Topic: **AUXIN: BIOSYNTHESIS**

Subject: Botany

M.Sc. (Semester II), Department of Botany
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Biosynthesis of auxin

Two pathways are known for auxin biosynthesis, tryptophan dependent and tryptophan independent pathways (IAA or Indole acetic acid is structurally related to amino acid tryptophan).

[I] Tryptophan dependent pathway

Since the 1930s, when K.V. Thimann first observed the synthesis of IAA in the mold *Rhizopus suinus*, which had been fed the tryptophan, the conversion of tryptophan to IAA has been studied in vivo in more than 20 different plant species and in vitro with atleast 10 different cell free enzyme preparations.

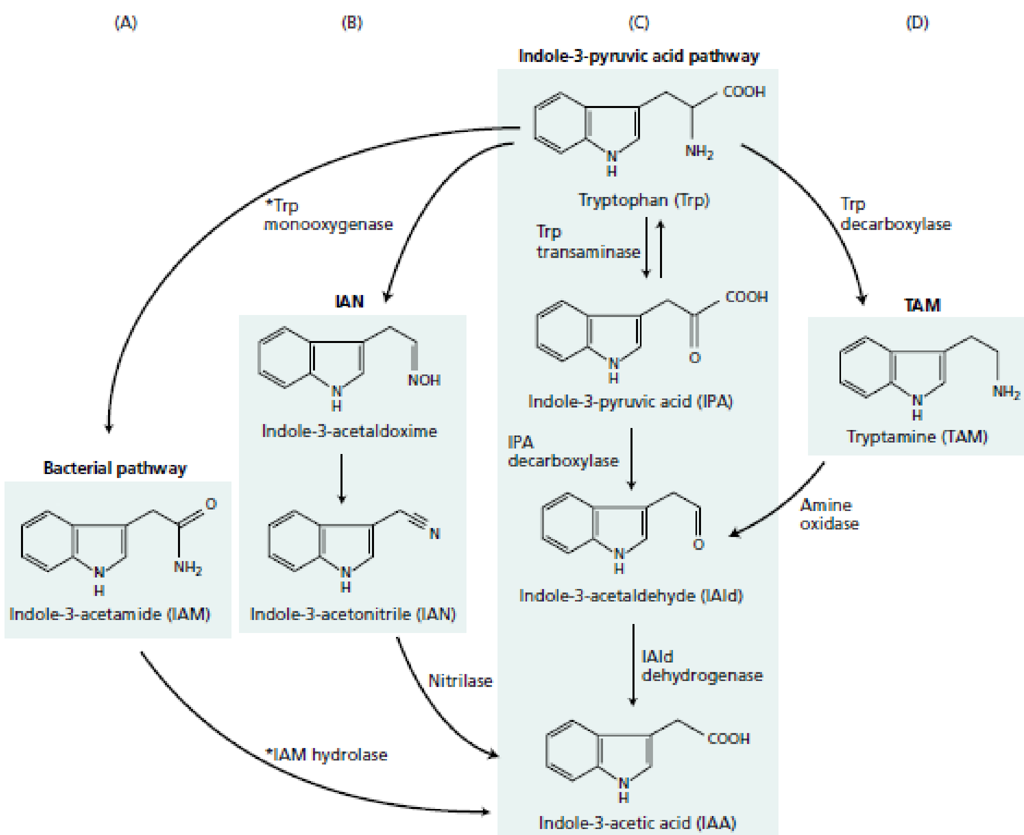

Fig. 1. Tryptophan-dependent pathways of IAA biosynthesis in plants and bacteria. The enzymes that are present only in bacteria are marked with an asterisk. (After Bartel 1997.)

[A] The IAM pathway; [B] The IAN pathway; [C] The IPA pathway; [D] The TAM pathway

In most plants, synthesis of IAA (IPA pathway) occurs in three steps,

a) Removal of amino group on the tryptophan side chain and forming indole-3-pyruvic acid (IPA); catalyzed by tryptophan amino transferase, a widely distributed multispecific enzyme.

b) Decarboxylation of IPA to form indole-3-acetaldehyde (IAld), catalyzed by indole-3-pyruvate decarboxylase.

c) Finally, IAld is oxidized to IAA by a specific dehydrogenase.

IPA pathway is found in most higher plants. Species generally not having IPA pathway have TAM pathway (here, deamination and decarboxylation reactions are reversed). Tomato has both IPA and TAM pathways.

IAN pathway is mostly present in members of the families Brassicaceae, Poaceae, and Musaceae. Recently, nitrilase like genes are identified in Cucurbitaceae, Solanaceae, Fabaceae, and Rosaceae.

IAM pathway is present in pathogenic bacteria.

[II] Tryptophan independent pathway

The mechanism of this pathway is still not very clear. “Although a tryptophan-independent pathway of IAA biosynthesis had long been suspected because of the low levels of conversion of radiolabeled tryptophan to IAA, not until genetic approaches were available could the existence of such pathways be confirmed and defined. Perhaps the most striking of these studies in maize involves the *orange pericarp* (*orp*) mutant, in which both subunits of the enzyme tryptophan synthase are inactive. The *orp* mutant is a true tryptophan auxotroph, requiring exogenous tryptophan to survive. However, neither the *orp* seedlings nor the wild-type seedlings can convert tryptophan to IAA, even when the mutant seedlings are given enough tryptophan to reverse the lethal effects of the mutation. Despite the block in tryptophan biosynthesis, the *orp* mutant contains amounts of IAA 50-fold higher than those of a wild-type plant (Wright et al. 1991). Signficantly, when *orp* seedlings were fed [15N] anthranilate, the label subsequently appeared in IAA, but not in tryptophan.

These results provided the best experimental evidence for a tryptophan-independent pathway of IAA biosynthesis. Further studies established that the branch point for IAA biosynthesis is either indole or its precursor, indole-3- glycerol phosphate. IAN and IPA are possible intermediates, but the immediate precursor of IAA in the tryptophan-independent pathway has not yet been identified”.[1]

[1] Taiz and Zeiger (2002)

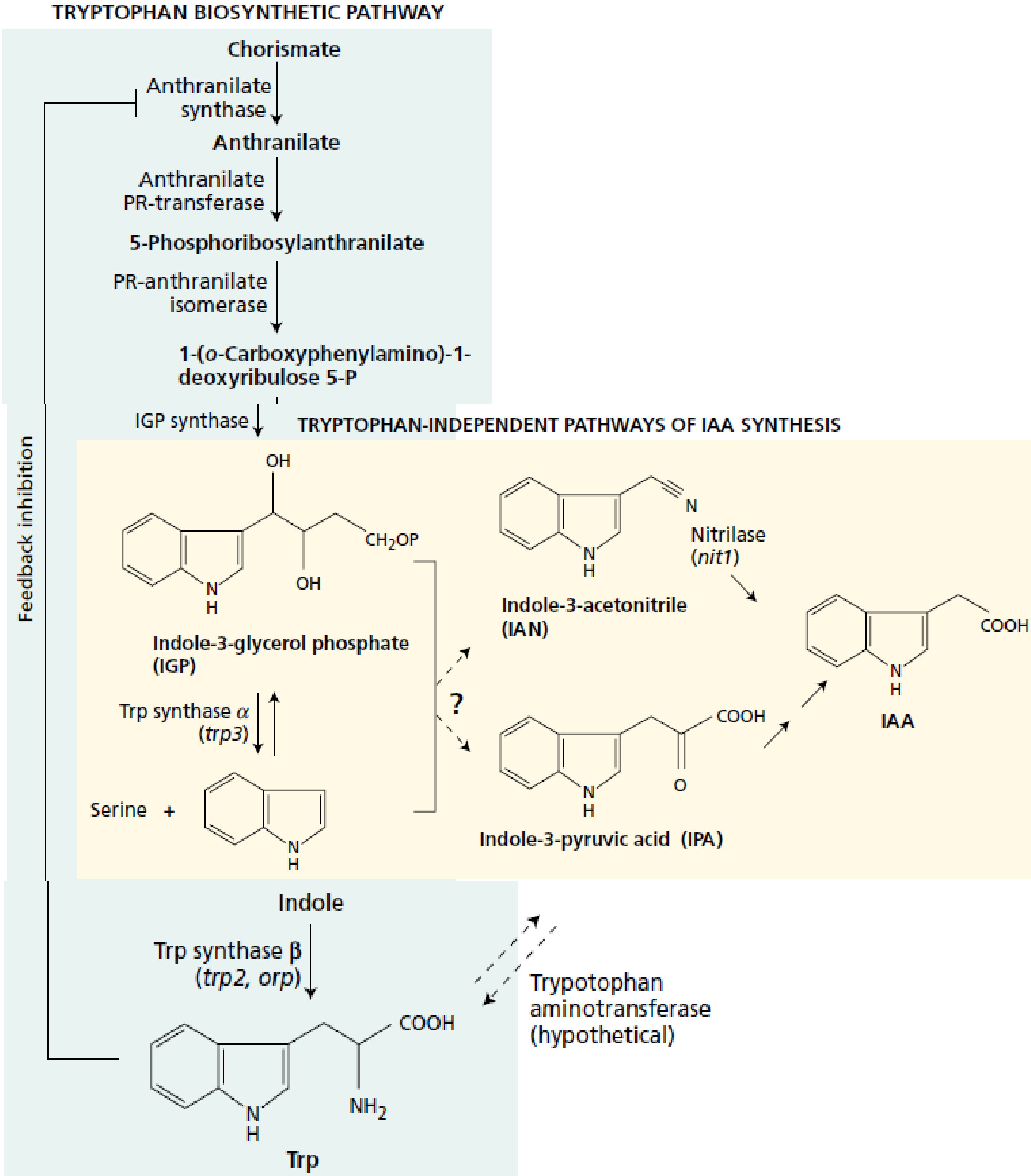

Fig. 2. Tryptophan-independent pathways of IAA biosynthesis in plants. The tryptophan (Trp) biosynthetic pathway is shown on the left. The branch-point precursor for tryptophan-independent biosynthesis is uncertain (indole-3-glycerol phosphate or indole), and IAN and IPA are two possible intermediates. PR, phosphoribosyl. (After Bartel 1997.)

Forms, biodegradation and sub-cellular pools of IAA

- IAA, the most abundant form of auxin in plants, exists mainly in 2 forms-

  a) *Free IAA* - biologically active form, highest concentration in apical meristems of shoots and in young leaves.
  b) *Conjugated /Bound IAA* – Hormonally inactive. Majority of auxin is in this form. IAA is conjugated to both high and low molecular weight compounds (e.g. IAA- glucan and IAA – N- aspartate respectively).

- Like IAA biosynthesis, the enzymatic breakdown (oxidation) of IAA may involve more than one pathway. Earlier, it was believed that peroxidative enzymes are chiefly responsible for IAA oxidation, primarily because these enzymes are ubiquitous in higher plants. However, two other oxidative pathways are more likely to be involved in the controlled degradation of IAA, where the end product is oxindole- 3-acetic acid (OxIAA), a naturally occurring compound in the endosperm and shoot tissues of *Zea mays*. In one pathway, IAA is oxidized without decarboxylation to OxIAA. In another pathway, the IAA-aspartate conjugate is oxidized first to the intermediate dioxindole-3-acetylaspartate, and then to OxIAA.

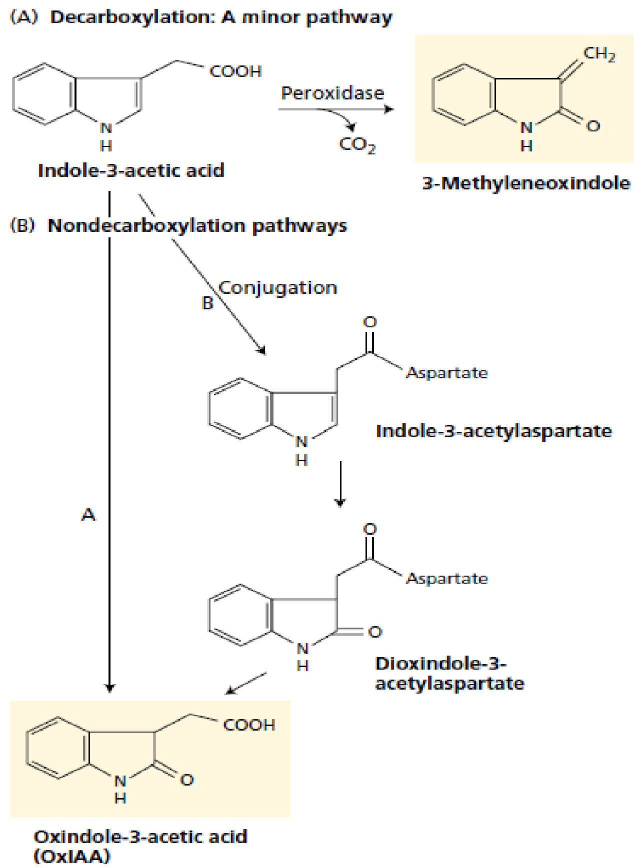

Fig. 3. Biodegradation of IAA. (A) The peroxidase route (decarboxylation pathway) plays a relatively minor role. (B) The two nondecarboxylation routes of IAA oxidative degradation, A and B, are the most common metabolic pathways.[2]

- Sub-cellular pools of IAA are –
  a) Cytosol – 2/3 rd of IAA are present here (mostly in the form of IAA conjugates).
  b) Chloroplasts – 1/3 rd of IAA.

[2] Taiz and Zeiger (2002)

Selected References

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