

Model Answers (AS-2841)

B.Sc-III- Plant Physiology (LBC 301)

Section-A

Question 1. Multiple choice/Fill in the blanks

- (i) Macronutrients and Micronutrients
- (ii) Cohesion-
- (iii) Necrosis
- (iv) (b) C4 plants
- (v) (b) Reduction of CO₂
- (vi) (c) FMN
- (vii) (d) without O₂
- (viii) (d) They produce ATP
- (ix) (a) ABA
- (x)(d) All of the above

Section-B. Descriptive type questions

Question 2.

Translocation of solutes

Plants largely depend on the mineral nutrients present on soil for their metabolism. Along with water, minerals are taken up by plants. But absorption and translocation of minerals in form of solutes is independent of water uptake. There involve special physiological process in transportation of minerals. Mineral solutes dissolved in water are ascended up through xylem or across the cell wall and plasma membrane. Absorption of mineral involves the entry of solutes in form of ions from the soil solution into the root through various methods. But translocation or transportation of these solutes is a distinct physiological phenomena. Besides minerals, organic food prepared in leaves are distributed throughout the plant body in downward/upward (bidirectional) translocation through phloem in form of solutes.

There are several theories have been put forwarded by different physiologist to explain the method of transport of solutes in plants. These theories are outlined below.

(I) Protoplasmic Streaming Theory:

This theory was propounded by De Vries (1885) and supported by Curtis (1935). According to this theory the movement of solute is caused by combined effect diffusion and cytoplasmic streaming

Diffusion occurs from sieve tube to sieve tube across the porous sieve plate. By cytoplasmic streaming movement solutes are carried by up and down movement from one end of sieve to other end. This process continues to transport solute for a very little distance This process can be comparable to cyclosis, but its magnitude is very low.

Objections: Thaine reported that cyclosis does not occur in mature sieve tube cells.

(II) Transcellular Streaming Theory:

Thaine also suggested that. there are presence of transcellular fibrils in form of strands in the sieve tubes, which contain particles. These strands move up and down, so that the cell fluid containing solutes moves along these strands during longitudinal flow.

Thus transcellular steaming is an attractive mechanism which explains bi-directional translocation.

Objections:

There are many criticism of this theory, that how the bioenergy could be transformed in to a physical force within the sieve tube cells. This theory fails to explain how does fluid solutes other than the solid particles translocate. It also fails to explain whether the strands are solid or hollow.

(III) Contractile Protein Theory :

Fenson and Williams (1974) observed that a network of interlinked microfibrils in the sieve tube oscillated in a manner resembling flagellar lashing in other organisms like protozoa. Microfibrils composed of contractile threads of protein. The contractility is due to inter-conversion of protein to lecithin and vice versa.

This theory further explains that particles which are attached to microfibrils move with a bouncing motion.

(IV) Electro Osmotic Theory:

Spenner and jones (1958-1970) suggested that an electro osmotic mechanism may account for the translocation of sugars in the sieve tubes. This theory explains that the current of potassium ion passes through the sieve pores by electro-osmosis and the sugar molecules adhered tightly to K ions are carried along the sieve tubes through the pores.

There is no experimental support to this theory.

(V) Pressure Flow Theory:

This theory was postulated by Munch (1926) According to this theory, translocation is a kind of circulation like that taking place in blood of animals. In plants leaves acts as the pressure pump like the heart and sieve tubes acts as blood vessels. This theory believes that there is an osmotic mechanism involved in the movement of solute inside the phloem.

During photosynthesis cell sap concentration in mesophyll becomes high to increase the osmotic pressure, as a result of which water is absorbed so that turgor pressure, become high in mesophyll cells. This pressure transmitted to the phloem of leaf from mesophyll by plasmodesmata. Through these connections solution is forced into sieve tubes due to turgor pressure. Loss of solute from mesophyll compensated by the photosynthetic product.

This theory was supported by Crafts (1961), Esau (1966), Maskell(1921) and Zimmerman (1958).

But there are also criticisms of this theory-

1. It holds the view of unidirectional flow only.
2. It fails to explain active participation of cytoplasm
3. It does not explain the necessity of ATP for translocation

(VI) Volume Flow Theory:-

Eschrich, Ewart and Young (1972) were in the view that pressure differences which as a driving force for transportation of solute is more may localized, even at the level a individuals seive tubes. They mathematically analyzed the flow of solutions along tubular semi-permeable membrane and came to the conclusion that the factor for flow of solute depends on its volume rather than the pressure only.

(VII) Solution Flow Theory:-

Marshall and Wardlaw (1973) proposed that materials move in the form of a solution. Both solute and solvent travel concurrently obeying the principles of flow of solution. Different solutes move at same speed in the solution under the physical influence of solution in relation to the sieve pores.

(VIII) Active Mass Flow Theory:-

Mason and Phillips (1936) proposed that translocation takes place by active diffusion of sugars enmasse. They also found out that oxygen is required to maintain some special state of cytoplasm which enable translocation to occur.

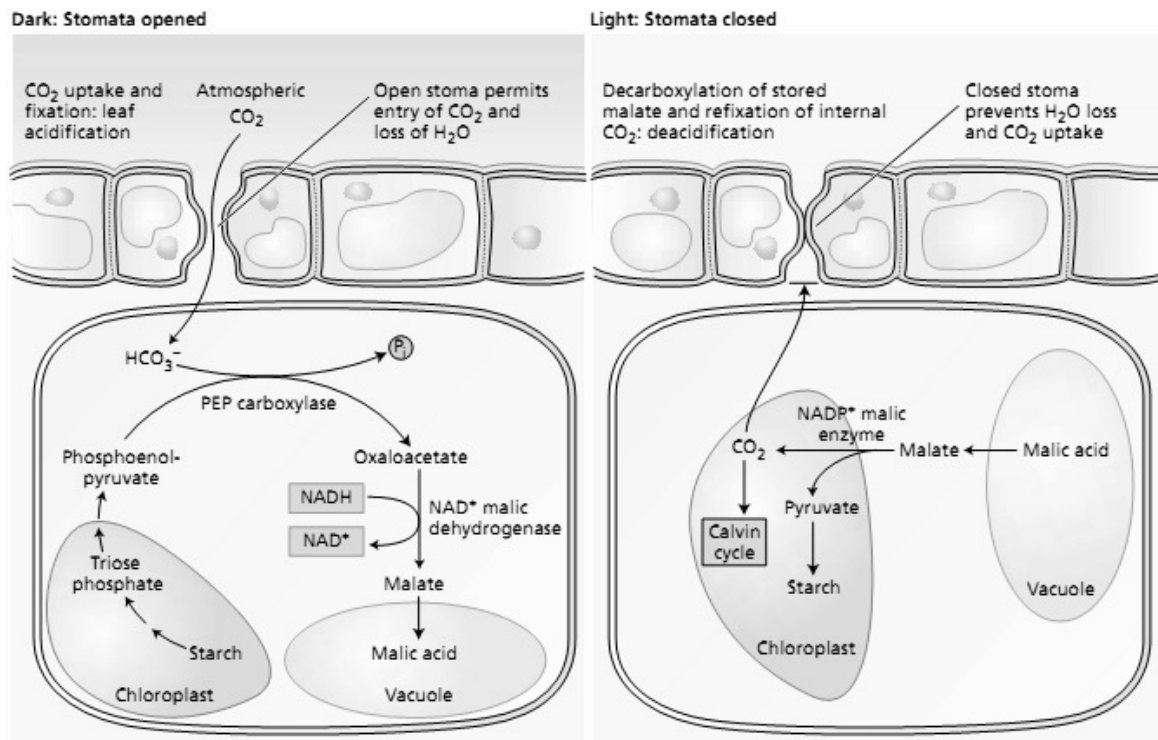
(IX) Bimodal Theory:-

Fenson (1971) proposed that two distinct processes are involved in the translocation. One is microperistaltic movement along hollow contractile protein fibrils present along the cytoplasm of sieve cells. Secondly he considered mass flow of solution around the contractile protein fibrils. He stated that microfibrillar material could also participate directly in the movement of solutes.

Factors effecting translocation of solute:-

There are several internal and external factors responsible for translocation of solute. Internal factors are cell sap concentration, volume of water absorbed by leaves, rate at which leaves produce sugar etc. External factors includes light, Oxygen availability, Moisture content, temperature etc, which influence the rate of translocation.

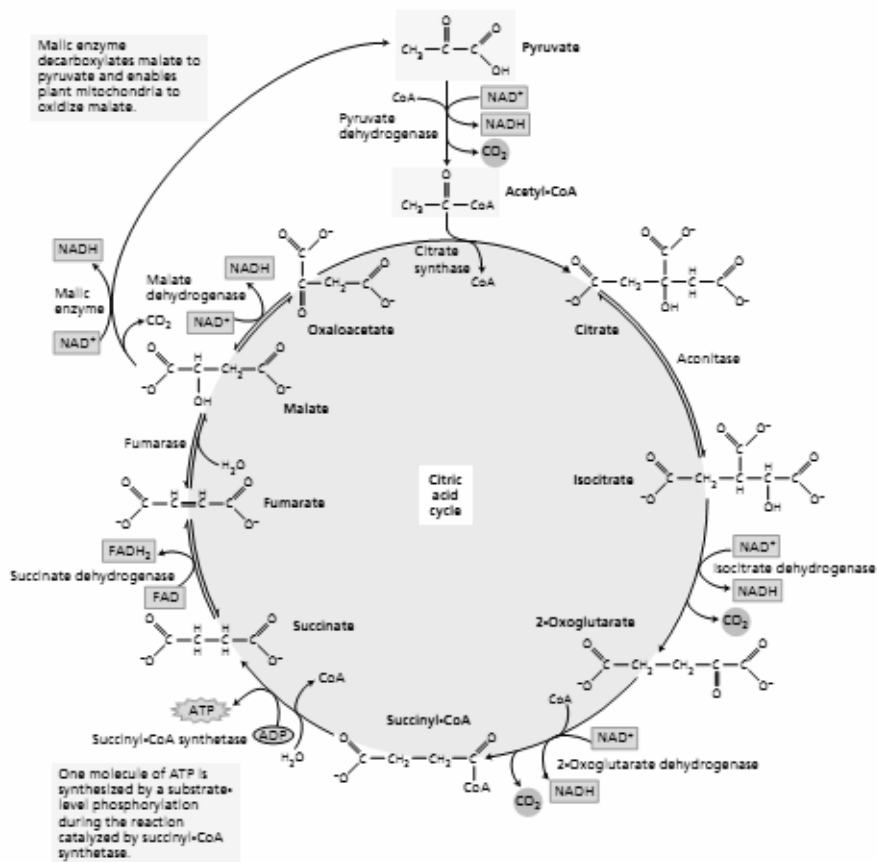
Question 3. CAM cycle



CAM plants such as cacti achieve their high water use efficiency by opening their stomata during the cool, desert nights and closing them during the hot, dry days. Closing the stomata during the day

minimizes water loss, but because H₂O and CO₂ share the same diffusion pathway, CO₂ must then be taken up at night. CO₂ is incorporated via carboxylation of phosphor-enolpyruvate to oxaloacetate, which is then reduced to malate. The malate accumulates and is stored in the large vacuoles that are a typical, but not obligatory, anatomic feature of the leaf cells of CAM plants. The accumulation of substantial amounts of malic acid, equivalent to the amount of CO₂ assimilated at night is nocturnal acidification of the leaf with the onset of day, the stomata close, preventing loss of water and further uptake of CO₂. The leaf cells deacidify as the reserves of vacuolar malic acid are consumed. Decarboxylation is usually achieved by the action of NADP-malic enzyme on malate. Because the stomata are closed, the internally released CO₂ cannot escape from the leaf and instead is fixed and converted to carbohydrate by the Calvin cycle. The elevated internal concentration of CO₂ effectively suppresses the photorespiratory oxygenation of ribulose bisphosphate and favors carboxylation. The C₃ acid resulting from the decarboxylation is thought to be converted first to triose phosphate and then to starch or sucrose, thus regenerating the source of the original carbon acceptor.

Question 4. Krebs cycle

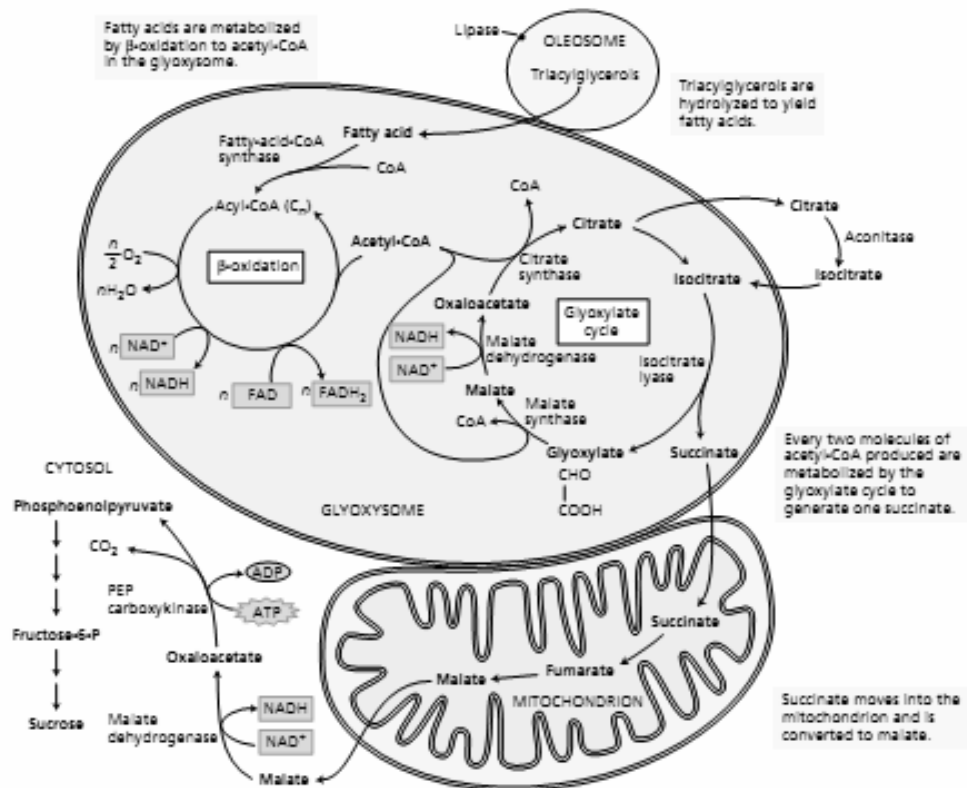


Unique Features of Kreb's cycle in Plants

It has all identical steps except a few with those carried out by animal mitochondria. For example, the step catalyzed by succinyl-CoA synthetase produces ATP in plants and GTP in animals. A feature of the plant citric acid cycle that is absent in many other organisms is the significant activity of NAD⁺ malic enzyme, which has been found in the matrix of all plant mitochondria analyzed to date. This enzyme catalyzes the oxidative decarboxylation of malate: Malate + NAD⁺ → pyruvate + CO₂ + NADH. The presence of NAD⁺ malic enzyme enables plant mitochondria to operate alternative pathways for the metabolism of PEP derived from glycolysis. Malate can be synthesized from PEP in the cytosol via the enzymes PEP carboxylase and malate dehydrogenase. Malate is then transported into the mitochondrial matrix, where NAD⁺ malic enzyme can oxidize it to pyruvate. This reaction makes possible the complete net oxidation of citric acid cycle intermediates such as malate or citrate. Alternatively, the malate produced via the PEP carboxylase can replace citric acid cycle intermediates used in biosynthesis. Reactions that can replenish intermediates in a metabolic cycle are known as anaplerotic. For example, export of 2-oxoglutarate for nitrogen assimilation in the chloroplast will cause a shortage of malate needed in the citrate synthase reaction. This malate can be replaced through the PEP carboxylase pathway. The presence of an alternative pathway for the oxidation of malate is consistent with the observation that many plants, in addition to those that carry out crassulacean acid metabolism (CAM), store significant levels of malate in their central vacuole.

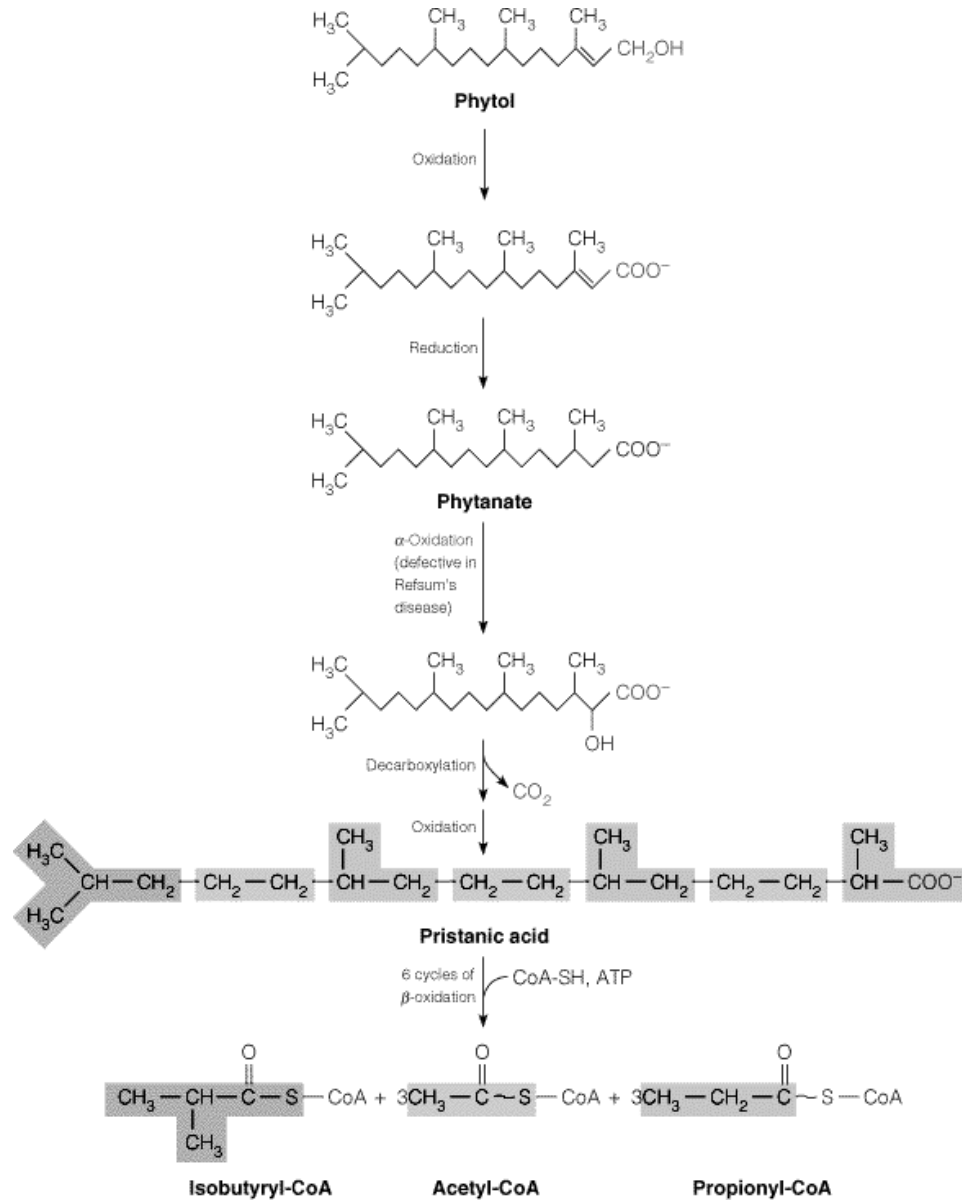
Question 6. Fat metabolism

β oxidation



After hydrolysis of the triacylglycerols, the resulting fatty acids enter the glyoxysome, where they are activated by conversion to fatty-acyl-CoA by the enzyme fatty-acyl-CoA synthase. Fatty-acyl-CoA is the initial substrate for the β -oxidation series of reactions, in which C_n fatty acids (fatty acids composed of n number of carbons) are sequentially broken down to $n/2$ molecules of acetyl-CoA. This reaction sequence involves the reduction of $1/2 O_2$ to H_2O and the formation of 1 NADH and 1 $FADH_2$ for each acetyl-CoA produced.

α oxidation



Question 7. Salt stress in Plants

On the basis of their responses to high concentration of salts in the soil, the plants are grouped into two categories: (i) Halophytes (ii) Glycophytes. Halophytes are native to saline soils, however, glycophytes cannot resist salts to the same degree as halophytes and exhibit signs of growth inhibition.

Halophytes can be further subdivide in to Euryhaline and Stenohaline based on their range of salt stress.

Salt injury

Both osmotic and specific ion effects. Can give rise to succulence, leaf edge burns, necrotic spots and chlorophyll bleach.

Salt resistance

(a) **Salt avoidance:** by (i) limiting germination (ii) growth and reproduction (iii) growing roots into non-saline regions (iv) limiting uptake of salts

(b) **Salt evasion:** In some halophytes such as *Tamarix pentandra*, heavy incrustations of salts can be observed on the surface of leaves as ecretion of excess salts. In *Atriplex spongiosa*, special salt glands (consisting of only 2 celss, a stalk and a terminal bladder) and found on the leaf surface.

(c) **Salt tolerance:** In plants where protoplasm can endure high salt content without apparent damage and functions normally.

Maize, peas, maize, peas, beans, onion, citrus are sensitive to salts stress. Cotton and Barley are moderately salt tolerant and sugarbeet and datepalms are highly salt tolerant species.

In many halophytes, compatible solutes (compatible osmotica) especially praline maintains the osmotic potential of the cells. Some other chemicals such as glycinebetaine and sugar alcohol sorbitol accumulate in the Cytosol without damaging the salt sensitive enzymes.

Question 8.

Vernalization

Vernalization (from Latin: vernus, of the spring) is the acquisition of a plant's ability to flower or germinate in the spring by exposure to the prolonged cold of winter.

Many temperate plants have a vernalization requirement and must experience a period of low winter temperature to initiate or accelerate the flowering process, or, as the case with many fruit tree species, to actually break dormancy, prior to flowering. Many plant species, including some ecotypes of *Arabidopsis thaliana* and winter cereals such as wheat, must go through a prolonged

period of cold before flowering occurs. This ensures that reproductive development and seed production occurs at the optimum environmentally favorable time, normally following the passing of winter. The needed cold is often expressed in chill hours.

Following vernalization, plants have acquired the competence to flower, although they may require additional seasonal cues or weeks of growth before they will actually flower. One of the most important influences that temperature has on the floral transition is the vernalization response. Vernalization activates a plant hormone called florigen present in the leaves which induces flowering at the end of the chilling treatment. Some plant species do not flower without vernalization. Many biennial species have a vernalization period, which can vary in period and temperature. Typical vernalization temperatures are between 5 and 10 degrees Celsius (40 and 50 degrees Fahrenheit).

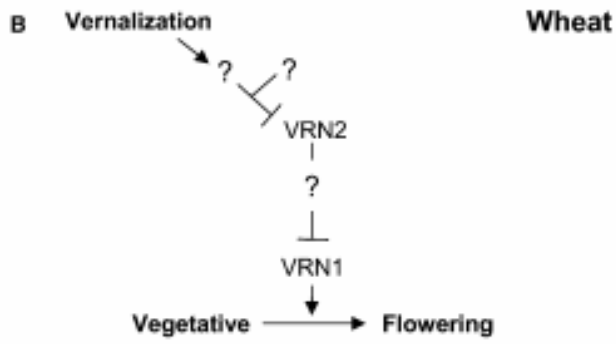
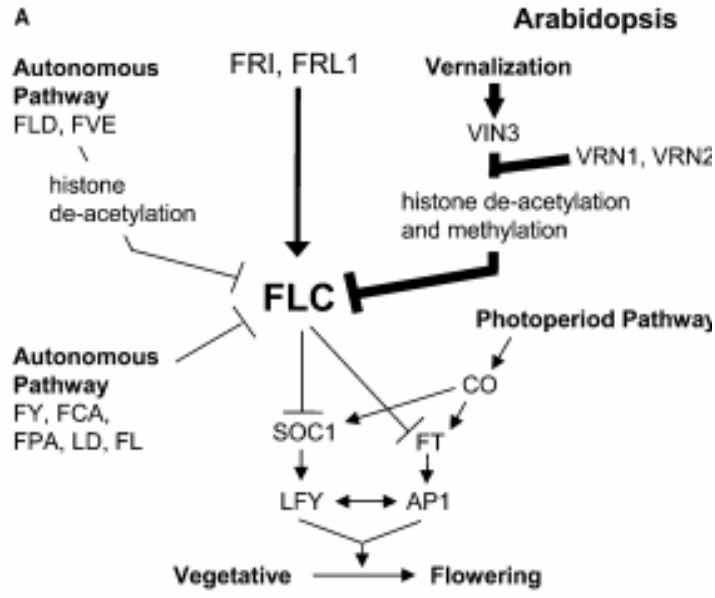
Vernalization in *Arabidopsis*

Vernalization is the process by which prolonged exposure to cold temperatures promotes flowering. Over the past century, this process has been studied extensively at the physiological level. Recent studies have provided some insight into the molecular basis of Vernalization.

In the much studied model species *A. thaliana*, the apical meristem, must be vernalized in order to promote flowering. Vernalization of the meristem appears to confer competence to respond to floral inductive signals on the meristem. A vernalized meristem retains competence for as long as 300 days in the absence of an inductive signal. It is possible to de-vernalize a plant by exposure to high temperatures subsequent to vernalization.

Devernalization

It is possible to devernalize a plant by exposure to high temperatures subsequent to vernalization. For example, commercial onion growers store seeds at low temperatures, however, devernalize them before planting, because they want the plant's energy to go into enlarging its bulb (underground stem), not making flowers.



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