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

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REPRODUCTIVE CYCLE

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Reproduction starts with bud differentiation and ends up with seed maturation and fruit ripening.

- ✓ MICRO E MACROSPOROGENESIS
- ✓ANTHESIS
- ✓ POLLINATION and POLLEN GERMINATION
- ✓ FERTILIZATION
- ✓ FRUIT SET
- ✓ FRUIT GROWTH and RIPENING

Microsporogenesis

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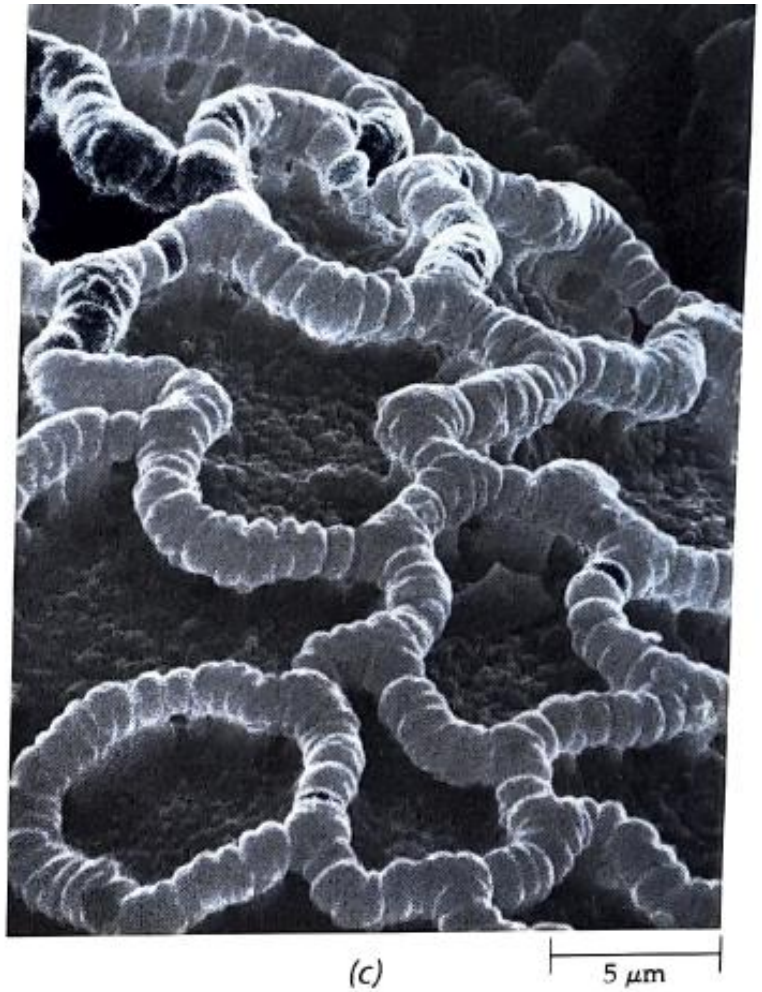
process of formation of **pollen grains** (or microspores) inside the pollen sacs (or microsporangium) by meiotic or reduction division.

- ✓ the anther is where the process take place
- ✓ take place before buds become dormant or in the following spring
- ✓ at the end of the process pollen is tri-nucleated

Pollen grains of the horse chestnut (*Aesculus hip pocastanum*). The pore of each grain through which a pollen tube may emerge is visible in- the furrow

Pollen grains of a lily (*Lilium longiflorum*)



Detail of the surface of a lily (*L. longiflorum*) pollen grain

Macrosporogenesis

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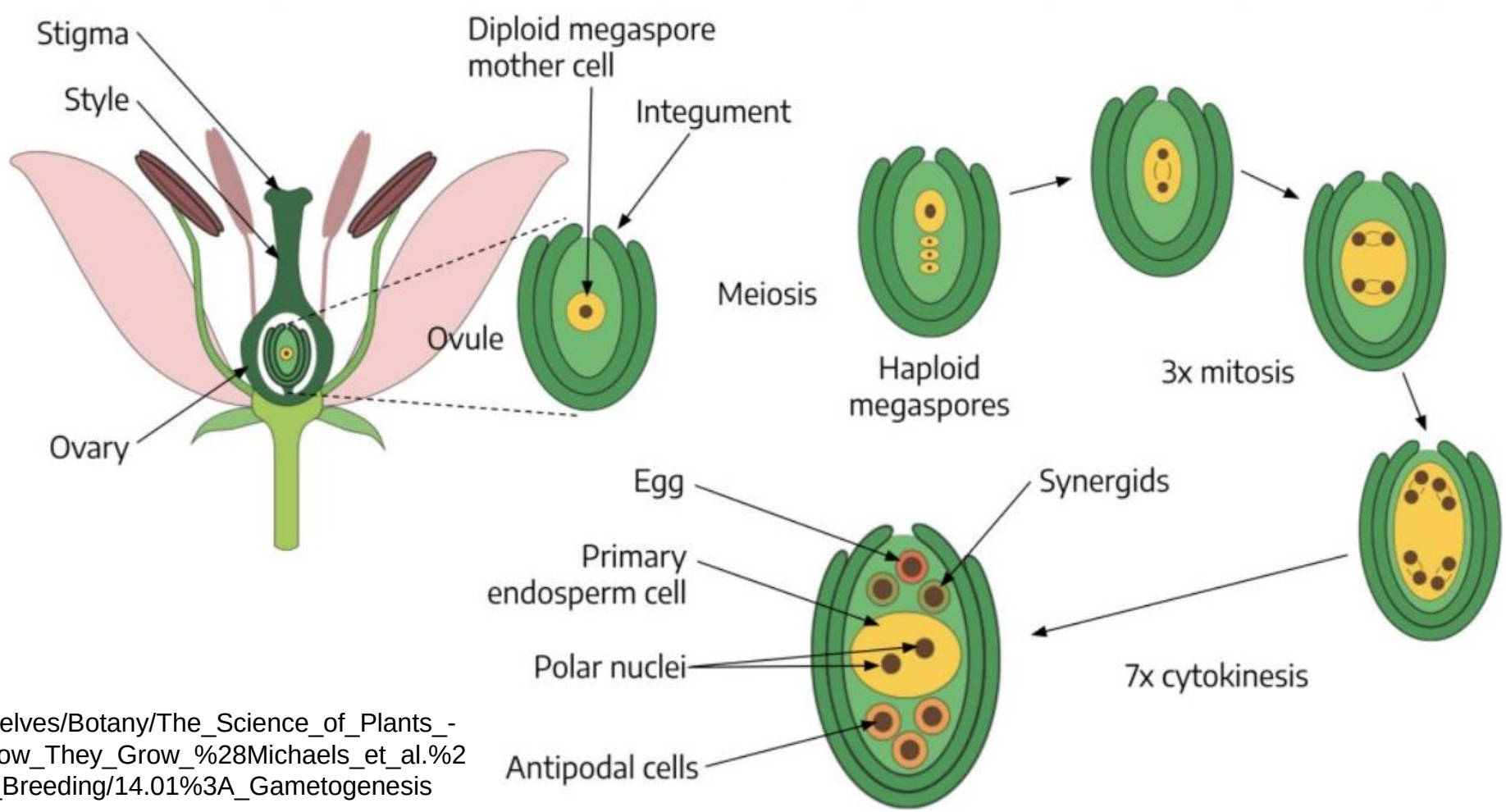
process of formation of **ovule** (female gametogenesis) that occurs within the pistil



https://bio.libretexts.org/Bookshelves/Botany/The_Science_of_Plants_-_Understanding_Plants_and_How_They_Grow_%28Michaels_et_al.%29/14%3A_Variation_and_Plant_Breeding/14.01%3A_Gametogenesis

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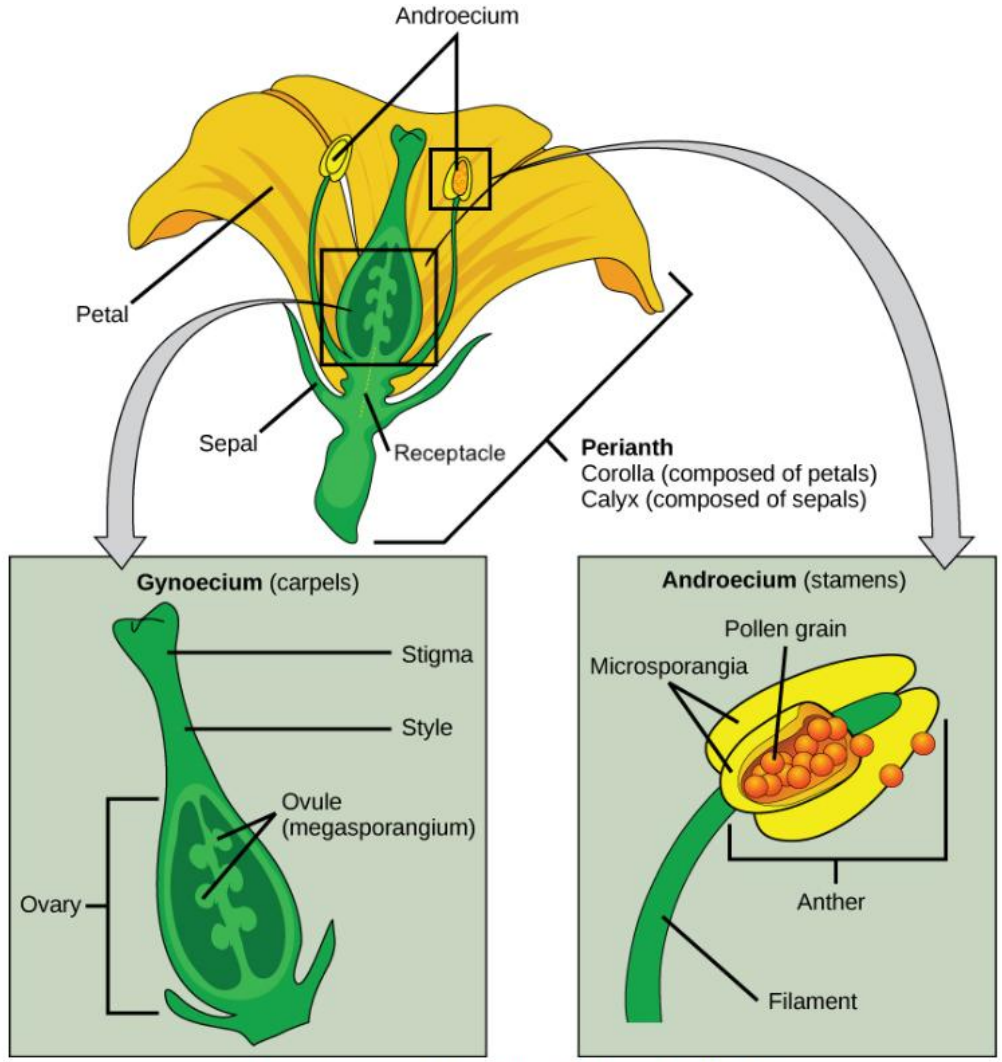
The androecium and gynoecium contain structures housing the (micro- and mega-) sporangia where meiosis takes place and the gametophyte generations develop



Parts of a flower. OpenStax Biology. CC BY 4.0

https://bio.libretexts.org/Bookshelves/Botany/The_Science_of_Plants_-_Understanding_Plants_and_How_They_Grow_%28Michaels_et_al.%29/14%3A_Variation_and_Plant_Breeding/14.01%3A_Gametogenesis

ANTHESIS

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- ✓ Phenological phase of bloom
- ✓ Sometimes floral stalk becomes longer
- ✓ Corolla opens
- ✓ Anther dehiscence and pollen emission
- ✓ Pistils becomes receptive
- ✓ Petal fall

ANTHESIS

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Dichogamy → the maturation of male and female sexual organs is not simultaneous. The period of stigma receptivity does not match the time of pollen shedding.

It is called:

- *protandry* when male organs mature before female ones;
- *protogyny* when female organs mature before male ones

This situation prevents self fertilization and should be taken into consideration when planning orchards

ANTHESIS

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- ✓ bud needs some GDH to break
- ✓ anthesis is asynchronous within the orchard and single plants:

  - Almond
  - Apricot
  - Peach, Plum, cherry
  - Apple, pear
  - Kiwifruit
  - grape, olive

changes from species to species and within the same species changes with variety

- ✓ Can last 7-10 days depending on environmental conditions

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POLLINATION

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It is the result of pollen transfer from anther to the stigma.

The main system of pollen transfer are *wind* and *insects*

Species that bloom abundantly, long distance

olive walnut, hazelnut, grape

Showy flowers with a lot of nectar

Drupes, pomes, fig

Some species are pollinated both by wind and insects

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honeybee

bumblebees

Syrphidae flies

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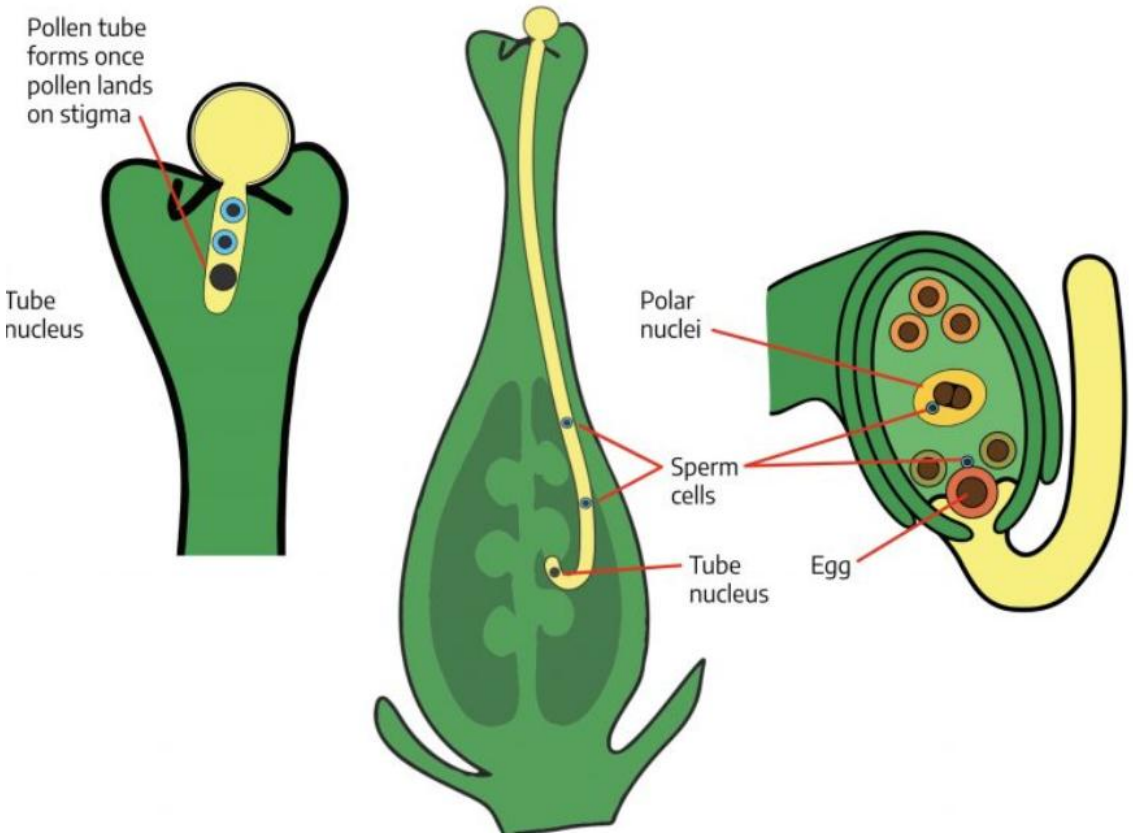
Pollen forms a tube that grows through the stigma and penetrates into the transmitting tube reaching the ovary.



The highest the number of pollen grains is, the higher/faster their germinability is

FERTILIZATION AND FRUIT SETTING

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The pollen tube growths until it reaches the base of the style and then jumps into the ovule trough the micropyle.

One sperm cell fused with the egg cell and generate the **zygote**; the other cell fuses with the polar central cells and form the first **endoderm cell**.

DOUBLE FERTILIZATION

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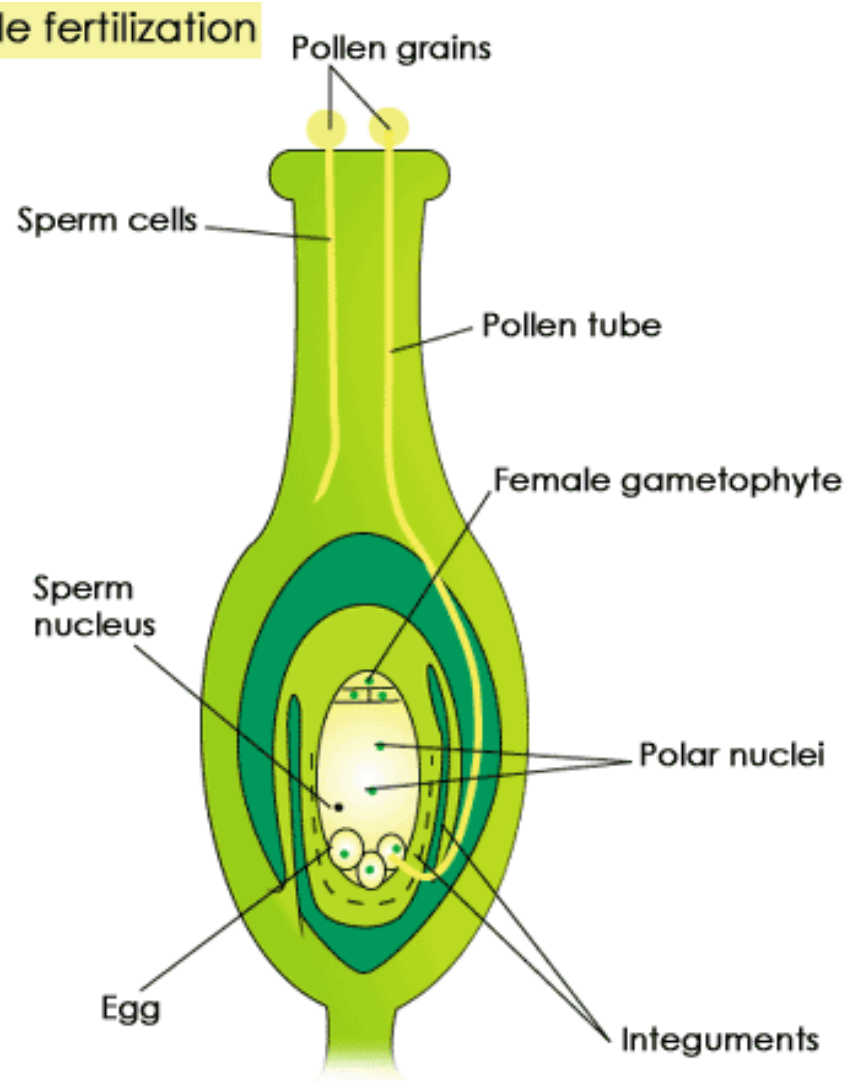

The pollen tube reaches the base of the style and then jumps into the ovule releasing sperm cells: ne sperm cell fused with the egg cell and generate the **zygote**; the other cell fuses with the polar central cells and form the first **endoderm cell**.

https://www.sparknotes.com/biology/plants/lifecycle/section2/

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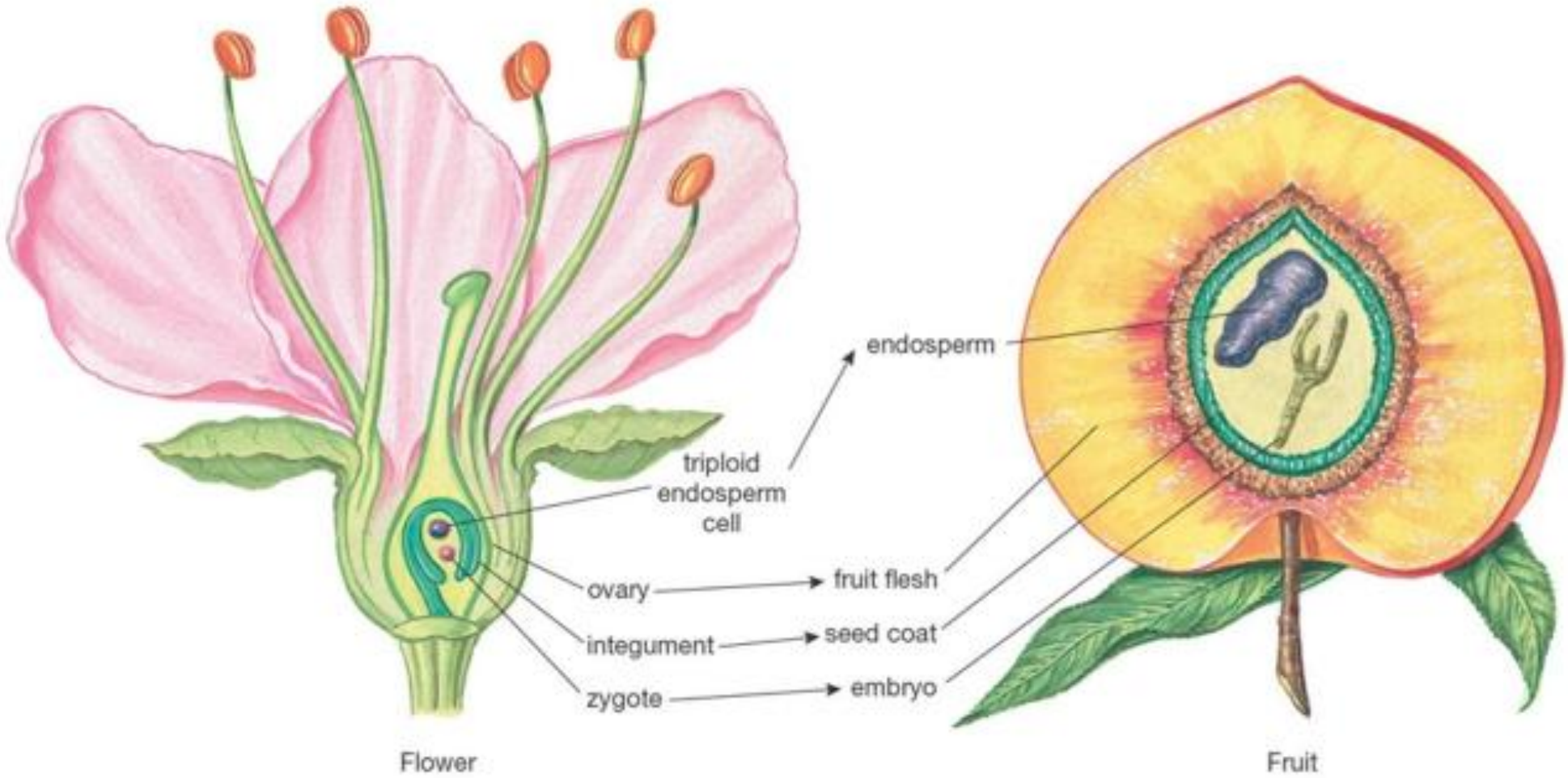

FERTILIZATION AND FRUIT SETTING

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The result of gamete fusion is **fruit setting**, first step of fruit formation

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Fruit set: 30-35 % peach

10 % apple

5 % olive

If there is not fertilization usually flower tends to drop (**blossom drop**); sometimes fruits can originates thank to **parthenocarpy**

FRUIT DROP

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Can be caused by low production of auxins by embryonies and reduced polarization of carbohydrates;

Also during the entire season due to genetic properties or environment

Self-regulating process that balance the number of fruits to resources availability

Water stress

Nutrients lack

Hormone imbalance

Pathogens

Adverse environmental conditions

STERILITY

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Flower fertilization can be prevented by several factors:

CLIMATE or CULTURAL causes: lack of some nutrients (B, N, Ca); heavy rain, low chilling units

GENETIC causes: morphological, cytological sterility and self-incompatibility

MORPHOLOGICAL STERILITY

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Is due to abnormal differentiation of flower organs that may affect pollen and ovule viability, causing *androsterility* or *gynosterility*

Defective stamen development with anomalies of pollen grain

Disturbance of ovary differentiation or anomalies in ovule formation

CYTOLOGICAL STERILITY

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- ✓ Caused by irregularities occurring during micro- and macro-sporogenesis leading to total or partial sterility of pollen and embryo sac
- ✓ The flowers are morphologically perfect, produce pollen, but are poorly viable and scarce

INCOMPATIBILITY

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- ✓ *Self-incompatibility* → the pollen is viable but unable to fertilize the flowers of the same cultivar. From a evolutionary point of view it is an advanced genetic strategy used by plants to avoid self-pollination.
- ✓ *Inter-incompatibility* → the pollen is viable but unable to fertilize the flowers of other cultivars of the same species

SELF-INCOMPATIBILITY

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- ✓ Present in *Malus domestica*, *Pyrus communis*, *Prunus avium*, *P. triflora*, *Corilus* spp., *Olea europea*
- ✓ Not present *in P. persica,* V*itis vinifera* and *Juglans regia*
- ✓ The SI reaction is controlled by a single multiallelic locus (**S-locus**). When the same allele is expressed in the pollen and pistil, the reaction of incompatibility occurs.

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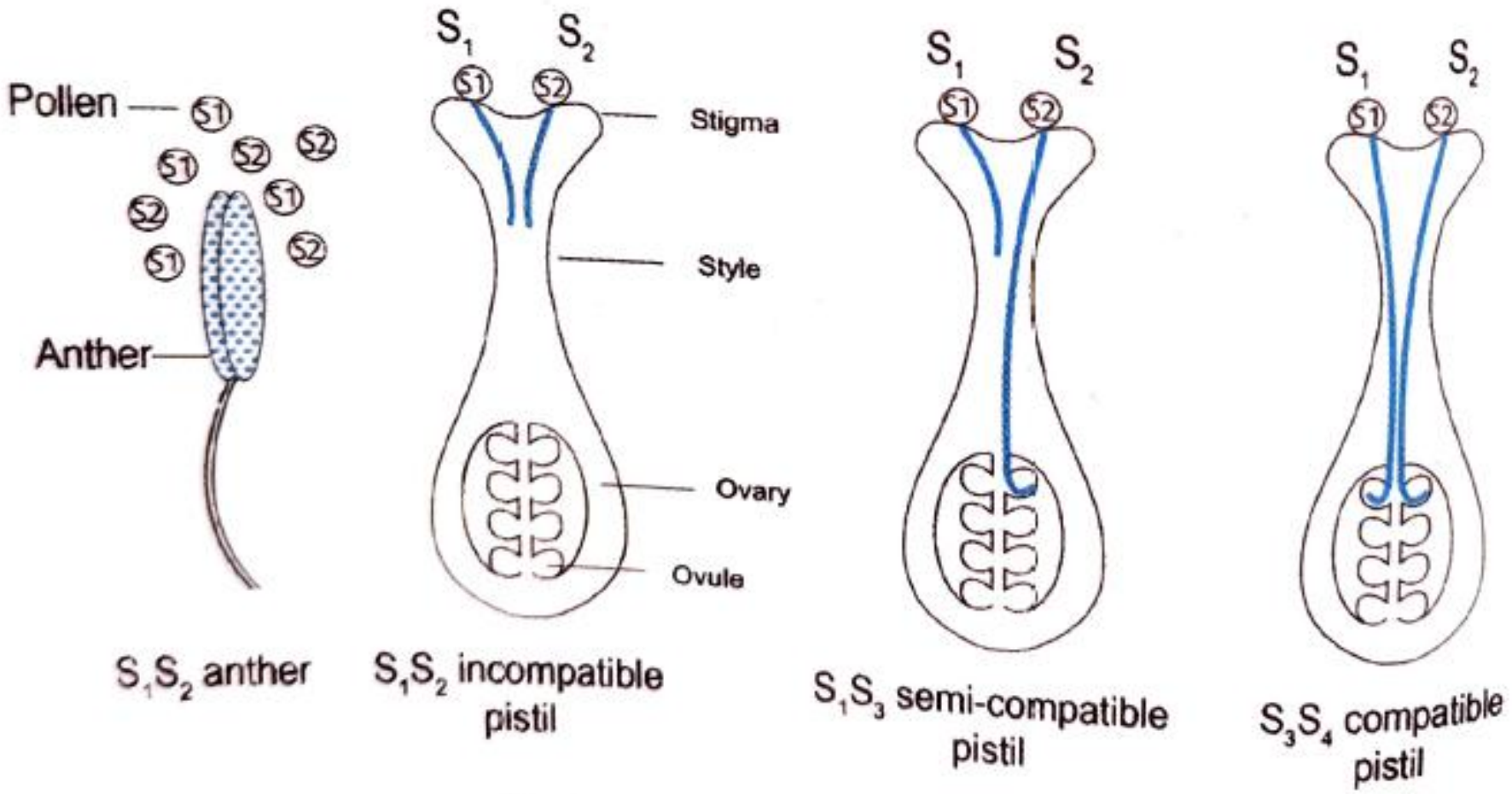

The tube growth is inhibited when the pollen and the pistil have the same S allele

Sansavini et al. 2019. Principles of modern fruit Sciences

POLLINIZERS

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- ✓ Simultaneous bloom
- ✓ Viable and abundant pollen
- ✓ 5-10% for plant pollinated by wind; 10-20% for those pollinated by insects
- ✓ on the tree row (kiwifruit) or on alternate rows

Cherry self-incompatible varieties

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Varieties	Locus S - Alleles	Incompatible group member
Stark Hardy Giant	S1S2	1
Summit	"	
Black Star	S1S3	2
Regina	"	
Van	"	
Bing	S3S4	3
Lambert	"	
Durone Nero 3	S3S6	6
Kordia	"	
Burlat	S3S9	16
Bigarreau Moreau	"	
Ferrovia	S3S12	22

Varieties	Locus S - Alleles
Blaze Star	S4'S6
Celeste	S1S4'
Grace Star	S4'S9
Lapins	S1S4'
Staccato	S3S4'
Stella	S3S4'
Sunburst	S3S4'
Sweetheart – Suntare*	S3S4'

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Pear self-incompatible varieties

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Locus S - Alleles	Varieties
S101/S102	Bartlett / William / William's Bon-Chrétien
S101/S103	Butirra Precoce Morettini
"	Packam's Triumph
"	Spadona estiva / Blanquilla
S101/S105	Dr. Jules Guyot / Limonera / William Precoce
"	Rocha
S104/S105	Abbé Fétel
"	Doyenne du Comice
S107/S114	Kaiser / Beurré Bosc
S108/S119	Conference
S110/S119	Passe Crassane

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POLLINIZERS POSITIONING

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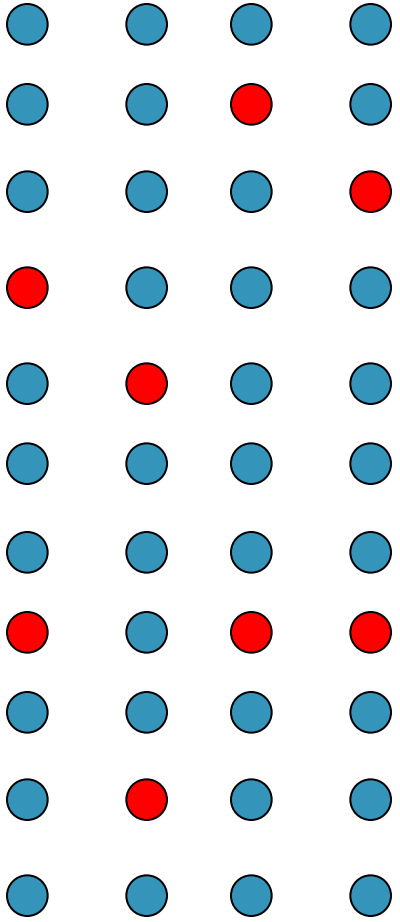

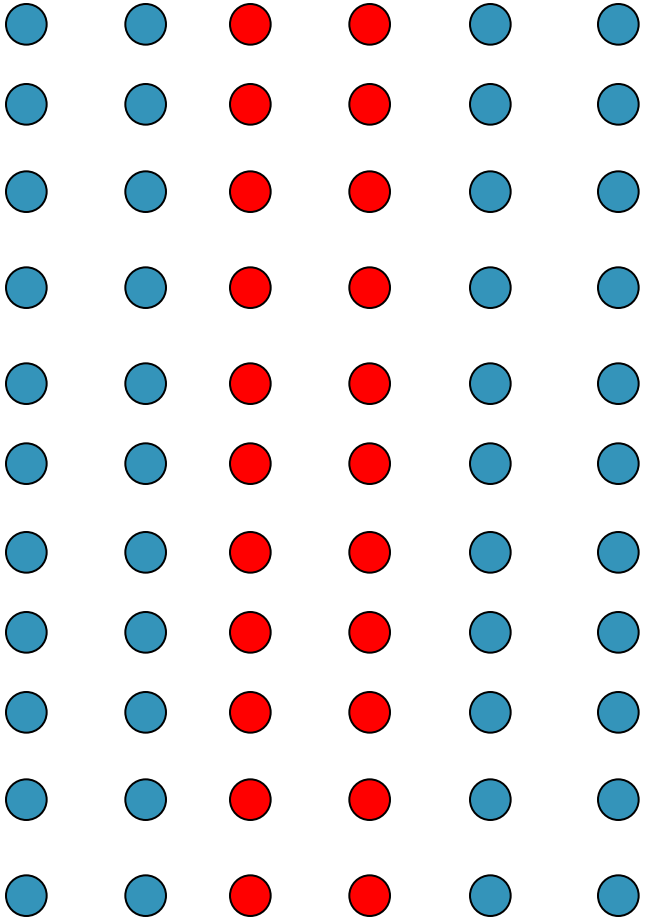

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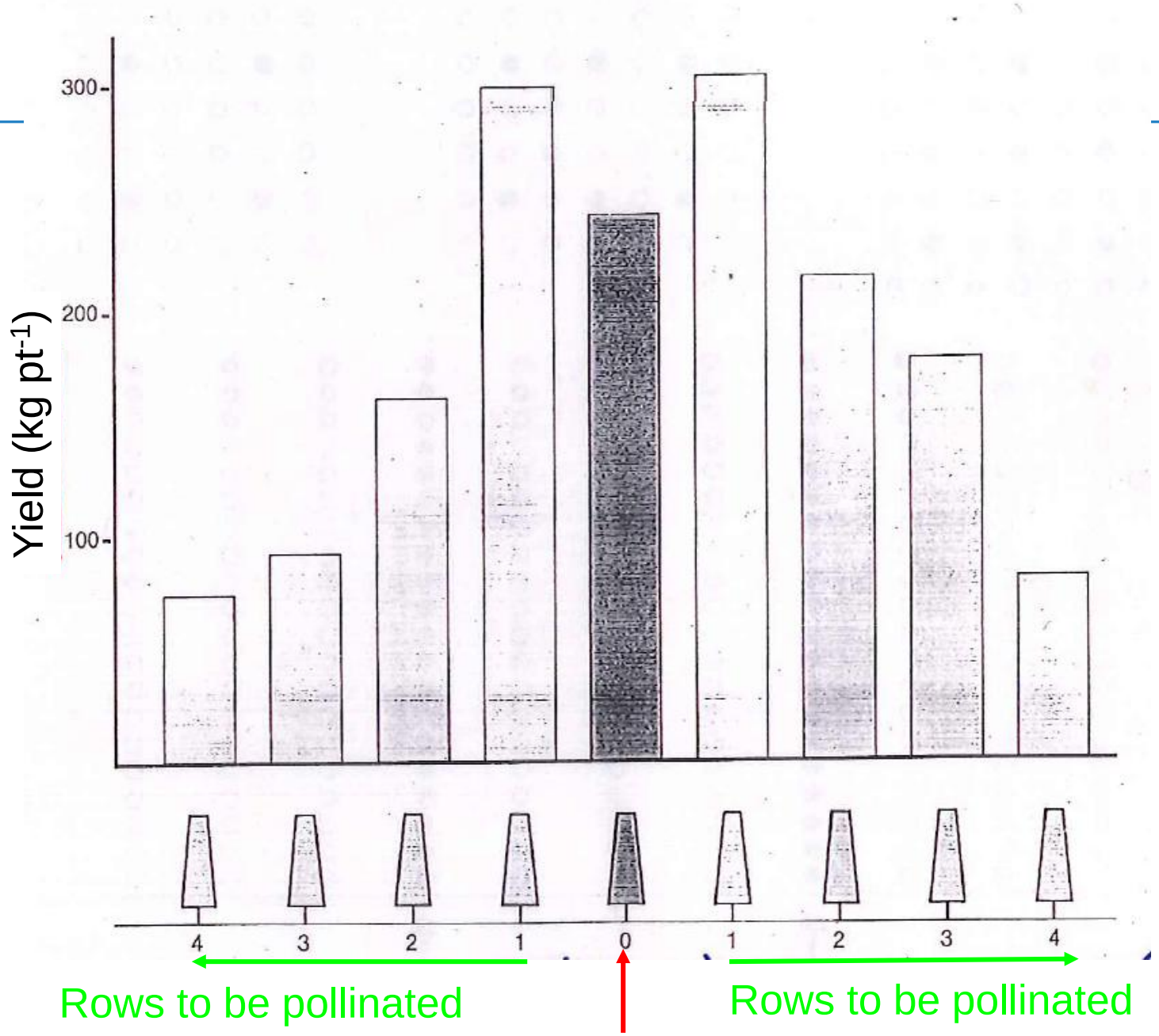

Baldini, 1986


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https://www.italiafruit.net/noce-limpollinazione-col-drone-aumenta-le-rese

https://toscana.coldiretti.it/news/innovazione-cresce-la-domanda-di-olio-il-volo-dei-droni-impollinatori-per-aumentare-produzione-regionale-e-tutelare-paesaggio/

PARTHENOCARPY

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Development of fruits without fertilization or, in case of fertilization has occurred, following seed abortion or collapse (*pseudo-parthenocarpy*) .

- ✓ Common in citrus, persimmon, banana, sometimes apple, pear and grape
- ✓ *Apomixis* → formation of seeds without fusion of gametes
- ✓ Fruits have a longer shape and tend to drop easily

Trend of fruit drop in relation to their formation

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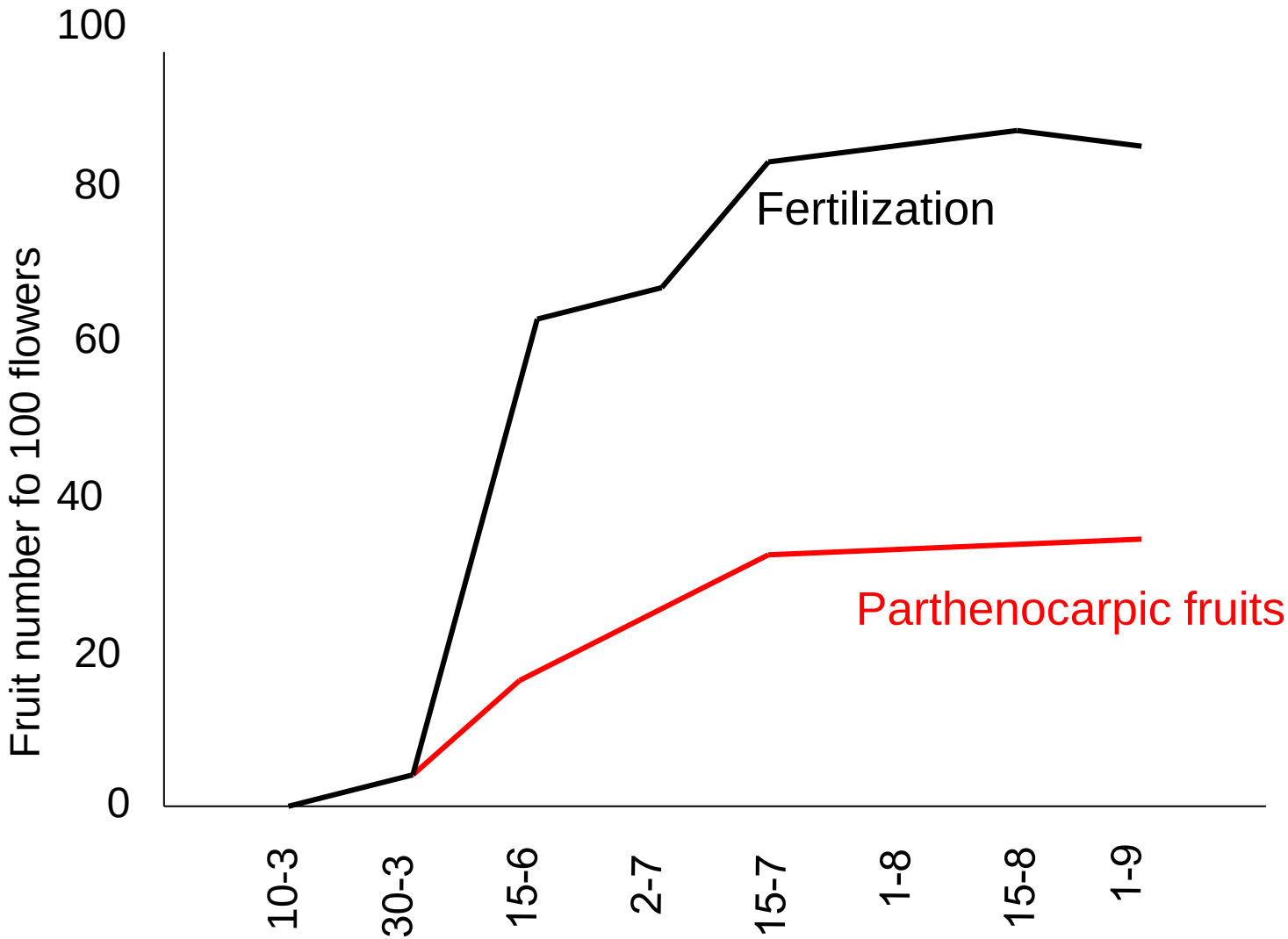

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The berries of seedless grape are smaller than berries with seeds.

Seeded berry

Stenospermocarpic fruits (elongated shape with herbaceous seeds)

Parthenocarpic fruits

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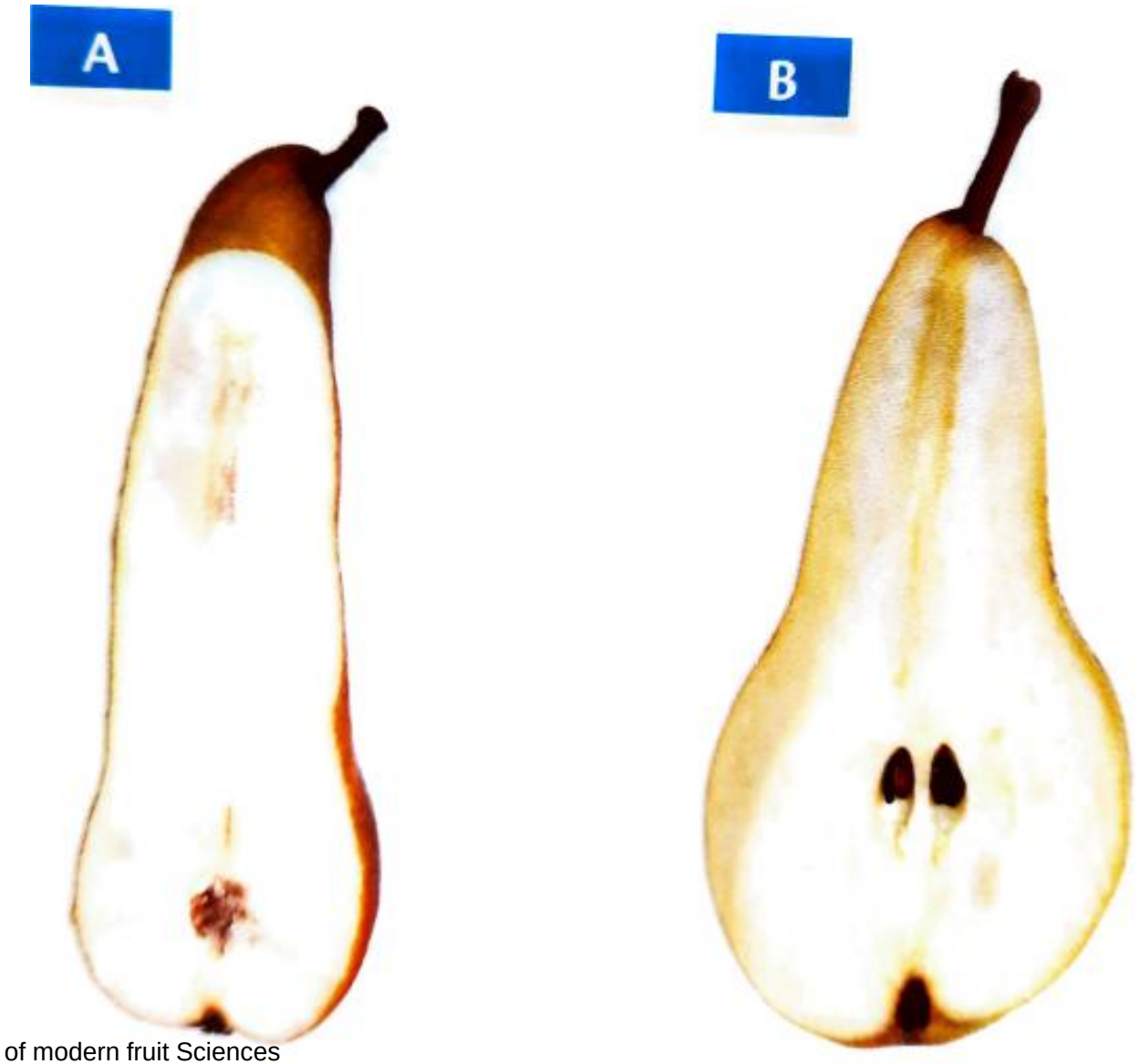

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FRUIT DEVELOPMENT

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- ✓ The fruits may derive from either the ovary development (**true fruits**) as for drupe and berry or other organs such as receptacle (**false fruits**) as for pome.
- ✓ Fleshy fruit development can be described according two models: **sigmoid** or **double sigmoid** curve

DRUPE and BERRY

POME FRUITS

Two main phase characterize fruit development:

- ✓ The length of *cell division* plays a relevant role in determining the final density of the fruit (number of cell per volume) at harvest → strong impact on storability and nutritional value
- ✓ *Cell expansion* is linked to increase of both vacuole nd cell wall volume

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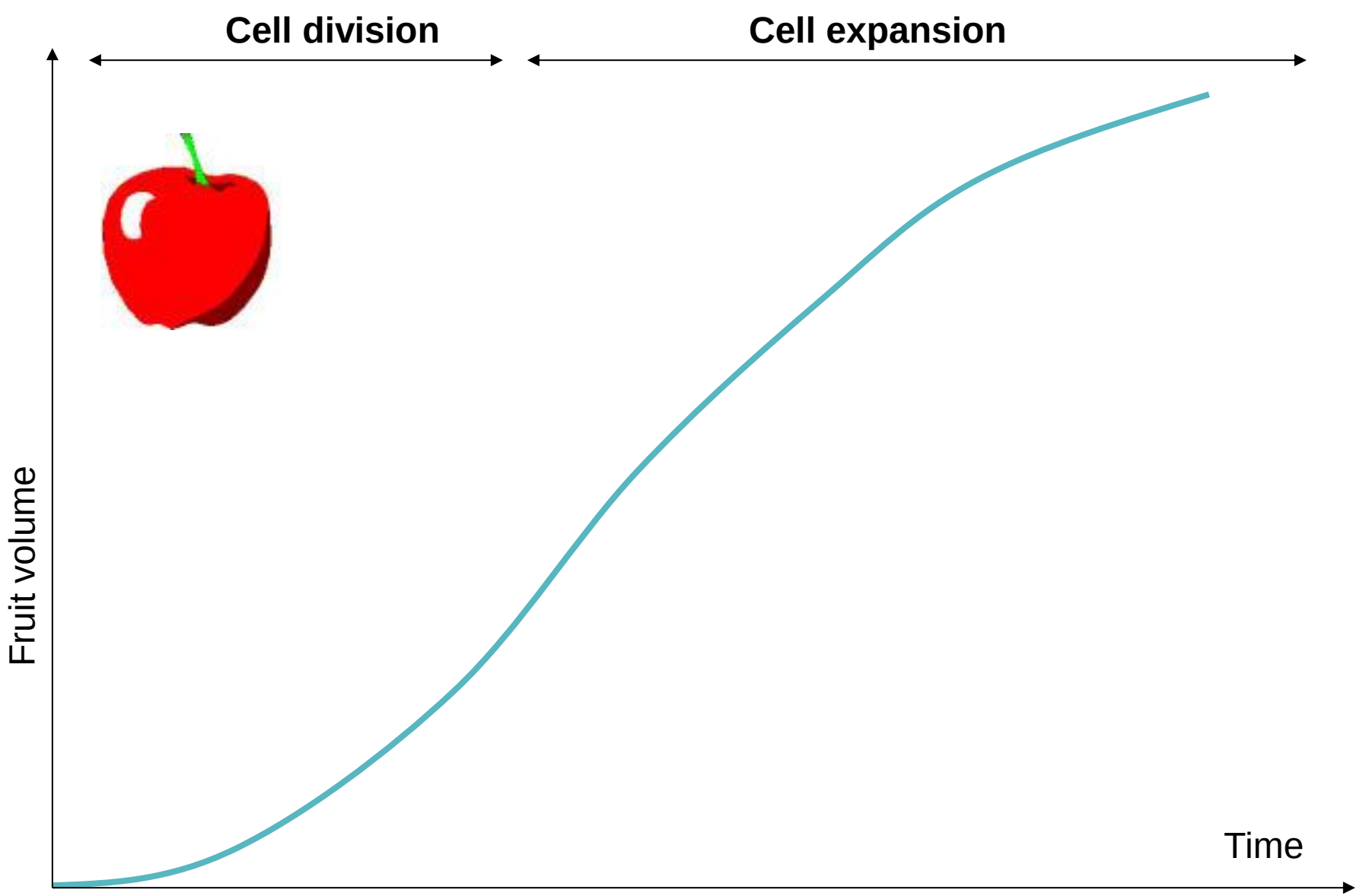

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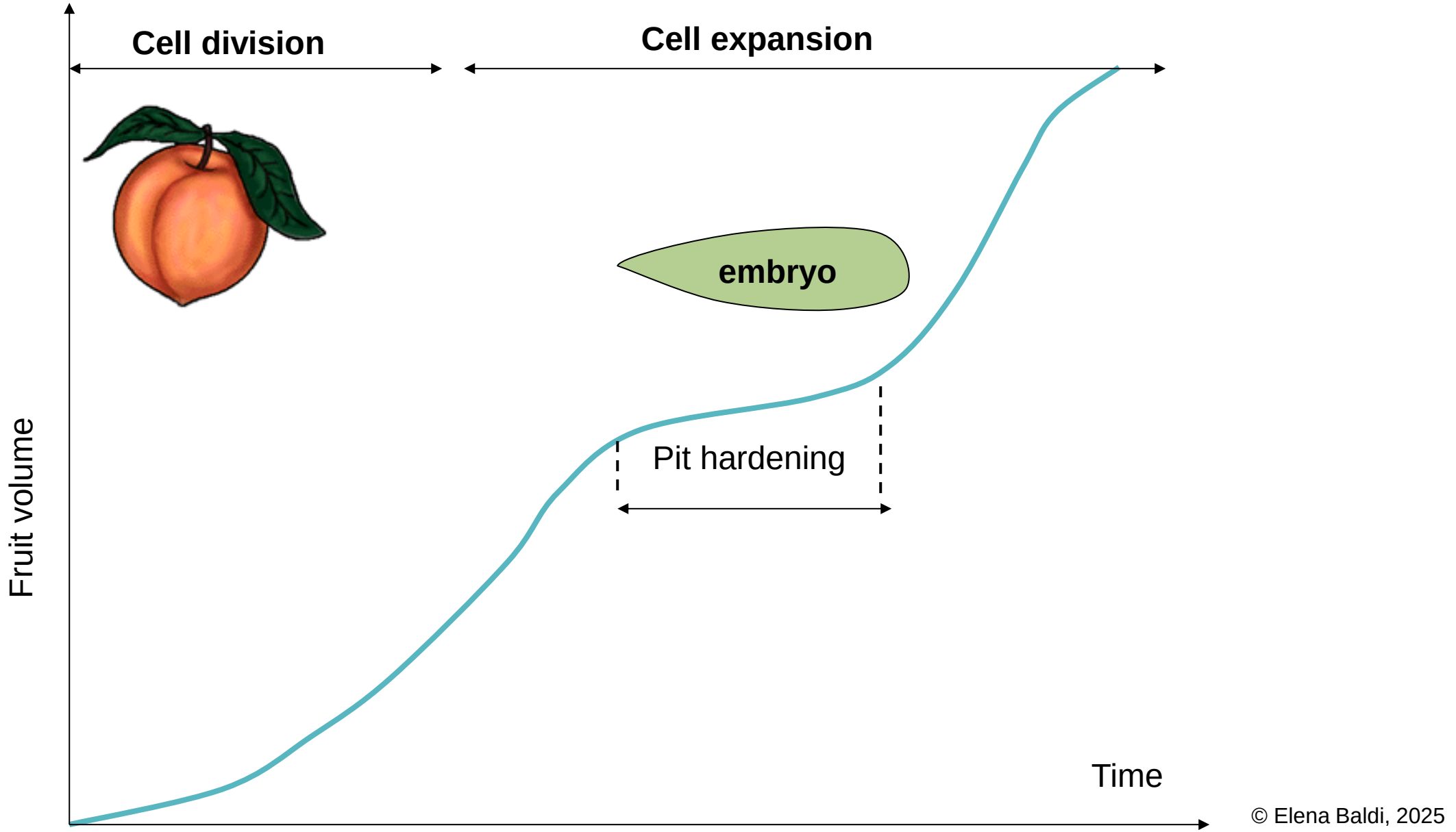

FRUIT RIPENING

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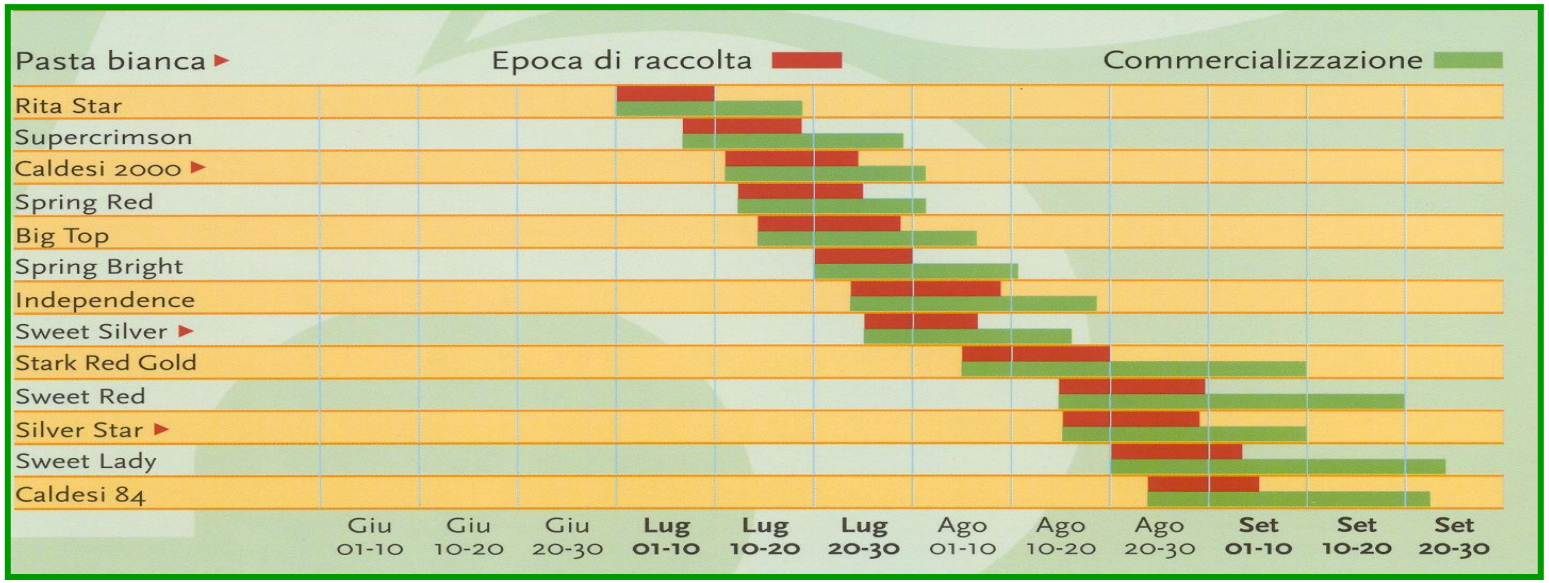
Is the summation of biochemical and physiological changes occurring at the terminal stage of fruit development and renders the fruit edible and desirable to seed-dispersing organism.

Fruit ripening phase varies between species, cultivar and also within the same plant.



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Fruit composition depends on several factors:

- Stage of ripening;
- Pedoclimatic conditions;
- Agronomic management (irrigation, fertilization);
- Position on the tree and quantity of fruits
- Post-harvest storage

Biochemical and physiological processes:

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- Change of colour → Degradation of chlorophyll and carotenoid and/or flavonoids accumulation
- Flesh softening → Depolymerization of cell wall components (idolization of insoluble protopectin to soluble pectin)

Trend of fruit hardness and concentration of soluble pectin during apple ripening

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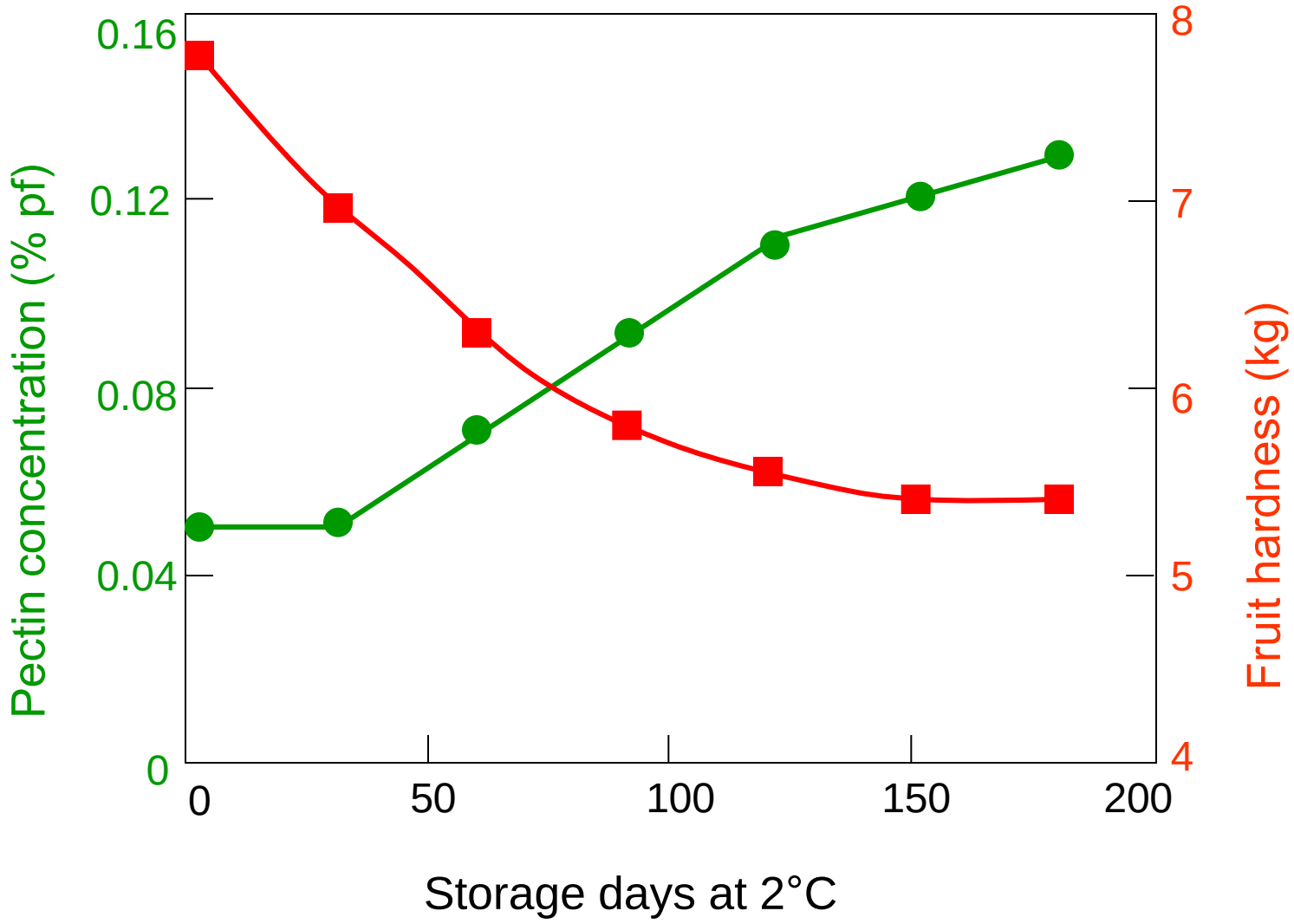

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- Increase of mono-and disaccharides → Fructose, glucose and saccharose (starch disappear)
- Decrease of organic acids → Citric, malic, tartaric, succinic acid

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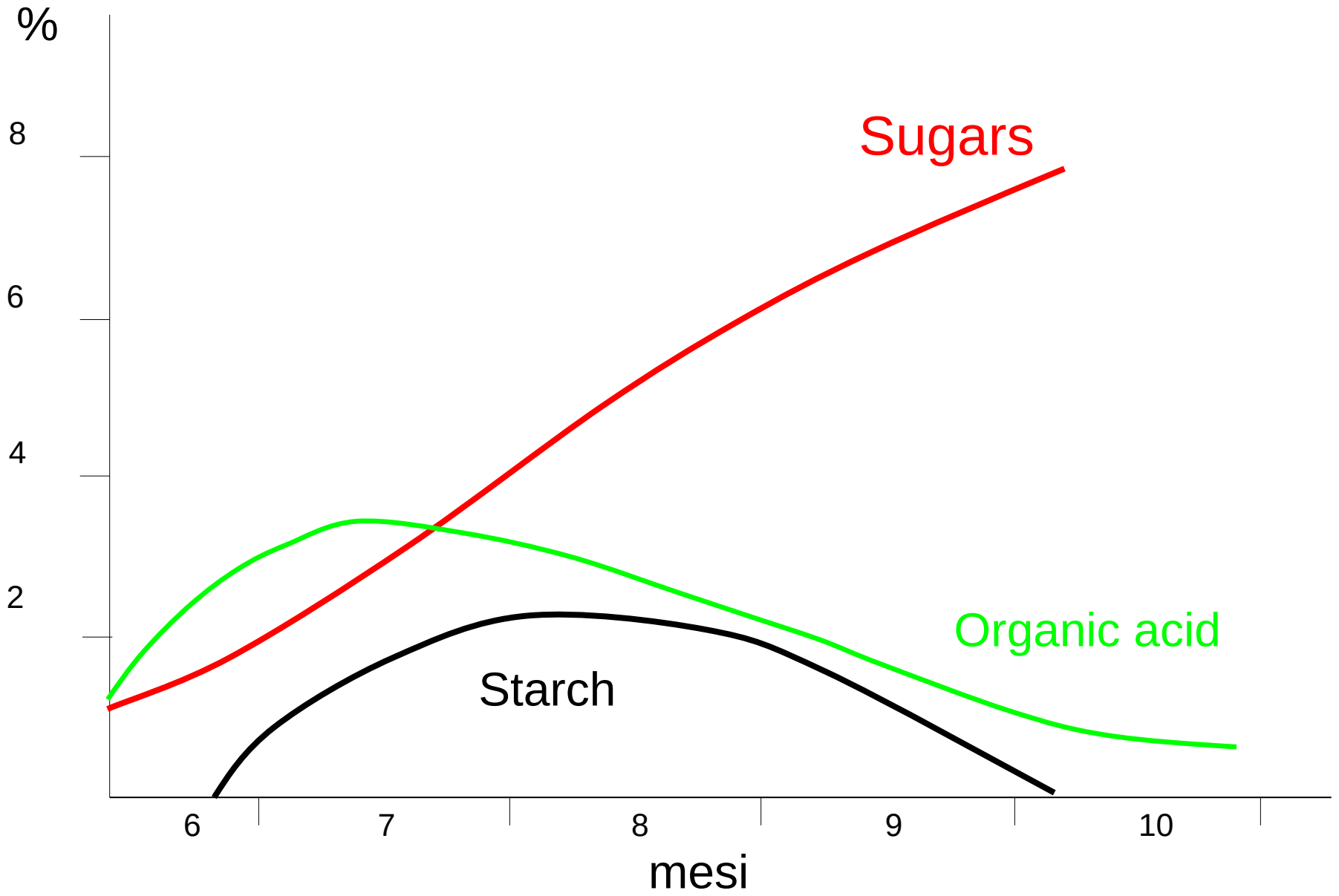

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- Increase of ethylene → Activation of enzymatic process that lead to increased permeability of cell wall
- Increase of abscisic acid → Mainly in seeds

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Fleshy fruits are divided into **CLIMACTERIC** and **NON-CLIMACTERIC** depending on the increase of respiration and of ethylene biosynthesis during ripening stage.

Tab. 5.2. Climacteric and non-climacteric fruits.

Non-climacteric	Ethylene production ($\mu L\ kg^{-1}\ h^{-1}$)
Blueberries	0.5–0.7
Cherry	0.3–0.4
Citrus spp.	0.1–0.2
Grapes	0.2–0.4
Pineapple	0.2–0.4
Strawberries	< 0.1

Climacteric	Ethylene production ($\mu L\ kg^{-1}\ h^{-1}$)
Apple	20–45
Apricot	500
Avocado	10–40
Banana	20–50
Kiwifruit	1–3
Mango	5–60
Melon	5–10
Peach	10–30
Pear	10–20
Plum	20–50
Tomato	

Sansavini et al. 2019. Principles of modern fruit Sciences

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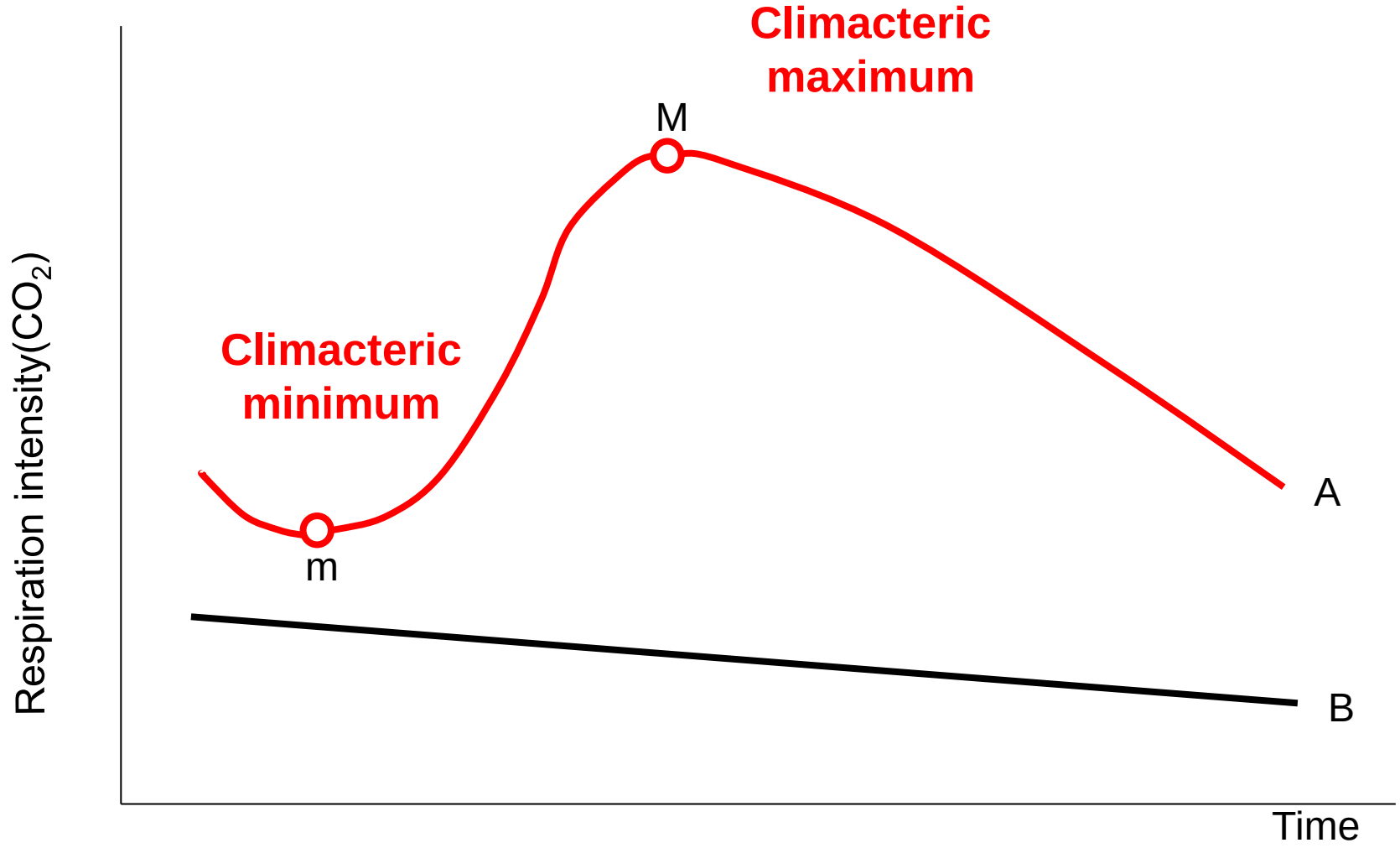

Non-climacteric fruit

Climacteric fruit

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Climacteric minimum

Optimal moment for harvest, fruits can be stored for long time in controlled conditions

Climacteric maximum

Fruits reach physiological ripening stage and have optimal organoleptic conditions

SUBSTANCES IN FRUITS

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- Polyphenols (flavonoids, anthocyanins, tannins, etc.
- Fat compounds (olive, walnut)
- Vitamins
- Volatile organic compounds - VOC's (alcohols, esters, aldehyde, chitons, terpenes)
- Antioxidants → reduce the formation of oxygen free radicals (O_2) as peroxide ($O_2^{\bullet}$), hydroxide (OH) etc and other reactive species of O_2 as H_2O_2, $½O_2$, HClO

COMPOUNDS WITH ANTIOXIDANT ACTIVITY

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- Polyphenols (flavonoids, anthocyanins, tannins, etc.
- Flavonoids (quercetin, epicatechin, catechin, chlorogenic acid)
- Vitamins of group B
- Tocopherols in dry fruits
- Carotenoids (β-carotene, β-criptoxantina)
- Ascorbic acid
- Coenzyme Q_{10}

COMPOUNDS WITH ANTIOXIDANT ACTIVITY

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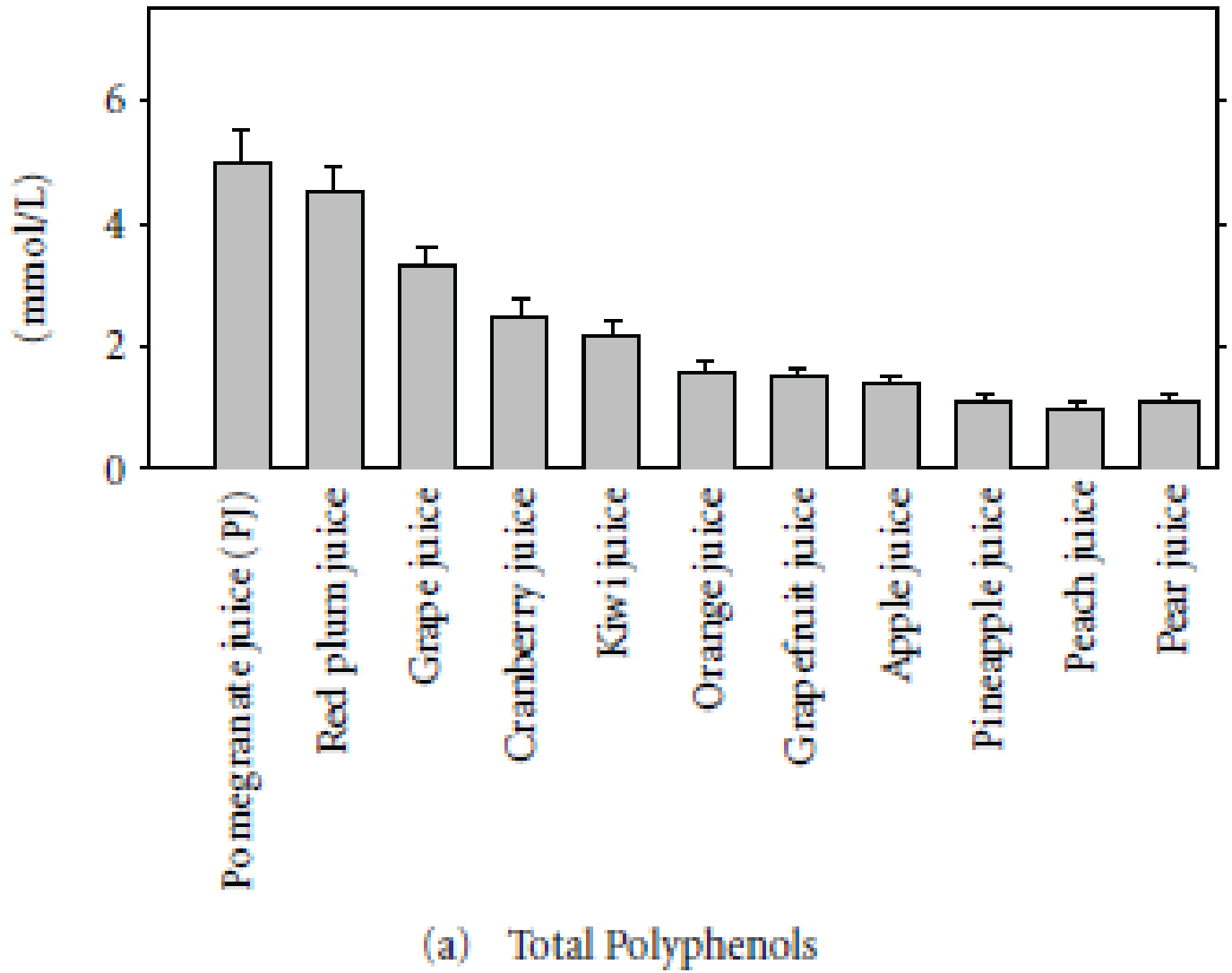
- Ascorbic acid
- coenzyme Q_{10}

Reduce cardiovascular disease, positive effect on some cancers, reduce cholesterol accumulation



(a) Total Polyphenols

Aviram and Rosenblat, 2012