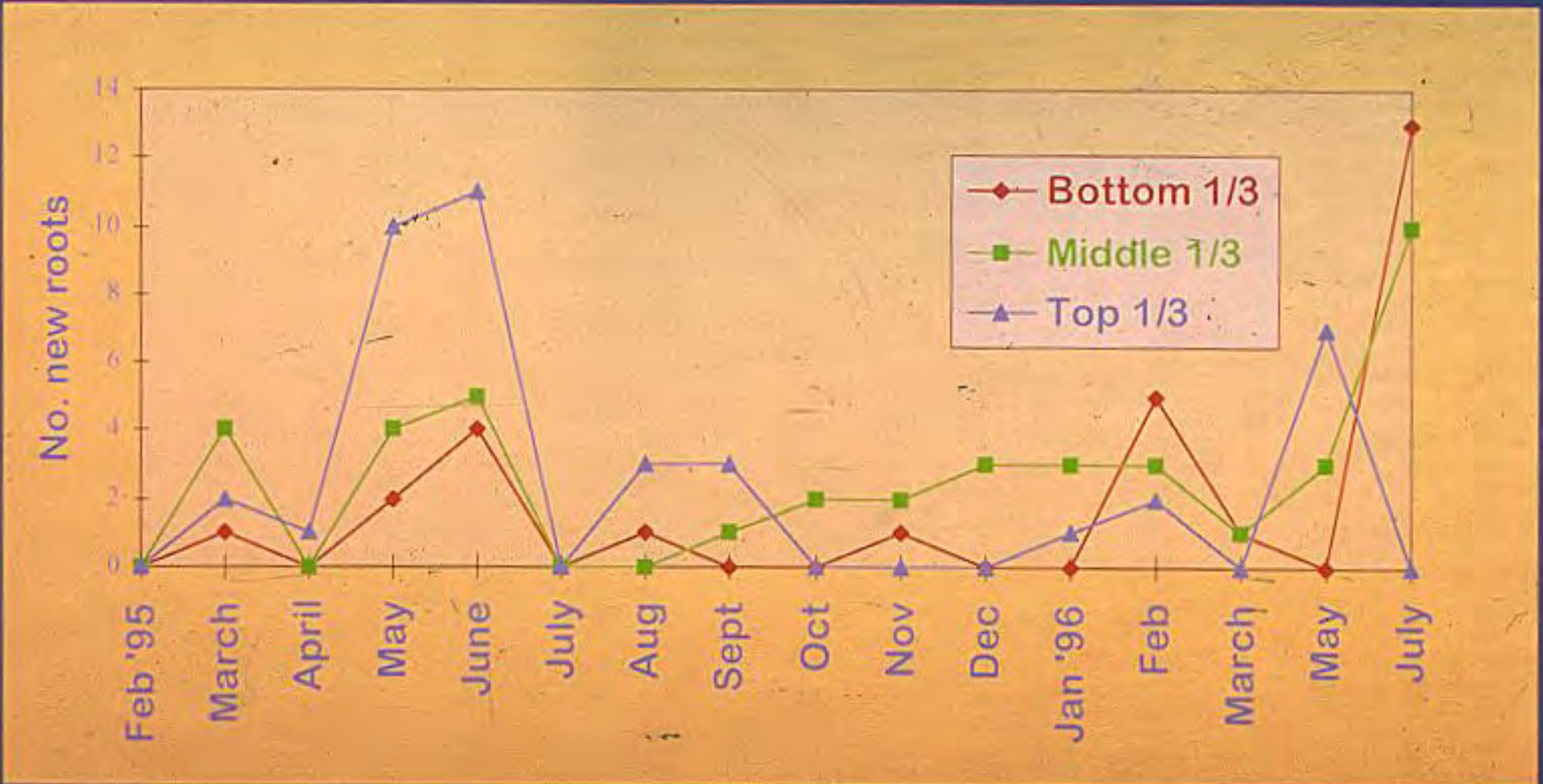
Figure 5. Relationship between growth of roots, shoots, and fruit of a late-season peach variety, showing growth stages of the fruit. During stage I all the cells of the fruit are formed. During stage II the endocarp (pit) hardens and the seed develops to full size. During stage III the cells of the mesocarp (flesh) and exocarp (skin) expand until fruit reaches full size.

- The plant only has a limited amount of resources to put towards growth
- Within a growing season, the roots, shoots, and fruits do not all grow at the same time or rate

Do Roots grow in the winter

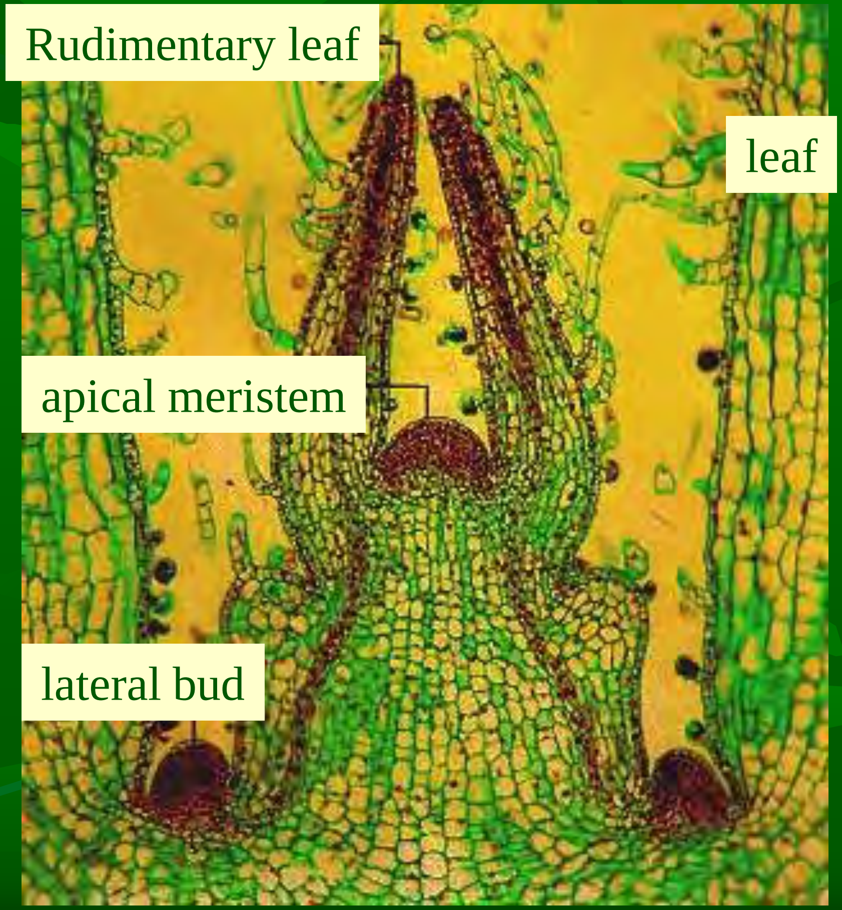
- Do roots under go endormancy
  - No, do not need a chilling requirement.
- Do roots grow in the winter
  - Yes but they need heat and
  - Oxygen

Minirhizotron Summary
February 1995 - July 1996



Shoot Growth

- Division of cells of the apical meristem
  - Elongation**
  - Differentiation
  - Maturation



REPRODUCTIVE GROWTH

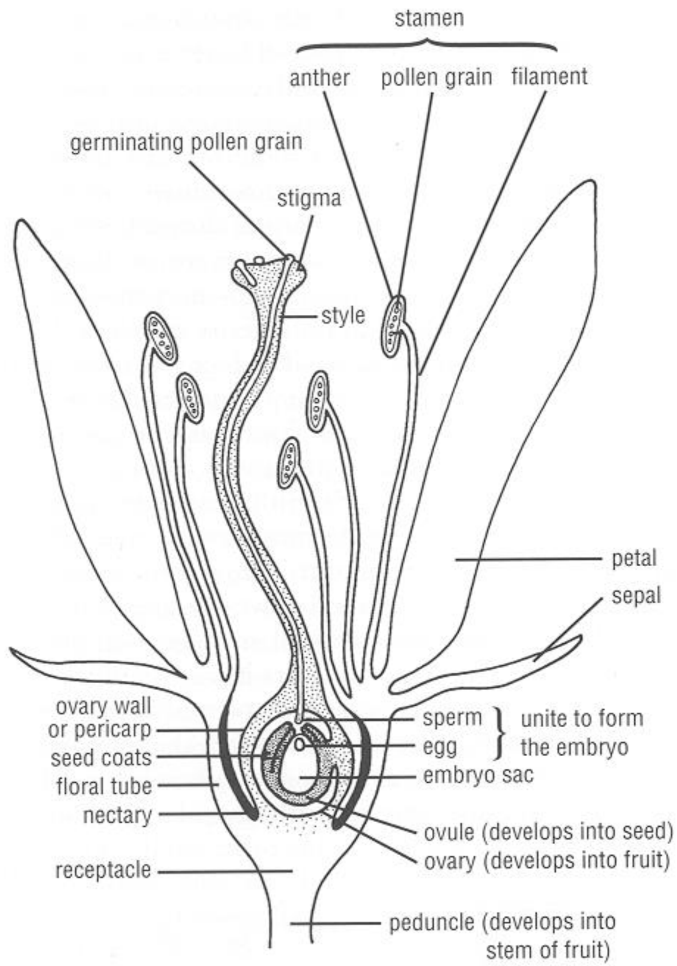


Figure 3. Structures of the stone fruit flower. The diagram above shows a flower in longitudinal section (drawing by Reid M. Brooks). In this figure a pollen tube has developed and fertilization is about to take place. Most of the structures illustrated in the diagram can be seen in the photo (*below*) of a cherry blossom with one petal and sepal removed.

Flower Bud Development

Affected by both external environmental conditions & internal physiological state

1. **Induction**: biochemical signals (CHOs, N, auxins, gibberellins) that induce a vegetative bud to become reproductive
2. **Initiation**: when bud first becomes reproductive
3. **Differentiation**: individual flower parts (sepals, petals, stamens, pistil) form
4. **Maturation**: growth of flower parts during winter
5. **Anthesis**: opening of flowers or bloom in spring

Time of Flower Bud Initiation

Apple	mid-June → mid-July
Pear	early July → early August
Sweet cherry	early July
Peach	late June → late July
Apricot	early August
Plum/prune	late June → mid-August

Flower bud initiation

- Timing: varies with species and variety.
  - Species time of initiation
  - Peach late June-late July
  - cherry, sweet Early July
  - cherry, tart mid-July
  - Apple mid June-early Aug
  - Pear early July-early Aug
  - Blackberry late Aug
  - Strawberry (June) Sept
  - Strawberry (DN) Early summer
  - Walnut, pecan Early spring

Table 7-1 Time of flower initiation and anthesis of some deciduous fruits and nuts.

Kind	Beginning of Initiation Period	Flowers Borne On	Season of Anthesis Relative to Season of Initiation
		Stone Fruits	
Almond	Mid-Aug.–mid-Sept.	Lateral buds, 1-yr. shoots	Next spring
Peach	Late June–late July	Lateral buds, 1-yr. shoots	Next spring
Apricot	Early Aug.	Lateral buds, 1-yr. shoots + 2-yr. spurs	Next spring
Prune	Late June–mid-Aug.	Lateral buds, 1-yr. shoots + 2-yr. spurs	Next spring
Plum, Japanese	Mid-July–early Aug.	Lateral buds, 1-yr. shoots + 2-yr. spurs	Next spring
Plum, wild goose	Early Sept.	Lateral buds, 1-yr. shoots + 2-yr. spurs	Next spring
Cherry, sweet	Early July	Lateral buds, 2-yr. spurs	Next spring
Cherry, sour	Mid-July	Lateral buds, 2-yr. spurs	Next spring
		Pome Fruits	
Apple	Mid-June–mid-July	Terminal buds, 2-yr. spurs	Next spring
Pear	Early July–early Aug.	Terminal buds, 2-yr. spurs	Next spring
Quince	Early spring before anthesis	Terminal shoots, current growth	Same spring
		Small Fruits	
Blackberry	Late Aug.	Lateral buds, 1-yr. canes	Next spring
Raspberry	Sept.–Nov.	Lateral and terminal buds, 1-yr. canes	Next spring
Strawberry	Sept. (short days)	Crown buds	Next spring
Strawberry, fall bearing	Early summer (long days)	Crown buds	Same summer
Currant	July	Lateral buds, 1-yr. canes	Next spring
Gooseberry	Aug.	Lateral buds, 1-yr. canes	Next spring
Cranberry	Mid-Aug.–mid-Sept.	Lateral buds, 1-yr. canes	Next spring
Blueberry	Late fall	Lateral buds, 1-yr. canes	Next spring
Grape	Mid-June	Lateral buds, 1-yr. canes	Next spring
		Other Fruits	
Fig—first crop	Late summer	Lateral buds, 1-yr. shoots	Next spring
Fig—second crop	Early summer	Lateral buds, current growth	Same season
Persimmon	July	Lateral buds, 1-yr. shoots	Next spring
		Tree Nuts	
Filbert, female	July–Sept.	Lateral buds, 1-yr. shoots	Next winter
Filbert, male	May	Lateral buds, 1-yr. shoots	Next winter
Walnut, female	Feb.–April	Terminals of current shoots	Same season
Walnut, male	Early summer	Lateral buds, 1-yr. shoots	Next spring
Pecan, female	Early spring	Terminals of current shoots	Same season
Pecan, male	Early summer	Lateral buds, 1-yr. shoots	Next spring
Pistachio	Late April	Lateral buds, 1-yr. shoots	Next spring

CHERRY ANNUAL CYCLE
Calendar date basis