Topic: AUXIN: TRANSPORT

Subject: Botany

M.Sc. (Semester II), Department of Botany
Course: MBOTCC- 7: Physiology and Biochemistry; Unit – III

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Auxin transport

The main axes of shoots and roots, along with their branches, exhibit apex–base structural polarity, and this structural polarity has its origin in the polarity of auxin transport. Soon after Went developed the coleoptile curvature test for auxin, it was discovered that IAA moves mainly from the apical to the basal end (*basipetally*) in excised oat coleoptile sections. This type of unidirectional transport is termed **polar transport**. Auxin is the only plant growth hormone known to be transported polarly.

A significant amount of auxin transport also occurs in the phloem, and this is the principal route by which auxin is transported *acropetally* (i.e., toward the tip) in the root. Thus, more than one pathway is responsible for the distribution of auxin in the plant.

Polar transport is not affected by the orientation of the tissue (at least over short periods of time), so it is **independent of gravity**.

Tissues differ in degree of polarity of IAA transport. In coleoptiles, vegetative stems, and leaf petioles, basipetal transport predominates. Polar transport of auxin in shoots tends to be predominantly basipetal. Acropetal transport here is minimal. In roots, on the other hand, there appear to be two transport streams. An acropetal stream, arriving from the shoot, flows through xylem parenchyma cells in the central cylinder of the root and directs auxin toward the root tip. A basipetal stream then reverses the direction of flow, moving auxin away from the root tip, or basipetally, through the outer epidermal and cortical cell files.

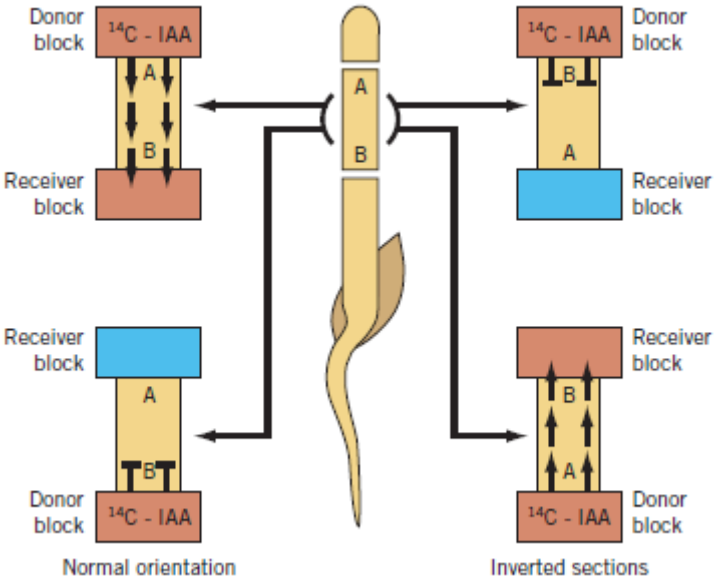

Fig. 1. Polarity in auxin transport in an oat coleoptile segment. The donor block contains 14C-IAA. Regardless of the orientation of the segment, translocation of the radio-labeled IAA is always from the morphologicallyapical end (*A*) to the morphologically basal end (*B*) of the segment.[1]

Fig. 2. Adventitious roots grow from the basal ends, and shoots grow from apical ends of grape hardwood cuttings, whether they are maintained in the inverted or upright orientation. The roots always form at the basal ends because polar auxin transport is independent of gravity. (From Hartmann and Kester 1983)[2]

[1] Hopkins and Huner (2009)

[2] Taiz and Zeiger (2002)

The major site of basipetal polar auxin transport in stems and leaves is the vascular parenchyma tissue. Coleoptiles appear to be the exception in that basipetal polar transport occurs mainly in the nonvascular tissues. Acropetal polar transport in the root is specifically associated with the xylem parenchyma of the stele.

Polar transport proceeds in a cell-to-cell fashion, rather than via the symplast. That is, auxin exits the cell through the plasma membrane, diffuses across the compound middle lamella, and enters the cell below through its plasma membrane. The loss of auxin from cells is termed *auxin efflux*; the entry of auxin into cells is called *auxin uptake* or *influx*. The overall process requires metabolic energy, as evidenced by the sensitivity of polar transport to O_2 deprivation and metabolic inhibitors. A **Chemiosmotic model** has been proposed by Rubery, Sheldrake and Raven in mid 1970s to explain polar transport of auxin.

According to this model, auxin uptake is driven by the proton motive force (ΔE + ΔpH) across the plasma membrane, while auxin efflux is driven by the membrane potential, ΔE. IAA is a weakly acidic, lipophilic molecule. Depending on the pH, IAA may exist in either the protonated form (IAAH) or the unprotonated, anionic form (IAA−). The cell wall space is moderately acidic with a pH of about 5.5. At that pH, approximately 20 percent of the IAA will be protonated (IAAH). Consequently, the cell wall space will contain both anionic and protonated IAA. Based on its lipid solubility, a small proportion of uncharged IAAH molecule would be expected to diffuse slowly across the plasma membrane from the cell wall space into the cell. The bulk of the IAA, however, will enter the cell as IAA− through an H+/auxin symport carrier (the influx carrier) that is uniformly distributed around the cell. Once in the cytoplasm, where the pH is closer to 7.0, IAAH will dissociate to IAA− and H+. The auxin is now trapped inside the cell because IAA− can not readily diffuse across the membrane. The key to the chemiosmotic model, however, is the existence of a carrier, located only in the basal membranes of the cell, which mediates the efflux of IAA− from the cell. It is the unique location of this efflux carrier, more than any other single factor, which establishes polarity in auxin transport. The repetition of auxin uptake at apical end of cell and preferential release from base of each cell in pathway gives rise to the total polar transport effect.

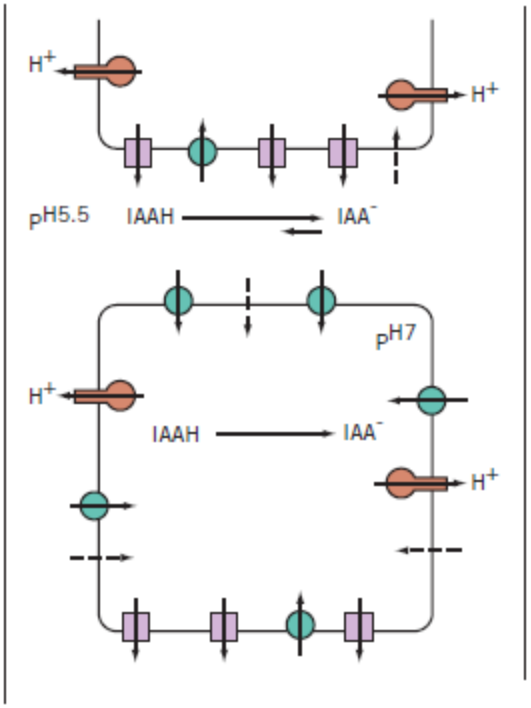

Fig. 3. The chemiosmotic-polar diffusion model for polar transport of IAA. In the acidic cell wall space (pH 5.5) approximately 20% of the IAA is protonated. Protonated IAA (IAAH) may enter cells by diffusion across the cell membrane (dashed arrows) while the anionic form (IAA−) may be taken up through AUX1 (circles),a proton/IAA symport carrier located randomly in the plasma membrane. Inside the cell (pH 7.0) the deprotonated form IAA− will dominate. IAA− can exit the cell only through efflux carriers of the PIN family (squares) which are located preferentially at the base of the cell. Membrane-bound ATPase-proton pumps help to maintain the appropriate pH differential across the membrane and provide protons for IAA/H+ symport. The uniquely basal location of the efflux carriers is the key to polar transport.[3]

Several compounds have been synthesized that can act as **auxin transport inhibitors** (**ATIs**), including NPA (1-*N*naphthylphthalamic acid) and TIBA (2,3,5-triiodobenzoic acid). These inhibitors block polar transport by preventing auxin efflux. Flavonoids like naturally occurring aglycone serve as endogenous ATIs. These compete with NPA for binding site on membranes.

Most of the IAA that is synthesized in mature leaves appears to be transported to the rest of the plant **non- polarly** via the phloem. Auxin, along with other components of phloem sap, can move from these leaves up or down the plant at velocities much higher than those of polar transport. This transport is mainly passive, not requiring energy directly. This transport is principal pathway for long distance auxin transport in root.

[3] Hopkins and Huner (2009)

Polar transport and phloem transport are not independent of each other. Studies with radiolabeled IAA suggest that in pea, auxin can be transferred from the non-polar phloem pathway to the polar transport pathway.

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