Gibberellins – Regulators of Plant Height

1. Discovery
2. Chemical structure
3. Physiological Roles
4. Mechanism of action

Gibberellins - Discovery

- 1930s … “Bakanae” in rice seedlings
  - Caused by: Gibberella fujikuroi
- 1950s Gibberelic acid isolated from fungal culture
- 1958 Gibberelic acid (GA1) isolated from bean seeds

Gibberellin Structure

- ent-Gibberellane skeleton
- 4 rings
- 20 carbons
- GA stimulates stem growth
  - Internode elongation in dwarf plants
  - Genetic dwarfism …GA deficiency

Physiological effects of Gibberellins

- GA stimulates bolting in rosette plants
  - Cabbage
    - short days → rosette growth
    - long days → bolting
    - GA → bolting
- Floral initiation in Long day plants
  - Short days → vegetative
  - Long days → flowering
  - Short days + GA → flowering
- GA bypasses endogenous triggers of:
  - Day length
  - Age
  - Temperature

Physiological effects of Gibberellins
Physiological effects of Gibberellins

- GA regulates transition from juvenile to adult state
  - IVY: GA promotes adult to juvenile
  - Conifers: Promotes juvenile to adult

GA induces cone formation in juvenile conifers

Physiological effects of Gibberellins

- GA influences sex expression in flowers
  - Monocots: GA suppresses stamen development. e.g. corn
  - Dicots: Just the opposite. GA stimulates stamen development. e.g. cucumbers, hemp

Physiological effects of Gibberellins

- GA induces fruit set in some plants...apple and berries
- GA induces development of larger fruit

Commercial application of Gibberellins

1. Longer grape berry stalks
2. Delay senescence in citrus
3. Malting barley
4. Increase sugar cane yield (2 tons sugar/acre)
5. Promote seed production
   - Shortens juvenility in conifers
   - Allows beets and cabbage to bolt

Commercial application of Gibberellins

- GA inhibitors
  - Ancymidol (A-Rest)
  - Paclobutrazol (Bonzi)

- Function: Prevent elongation of many flowering plants
  - Control height growth in the culture of lilies, poinsettias, tulips, chrysanthemums, geraniums, and bedding plants.
  - Reduce lodging in cereal grains.
Gibberellins Part I

1. Detecting GA
2. GA synthesis – terpenoid pathway
3. Discoveries related to GA synthesis pathway
   - Mendel's peas
   - Environmental effects on GA biosynthesis
   - Photoperiodism
   - Vernalization

Gibberellins Part II

Gibberellin detection

1. Bioassay – dwarf rice sheath bioassay
2. GCMS

Gibberellin Synthesis – terpenoid pathway

1. It all starts with isoprene
   \[ \text{Isoprene} \rightarrow \text{ent-kaurene} \]
   \[ \text{Isoprene} \rightarrow \text{isopentenyl diphosphate} \]

1. Cyclization - Plastid synthesis of ent-kaurene

Plastids: make ent-kaurene from geranylgeranyl diphosphate

GGPP = Geranylgeranyl diphosphate

Gibberellin Synthesis

3. ER Oxidation reactions
carboxyl groups added
   hydroxyl groups added

4. Cytosol Oxidation reactions
   completes GA synthesis
   a. lactone ring forms
   b. hydroxylation

5. GA1 is active GA in cereals
   GA4 is active GA in Arabidopsis

GA Synthesis
Abbreviated Pathway

Plastid

ER

Cytosol
Phenotypes of wild-type and GA-deficient Arabidopsis mutants

Mendel’s Peas revisited
1. Mendel’s genetics
2. The biosynthetic pathway
3. The molecular genetics
1. Le allele converts GA20 -> GA1
2. Dwarf peas don’t convert GA20 to GA1
3. GA3 oxidase gene recessive allele has one base different from normal allele

Blocking GA Biosynthesis
1. inhibitors of GA synthetic pathway
   Blocked by AMO-1618

GA Inactivation by GA oxidase
Genetically engineered wheat plants with different levels of GA 2-oxidase under control of a constitutive promoter to inactivate GA1.

GA Promotes Elongation
GA affects Cell division & Cell elongation:
1) induces cyclin-dependent kinase gene expression in G1->S and G2->M
2) Modifies cell wall properties ...
   No osmotic effect
   No wall acidification
Mechanism of cell wall loosening?
GA may influence gene expression of an expansin named OsEXP4...

GA promotes Cell Division
GA increases cell division
Activates genes responsible for cyclin-dependent kinases affecting cell cycle at G1

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Activates genes responsible for cyclin-dependent kinases affecting cell cycle at G1
**Gibberellin Signal Transduction**

The Cereal Aleurone System

α-amylase

Time course of events in GA stimulation of α-amylase production

1. **Molecular Mechanism of GA Action**
   - GA secreted by embryo diffuses to aleurone
   - GA binds to G-Protein on surface of plasma membrane of aleurone cells... doesn’t enter cell.
   - CyclicGMP (cGMP) synthesis is stimulated by plasma membrane G-Protein activated by GA
   - Protein phosphorylation by protein kinases is the signaling pathway from plasma membrane to nucleus.
   - GA signaling intermediate blocks/degrades DELLA-domain repressor that represses GA-MYB gene.
   - Transcription factor GA-MYB is produced.
   - GA-MYB induces transcription of α-amylase gene
   - α-amylase gene synthesizes α-amylase
   - α-amylase secretion regulated by calcium-calmodulin pathway... secretes enzymes into endosperm for starch degradation

**Summary of GA action in aleurone**

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