Plant Growth Regulators/ phytohormones are simple molecules of diverse chemical composition.

1. **Auxin** was first isolated from human urine. It is generally produced at stem and root apex and migrate to site of action.
   Natural Auxin: Indole 3-acetic acid (IAA), Indole Butyric Acid (IBA)
   Synthetic Auxin: Naphthalene Acetic Acid(NAA), 2,4-Dichlorophenoxyacetic (2,4-D)

Discovery:

- Charles Darwin and his son Francis Darwin were performing an experiment on Phototropism when they observed that the coleoptiles (sheet protecting young shoot) of canary grass responded to unilateral illumination by growing towards the light source.
  It was observed if tip was cut no bending was caused. Hence concluded that, the tip was responsible for bending of entire coleoptile.
- Auxin was isolated by F.W. Went from tips of coleoptiles of oat seedlings.

Functions-

1. Cell enlargement. Eg: Xylem differentiation
2. Apical dominance i.e. increase in hight of plant and ingibit lateral growth of axillary buds.
3. Cell division
4. Promote abscission of older leaves & fruits and Inhibit in younger.
5. Induce Parthenocarpy. Eg: Tomato
6. Used as Herbicides. Eg: 2,4-D kill dicot weed in monocot crops.

2. **Gibberellins** (terpenes)- are more than 100 forms named as GA_1, GA_2, GA_3.... GA_{100}. The most common & first discovered is GA_3 (Gibberellic Acid).

Discovery:

- The 'bakanae disease or foolish seedling' (plant increase in height with partially or empty grains) of rice seedlings is caused by fungal pathogen *Gibberella fujikuroi*. E. Kurosawa found that this disease is caused due to presence of Gibberellic acid.

Functions-

1. Internodal stem elongation hence overcome dwarfism.
2. Spraying GA in Juvenile conifers hasten (fast) maturity hence promoting flowering & early seed production.
3. Seed germination by breaking seed dormancy.
4. Speed up malting process in brewing industry.
5. Bolting (internode elongation just prior to flowering) in beet, cabbages & many plants with rosette (leaves in cluster) habit.
6. Increase length of axis. Increase grapes stalk length.

3. **Cytokinin's (adenine (purines) derivatives like kinetin (N6-furfurylamino purine), Zeatin)- Only Basic Hormone**
   Most common forms include kinetin, zeatin, etc. They are mainly synthesized in roots.
   Discovery: F. Skoog & co-worker observed that from internodal segments of tobacco stems, the callus proliferated only if nutrients medium was supplemented with extracts of vascular tissue, yeast extracts, coconut milk or DNA.
   Later Skoog & Miller identified and crystallized the active substance called kinetin from autoclaved herring sperm DNA. Kinetin does not occur naturally in plants (was thought till 1966)

   Zeatin (isolated from Plant source corn-kernels & coconut milk)
   Natural Cytokinin's synthesised in region of rapid cell division (Root apices, shoot buds, young fruit etc.

Functions-

1. Cell division(cytokinesis) and cell differentiation (Essential for tissue culture).
2. Help produce new leaves, chloroplast, lateral shoot growth & adventitious shoot.
3. Overcome apical dominance by promoting lateral development.
4. Promote nutrient mobilisation that delay senescence.

Ethylene (C_2H_4) – it is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal growth. Synthesised in large amount by the tissue undergoing senescence.
Discovery: Cousins confirmed the release of a volatile gaseous substance (ethylene) from ripened oranges that hastened ripening of bananas.
Functions–

1. Influence horizontal growth of seedling, swelling of axis & apical hook formation in dicot seedling.
2. Inhibition of longitudinal growth.
3. Promote internode/petiole elongation in deep water rice plants.
4. Increase surface area by promoting root growth and root hair formation.
5. Initiate flowering and for synchronising Fruit-set in pineapples. Induce flowering in Mango.
6. Promote Senescence & abscission.
7. Promote Fruit Ripening hence widely used in agriculture.
8. Enhance respiration rate during fruit ripening called **Respiration Climactic.**

Abscisic Acid (derivatives of carotenoids) **–** Stress hormone. Produced in roots & terminal buds at the top of plant.
Discovery: In mid 1960 reported 3 chemically identical Growth inhibitor: **1st –** abscisin II,. 2nd – Inhibitor -B, 3rd Dormin.
Function-

1. Inhibit growth & metabolic activity.
2. Induce Seed & Bud dormancy and inhibit seed germination.
3. Induce leaf senescence & abscission.
4. Induce Parthenocarpy
5. Control seed development, maturation and dormancy (helps seeds to withstand desiccation and other factors unfavourable for growth)
6. Increase plant tolerance hence called **Stress Hormone. Ex:** Closer of Stomata in extreme condition.

Interaction of Plant Growth Regulators
Seed Dormancy – GA & ABA (Antagonist)
Apical Dominance- Auxin & Cytokinin (Antagonist)
Tissue Culture – Auxin & Cytokinin (Agonist)
Abscission- Auxin & Ethylene (Agonist)
Flowering in Pine apple- Auxin & Ethylene (Agonist)