Gibberellins: A brief account

Subject: Botany

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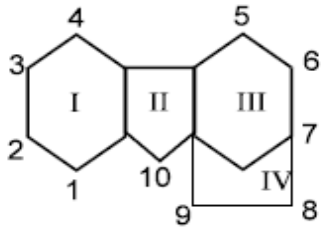
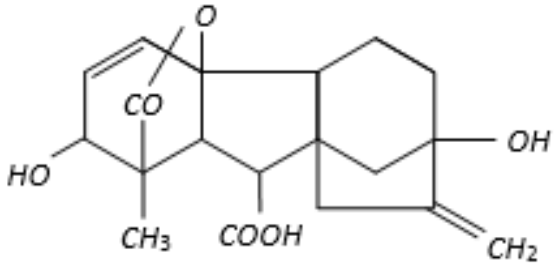
- Gibberellins are named after the fungus *Gibberella fujikuroi*, and have been identified for the first time in1926 by Kurosawa who identified the above fungus as the causal organism for the bakanae disease of rice (foolish seedlings).

- From the chemical point of view, they are tetracycle diterpenoids. The symbol used for gibberellin / gibberellic acid notation is GA, equipped with a numeric index starting with 1 (GA_1, GA_2, GA_3, …). There have been identified over 125 types of gibberellins, gibberellic acid 3 (GA_3) is considered more active.

- Gibberellins are found in the free state and bound with glycosides. They are basically unsaturated hydrocarbons with basic structure of 2 or more linked isoprene units. Basic ring is known as gibbane ring.



Gibbane ring



Gibberellic acid

Biosynthesis and transport

- Developing seeds and fruits show highest GA levels. Also occurs in young actively growing buds, leaves and upper internodes. May be conjugated to sugars forming GA glycosides.

- They mainly regulate the physiological processes, like, seed germination, mobilization of endosperm storage reserves, shoot growth, flowering, floral development, and fruit set.

- The passive transport of gibberellins happens with the phloemic and xylemic flow. Some authors claim that they migrate like organic metabolites and are accumulated in areas of growth.

- GA, constitutes a large family of diterpene acids, and are synthesized via terpenoid pathway, having 3 different stages.

Stage 1: **Cyclization**

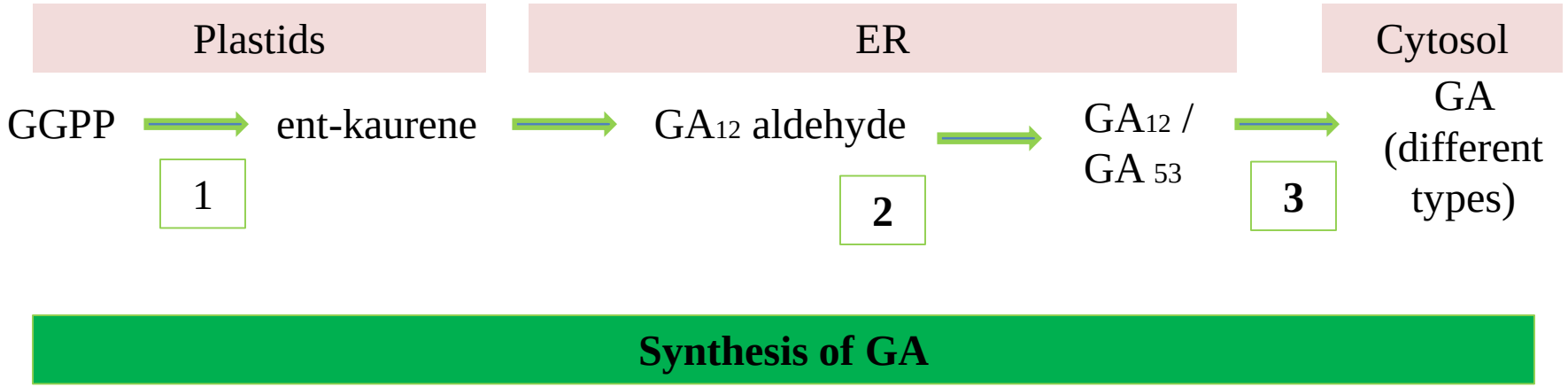
This reaction takes place in plastids, in which GGPP(Geranyl geranyl diphosphate) is converted to ent kaurene.

Stage 2: **Oxidation** to form GA_{12} aldehyde, and then to GA_{12} or GA_{53}

A methyl group is oxidized to a carboxylic acid and 1st GA is formed as reported in all the plants which is basically precursor of all other GA. All this takes place in ER (endoplasmic reticulum).

Stage 3: **Formation** of all other GA from GA_{12} or GA_{53}

GA_{12} is converted to other GA. Takes place in cytosol.



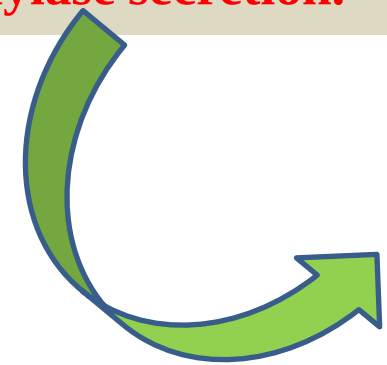
Synthesis of GA

Effects

- stimulates stem elongation in dwarf plants, so many dwarfism genes are gibberellin deficiency genes
- accelerates flowering in long day plants
- stimulates caryopsis germination in cereals, stimulates fruit growth
- determines changes in the photoperiod
- intervenes in ceasing bud dormancy. Brings seeds out of the dormant state and influences their germination by intensifying the formation of ribosomes and nucleic acids, but also by permeating membranes
- in the endosperm gibberellins participates in endoplasmic reticulum development, cell wall degradation and synthesis of a large number of hydrolytic enzymes that catabolize seed reserves and the formed metabolites ensure embryo and seedling development
- among the enzymes induced by gibberellins are α-amylase, some proteases, acid phosphatase, β-gluconase, α-glucosidase and ribonuclease

Composite model for the induction of α-amylase synthesis in barley aleurone layers by gibberellin.

A calcium- independent pathway induces α-amylase gene transcription;
a calcium-dependent pathway is involved in α-amylase secretion.



1. GA_1 from the embryo first binds to a cell surface receptor.

2. The cell surface GA receptor complex interacts with a heterotrimeric G-protein, initiating two separate signal transduction chains.

3. A calcium-independent pathway, involving cGMP, results in the activation of a signaling intermediate.

4. The activated signaling intermediate binds to DELLA repressor proteins in the nucleus.

5. The DELLA repressors are degraded when bound to the GA signal.

6. The inactivation of the DELLA repressors allows the expression of the *MYB* gene, as well as other genes, to proceed through transcription, processing, and translation.

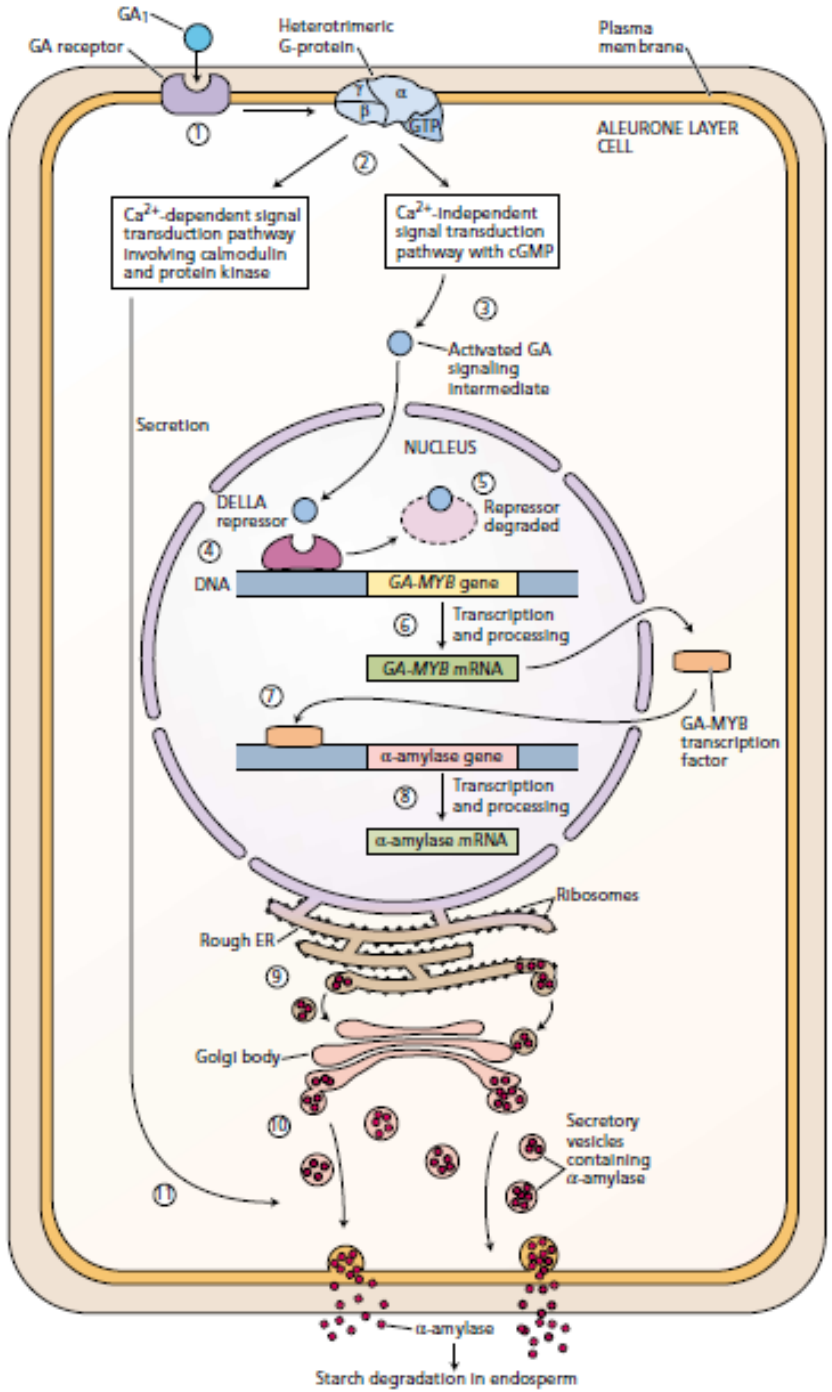
7. The newly synthesized MYB protein then enters the nucleus and binds to the promoter genes for α-amylase and other hydrolytic enzymes.

8. Transcription of α-amylase and other hydrolytic genes is activated.

9. α-Amylase and other hydrolases are synthesized on the rough ER.

10. Proteins are secreted via the Golgi.

11. The secretory pathway requires GA stimulation via a calcium–calmodulin-dependent signal transduction pathway.



- determines the sex in plants, causes parthenocarpy
- intensifies transpiration, photosynthesis and respiration
- by stimulating cell division, gibberellins control mitotic activity, activate enzymes responsible for phospholipid biosynthesis.

Practical applications. ….

Based on these properties, gibberellins have wide application in practice— they are used to stimulate tomato fruit formation, to stop dormancy in tubers, buds, seeds, etc, malting of barley, increasing sugarcane yield, plant breeding etc.

Cabbage, a long-day plant, remains as a rosette in short days, but it can be induced to bolt and flower by applications of gibberellin.
In the case illustrated, giant flowering stalks were produced. (© Sylvan Wittwer/Visuals Unlimited.)

Gibberellin induces growth in Thompson's seedless grapes. The bunch on the left is an untreated control. The bunch on the right was sprayed with gibberellin during fruit development. (© Sylvan Wittwer/Visuals Unlimited.)
Gibberellin stimulates the stalks to grow longer, thereby allowing the grapes to grow larger by alleviating compaction, and it promotes elongation of the fruit.

Suggested readings

- Maria Duca (2015). Plant Physiology. *Biological and Medical Physics, Biomedical Engineering*. Springer DOI 10.1007/978-3-319-17909-4 [ISBN 978-3-319-17909-4].

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- Salisbury, F.B. and Ross, C.W., 1934- (1985). *Plant physiology*. 3rd edition. Belmont, Calif Wadsworth Pub. Co.