GROWTH HORMONES: GIBBERELLIN

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For B.Sc. Part II (Sub.) Group C (Plant Physiology)

Lecture No. 42

Gibberellins ????

Gibberellins are a class of diterpene plant hormones that regulate various developmental processes including stem elongation, seed germination, dormancy, flowering, flower development, and leaf and fruit senescence.

Gibberellins are produced in the plant cell's plastids or the double membrane-bound organelles responsible for making food and are eventually transferred to the endoplasmic reticulum of the cell where they are modified and prepared for use .Gibberelllin is mostly found in plant roots and young leaves.

Discovery of Gibberellins

Although gibberellins did not become known to American and British scientists until the 1950s, they had been discovered much earlier by Japanese scientists. Rice farmers in Asia had long known of a disease that makes the rice plants grow tall but eliminates seed production. In Japan this disease was called the “foolish seedling,” or *bakanae*, disease.

- Plant pathologists investigating the disease found that the tallness of these plants was induced by a chemical secreted by a fungus that had infected the tall plants.
- This chemical was isolated from filtrates of the cultured fungus and called gibberellin after *Gibberella fujikuroi*, the name of the fungus.
- In the 1930s Japanese scientists succeeded in obtaining impure crystals of two fungal growth-active compounds, which they termed *gibberellin A and B.*
- Department of agriculture (USDA) in Peoria, Illinois—succeed in elucidating the structure of the material that they had purified from fungal culture filtrates, which they named *gibberellic acid:*

- At about the same time scientists at Tokyo University isolated three gibberellins from the original gibberellin A and named them gibberellin A1, gibberellin A2, and gibberellin A3. Gibberellin A3 and gibberellic acid proved to be identical.
- It became evident that an entire family of gibberellins exists and that in each fungal culture different gibberellins predominate, though gibberellic acid is always a principal component.

As we will see, the structural feature that all gibberellins have in common, and that defines them as a family of molecules, is that they are derived from the *entkaurene* ring structure.

- Japanese work came to light only after World War II. Gibberellic acid or GA_3 was isolated in pure form by **Brian et al in 1955**. **Cross (1961)** worked out the structure of gibberellic acid, GA_3 .
- It is chemically $C_{19}H_{22}O_6$. GA_3 is one of the most intensively studied gibberellin.
- A mixture of GA_4 and GA_7 is used commercially.
- Until now 125 different gibberellins have been identified. Many of them occur naturally in plants and fungi.
- *Gibberella fujikori* has as many as 15 gibberellins.

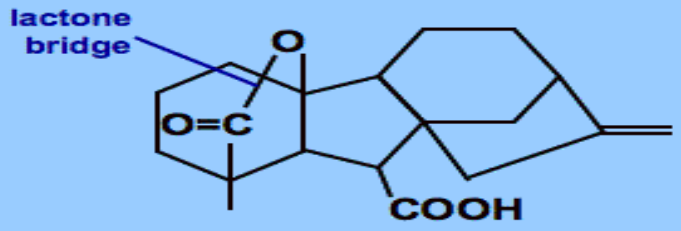
- A single plant also possesses a number of gibberellins.
- This is in contrast to auxin, where a single natural hormone occurs.
- Gibberellins are synthesized in the apical shoot buds (young leaves), root tips and developing seeds.
- The precursors for their synthesis is **mevalonic acid** (derived from acetyl coenzyme A).
- Gibberellin transport occurs through simple diffusion as well as through conducting channels.

Chemistry of gibberellins

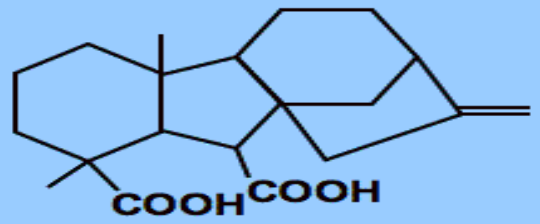
- Gibberellins are tetra cyclic diterpene acids. There are two classes based on the presence of either 19 or 20 carbons.
- The 19-carbon gibberellins, such as giberellic acid have lost carbon 20 and in place possess a five-member lactone bridge that links carbons 4 and 10. The 19-carbon forms are in general, the biologically active forms of gibberellins

- Hydroxylation also has a great effect on the biological activity of the gibberellins.
- In general, the most biologically active compounds are dihydroxylated gibberellins, which possess hydroxyl groups on both carbon 3 and carbon 13.
- Giberellic acid is a dihydroxylated gibberellins.
- The bioactive GAs are **GA1, GA3, GA4**, and **GA7**

There are two fundamentally different forms of Gibberellins

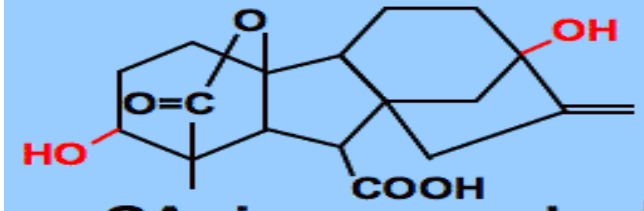


GA_9 is a C-19 gibberellin

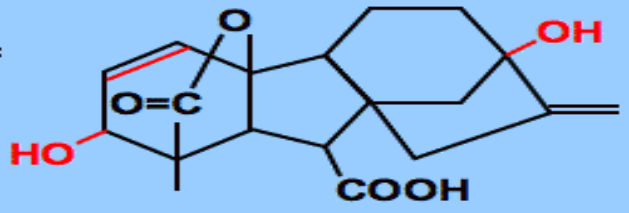


GA_{12} is a C-20 gibberellin

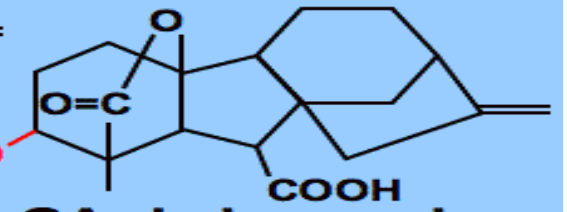
These are three active Gibberellins



GA_1 is more-polar



GA_3 is more-polar



GA_4 is less-polar

Physiological role of gibberellins

1. Stem elongation

➢ Gibberellin elongates the stem by elongation of the internode of the stem.

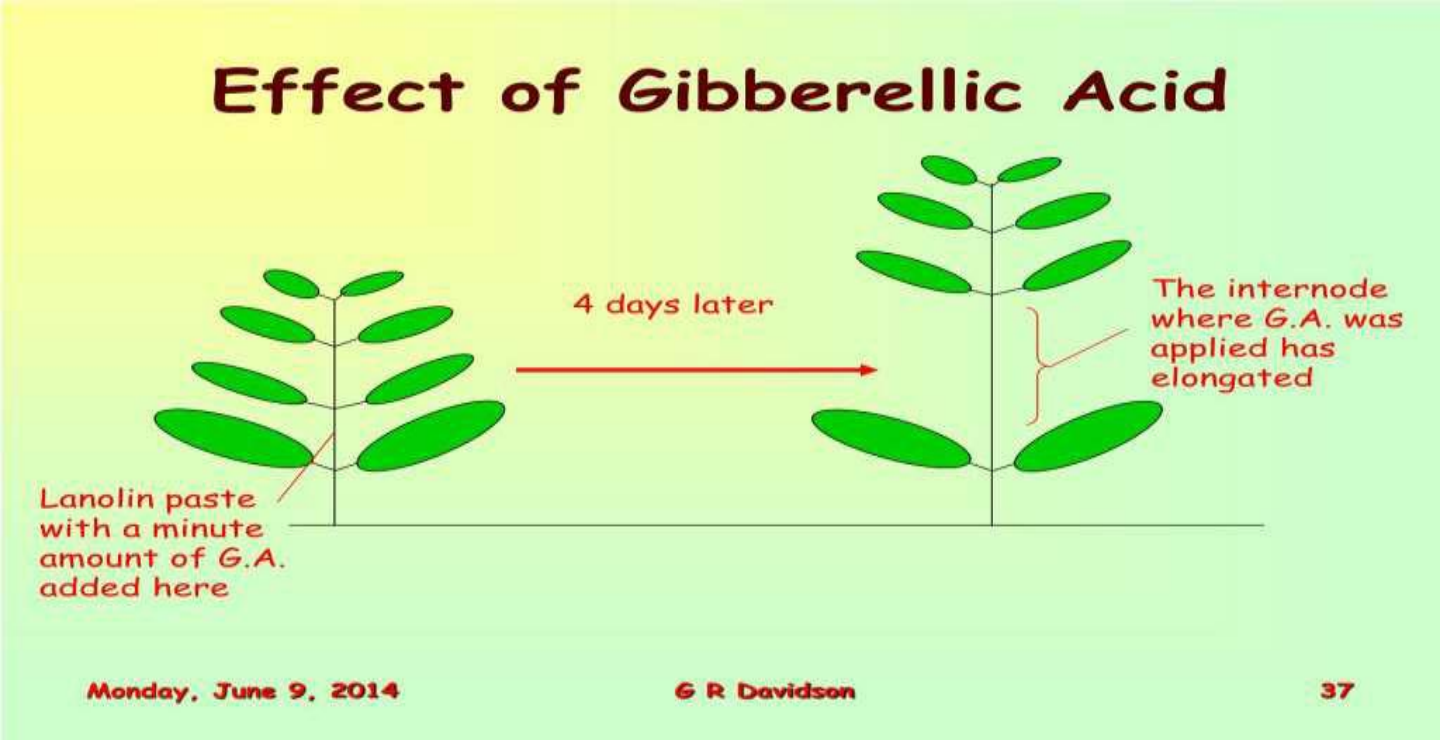
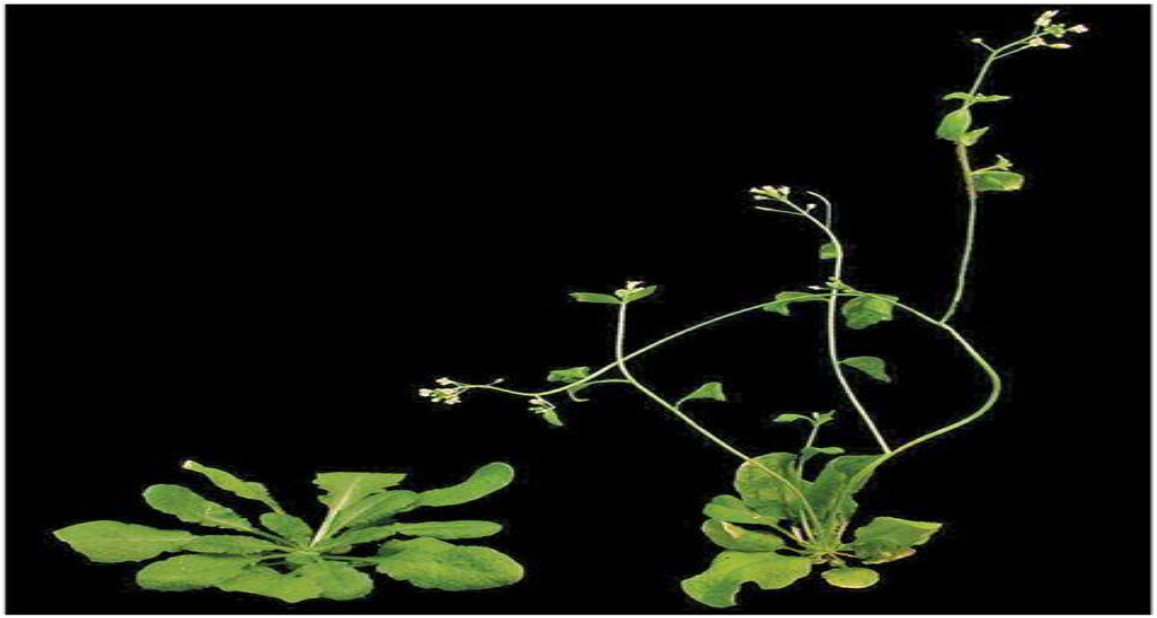


Figure: Effect of gibberellin on stem elongation

➢ Gibberellins enhance the growth of internodes and increases the crop productivity and sugar yield of the sugarcane crop

2. Bolting and Flowering

- Plants which are having rosette pattern of growth such as cabbage, henbane etc show remarkable growth after treatment with the gibberellins.
- Gibberellins induce stem elongation in these types of plants. this effect is called as **bolting effect (stem** elongation) and also induce flowering in rosette plants.
- Promote the flowering of long day plants in short days. eg. *Hyoscyamus niger*



(a) Rosette form (left) and gibberellin-induced bolting (right)

3. Gibberellins influence floral initiation and sex determination

- Gibberellin can substitute for the long day or cold requirement for flowering in many plants, especially rosette species. Gibberellin is thus a component of the flowering stimulus in some plants, but apparently not in others.
- In plants where flowers are unisexual rather than hermaphroditic, floral sex determination is genetically regulated. However, it is also influenced by environmental factors, such as photoperiod and nutritional status, and these environmental effects may be mediated by gibberellin.
- In maize, for example, the staminate flowers (male) are restricted to the tassel, and the pistillate flowers (female) are contained in the ear. Exposure to short days and cool nights increases the endogenous gibberellin levels in the tassels 100-fold and simultaneously causes feminization of the tassel flowers. Application of exogenous gibberellic acid to the tassels can also induce **pistillate flowers.**
- For studies on genetic regulation, a large collection of maize mutants that have altered patterns of sex determination have been isolated.

➢ Mutations in genes that affect either gibberellin biosynthesis or gibberellin signal transduction result in a failure to suppress stamen development in the flowers of the ear.

➢ Thus the primary role of gibberellin in sex determination in maize seems to be to suppress stamen development (Irish 1996).

➢ In dicots such as cucumber, hemp, and spinach, gibberellin seems to have the opposite effect.

➢ In these species, application of gibberellin promotes the formation of staminate flowers, and inhibitors of gibberellin biosynthesis promote the formation of pistillate flowers.

4. Gibberellins Promote Fruit Set

➢ Applications of gibberellins can cause *fruit set (the initiation* of fruit growth following pollination) and growth of some fruits, in cases where auxin may have no effect. For example, stimulation of fruit set by gibberellin has been observed in apple (*Malus sylvestris).*

5. Dormancy:

Gibberellins overcome the natural dormancy of buds, tubers, seeds, etc. and allow them to grow. In this function they are antagonistic to abscisic acid (ABA).

6. Seed Germination:

➢ During seed germination, especially of cereals, gibberellins stimulate the production of some messenger RNAs and then hydrolytic enzymes like amylases, lipases ribonucleases and proteases. The enzymes solubilize the reserve food of the seed. The same is transferred to embryo axis for its growth.

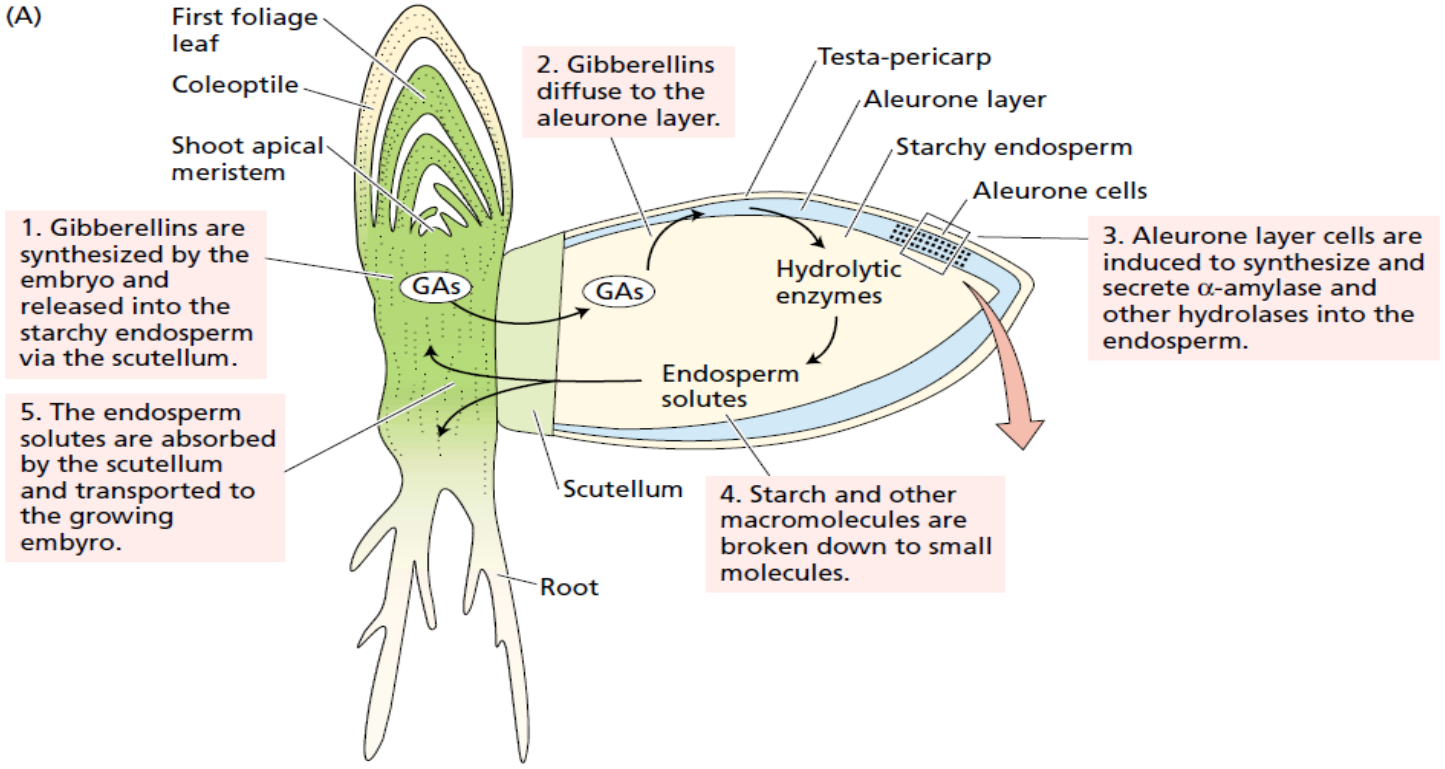


Figure: Structure of a barley grain and the functions of various tissues during germination .

7. Fruit Development:

Along with auxin, gibberellins control fruit growth and development. They can induce parthenocarpy or development of seedless fruits from unfertilized pistils, especially in case of pomes (e.g., Apple, Pear).

8. Vernalization:

Vernalization or low temperature requirement of some plants can be replaced by gibberellins.

9. Curvatures:

In Sunflower, phototropic and geotropic responses of shoot tips are due to redistribution of gibberellins.

Thank You!!!

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