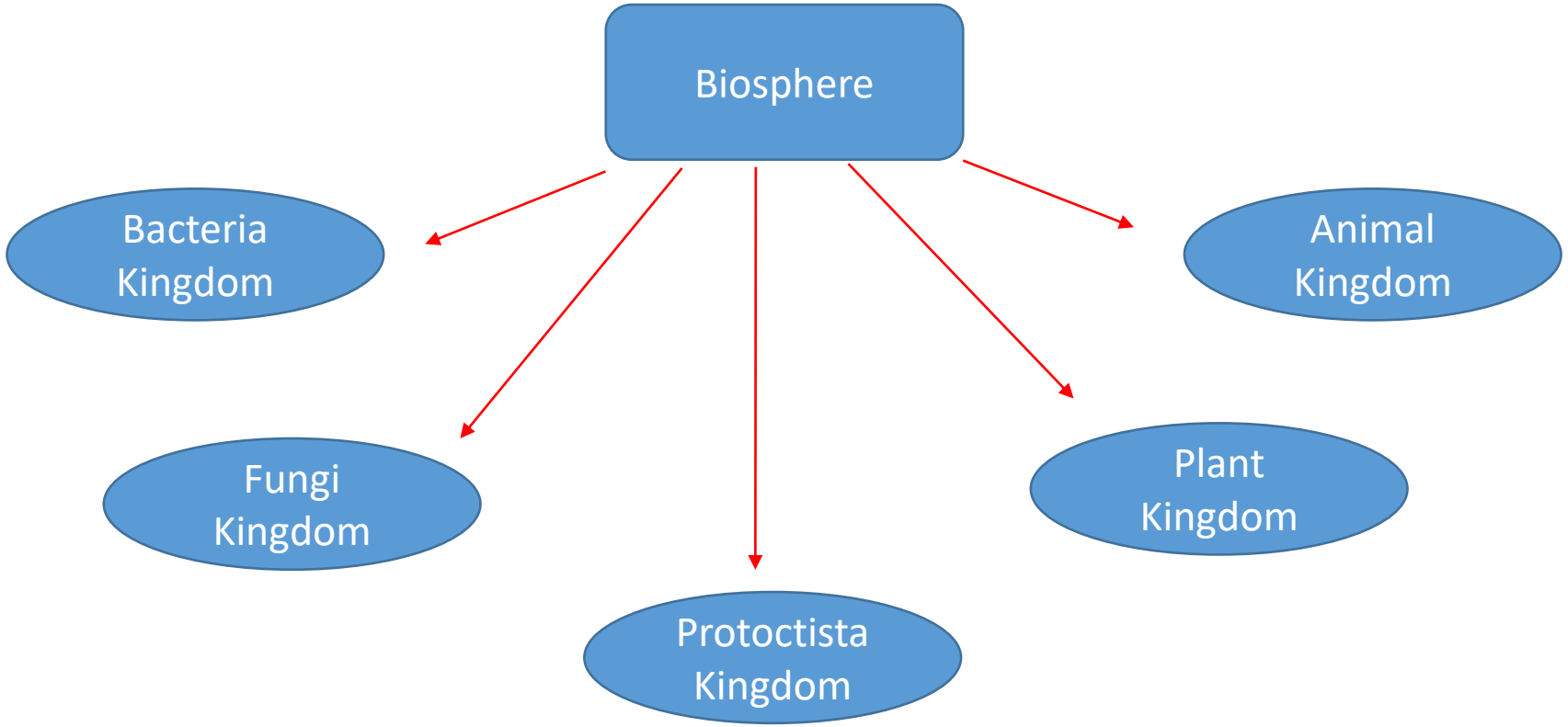
INTRODUCTION

TO

HERBAL MEDICINE


Biosphere
Bacteria Kingdom
Animal Kingdom
Fungi Kingdom
Plant Kingdom
Protoctista Kingdom

Plant Kingdom

Angiosperms

Gymnosperms

Pteridophytes

Bryophytes

What is Plant?

- Plant is multicellular
- Living organism
- Is non-motile (not capable of independent movement)
- Has eukaryotic cells (cells have distinct membrane-bound organelles, including a nucleus with chromosomes)
- Has cell walls comprised of cellulose
- Is autotrophic:- capable of sustaining itself through conversion from inorganic substances to organic material

What is natural product?

- A natural product is a chemical compound or substance produced by a living organism
- They may be extracted from tissues of plants, marine organism or micro - organism fermentation
- Any biological molecule is a natural product
- In general, the term is reserved for secondary metabolites (carotenoids, saponines, phenolic compounds, alkaloids, terpenes etc.), produced by an organism
- They are not essential for normal growth, development or reproduction and its survival

History of plant natural products

- The history of the extraction of natural products dates back to Mesopotamian and Egyptian times, where production of perfumes or pharmaceutically - active oils and waxes was a major business.
- In archaeological excavations 250 km south of Baghdad extraction pots from about 3500 BC were found, made from a hard, sandy material presumably air - dried brick earth.
- Several Sumerian texts also confirm that a sophisticated pharmaceutical and chemical technology existed

History of plant natural products

- Natural extracts were subjected to separation into component compounds, which were then purified and analyzed.
- In the late 1800's, synthetic methods were being developed for some of these natural compounds.
- It was discovered that natural extracts had more complex compositions and properties than salts and minerals.

Natural products are often divided into two major classes:

1. **Primary metabolites**

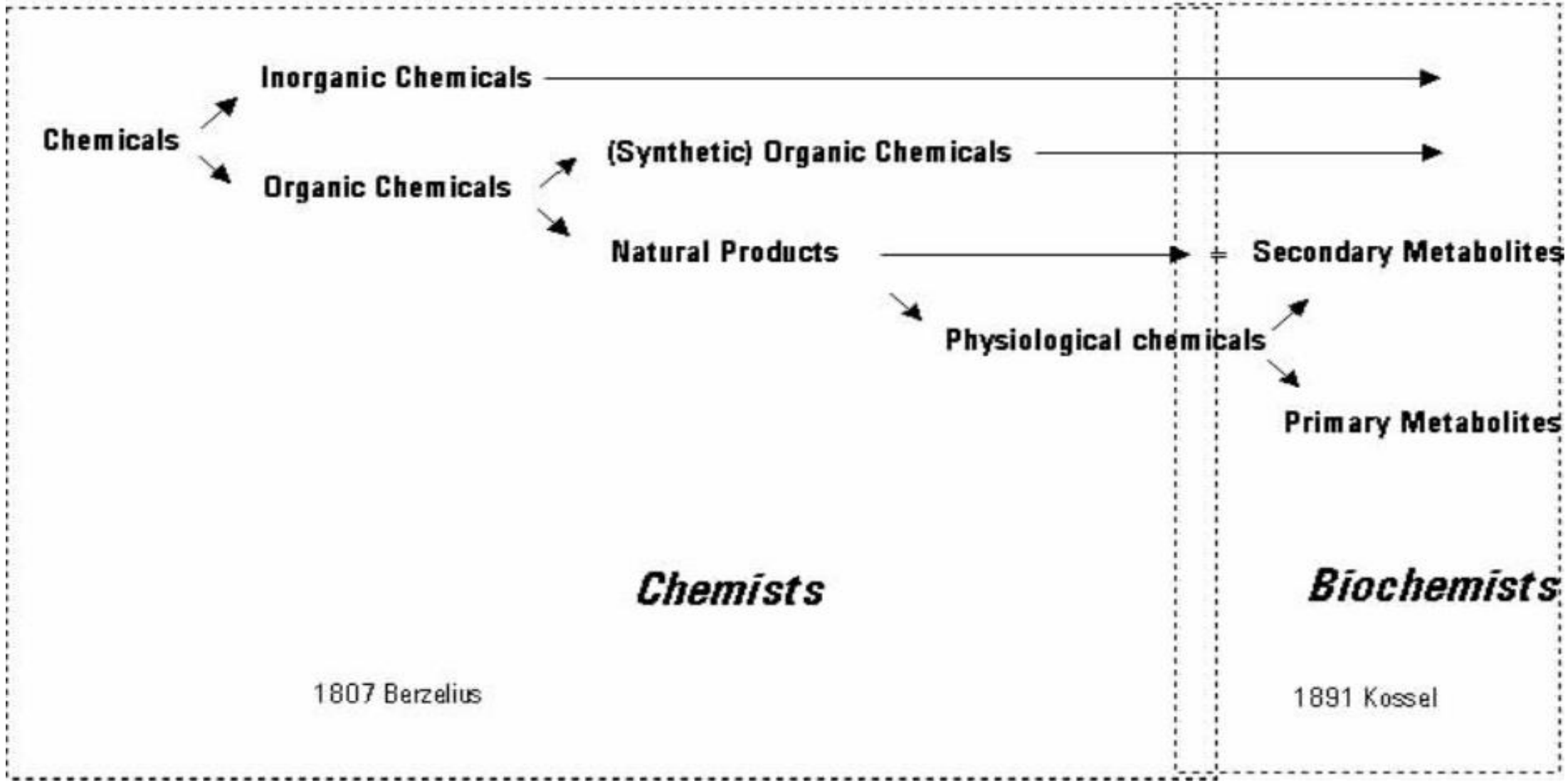
2. **Secondary metabolites**

Primary metabolites

- Organic molecules that have an intrinsic function that is essential to the survival of the organism that produces them (i.e. the organism would die without these metabolites).
- Examples of primary metabolites include the core building block molecules (nucleic acids, amino acids, sugars, and fatty acids) required to make the major macromolecules (DNA, RNA, proteins, carbohydrates, and lipids) responsible for sustaining life.

Secondary metabolites

- Organic molecules that typically have an extrinsic function that mainly affects other organisms outside of the producer.
- Secondary metabolites are not essential to survival but do increase the competitiveness of the organism within its environment.
- Secondary metabolites, in contrast to primary metabolites are dispensable and not absolutely required for survival.


Chemicals
Inorganic Chemicals
Organic Chemicals
(Synthetic) Organic Chemicals
Natural Products
Secondary Metabolites
Physiological chemicals
Primary Metabolites
Chemists
Biochemists
1807 Berzelius
1891 Kossel

The study of natural products is multidisciplinary

Biology ← → **Chemistry**
Taxonomy . Botany
Organic synthesis
Agriculture . Pharmacology . Pharmaceutical Science . Organic analytical chemistry
Entomology . Microbiology . Biotechnology/Molecular Biology . Biochemistry
Genomics . Proteomics
Metabolonomics

Where do we find natural products?

- Natural products may be extracted from the cells, tissues, and secretions of microorganisms, plants and animals.
- A crude (unfractionated) extract from any one of these sources will contain a range of structurally diverse and often novel chemical compounds.
- Chemical diversity in nature is based on biological diversity, so researchers travel around the world obtaining samples to analyze and evaluate in drug discovery screens or bioassays.
- This effort to search for natural products is known as bioprospecting.

Natural products as a bioherbicide

- Many secondary plant natural products are linked with bioherbicidal influences.
- Some secondary plant metabolites, such as phenolics and alkaloids, play an essential role in natural plant activities such as germination and early growth.
- Certain crop species can be used as bioherbicide and their allelochemical extracts can be used to advantage to suppress and reduce negative effects of weeds on crop production

Allelopathy

- The phenomenon of plants affecting other neighbouring plants through releasing chemicals was originally mentioned as early as 370 BC by Theophrastus

- The term Allelopathy was first mentioned by Molisch in 1937

- It is a Greek hybrid word, “Allelon”, which means “of each other” and “pathos” meaning “suffer”

What is Allelopathy?

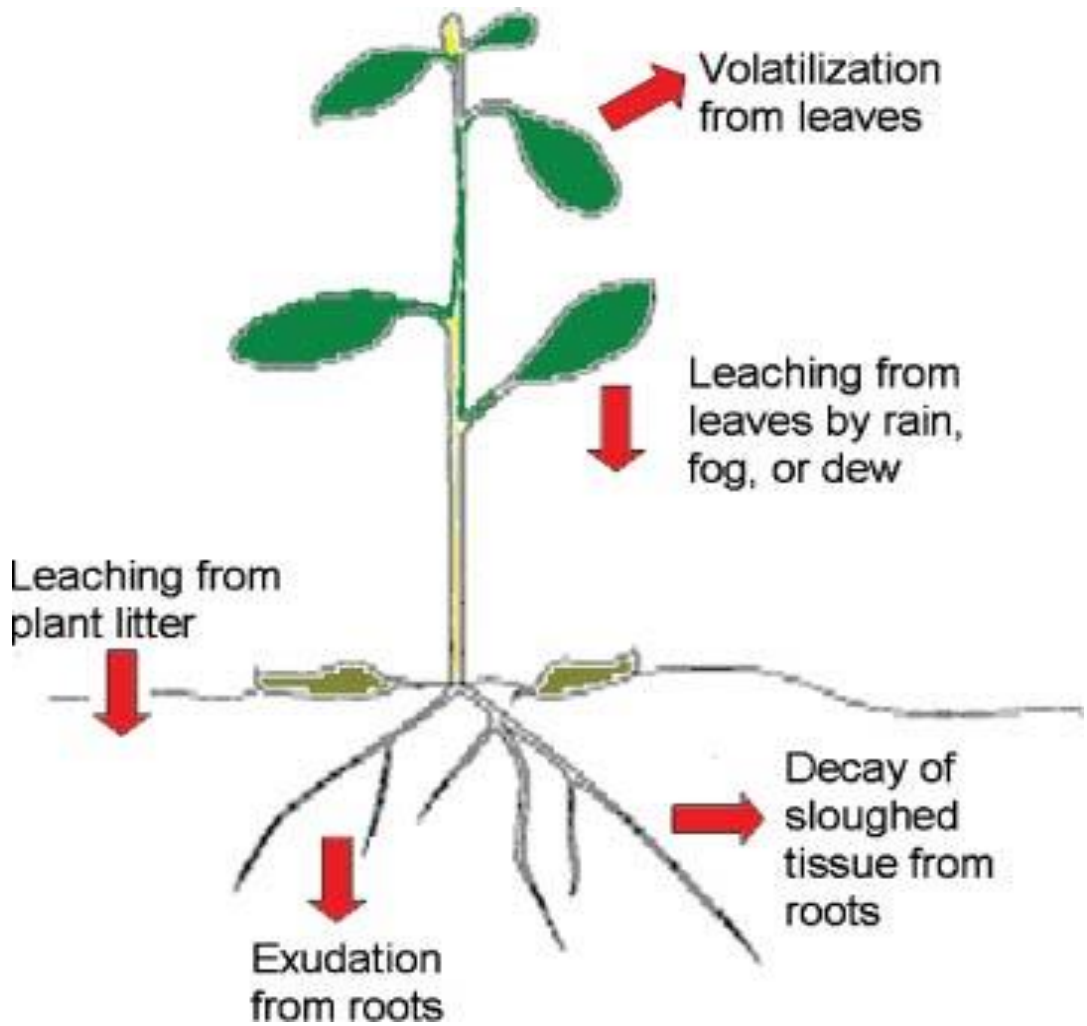
- Any direct or indirect harmful or beneficial effect of one plant or a microorganism on other plants by releasing chemicals termed allelochemicals to the environment

- According to the International Allelopathy Society (International Allelopathy Society, 1996), allelopathy is

“any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influences the growth and development of agricultural and biological systems

- Plants which have allelopathic potential must produce allelochemicals, which must be released into the environment and must be available for transport to the target plant to be taken up

- Allelochemicals are released to neighbouring plants by different mechanisms involving
- Root exudation,
- Leaching,
- Volatilization and
- Decomposition of plant residue


Volatilization
from leaves
Leaching from
leaves by rain,
fog, or dew
Leaching from
plant litter
Decay of
sloughed
tissue from
roots
Exudation
from roots

Field Crop Production

- Certain crop species can be used as allelopathic plants and their allelochemical extracts can be used to advantage to suppress and reduce negative effects of weeds

- It could help to avoid environmental pollution soil contamination

- Crop allelopathy could be achieved by using such crops as cover crops, companion crops as well as components of the crop rotation system

- Selecting crops to release allelochemicals may minimize the intensity not only of weeds, but also pests, diseases and nematodes

- Crop Allelopathy may play an essential role in the development of biological herbicides

- Some weeds have been shown to have allelopathic properties against some crop plants

Weed Management

- Weeds are defined as plants growing in unwanted locations which compete with other plants for resources such as water, nutrients, and light, reduce the yield and quality of crops and may contaminate produce with weed seeds

- About 7000 weed species have been identified
- Nearly 200-300 of them are problems for farmers .
- Using herbicides to minimize the negative impact of weeds on crop yield has many risks.

- Using chemical herbicides to suppress weeds, poses risks to environment, health, water contamination, and soil microorganisms

- There are more than 470 biotypes of weeds that are resistant to chemical herbicides

- Plants that have allelopathic activity can be used as bioherbicides for weed suppression

- Allelopathy may be considered as a possible tool to minimize weeds and enhance crop production

Soil and Allelopathy

- Soil is a system which gives a living biological environment for living microorganisms such as fungi, bacteria, algae, protozoa and actinomycetes

- Soil is the environment where allelopathic activities happen

- Soil type significantly affects the allelopathic potential of allelochemicals

- Allelopathic activity of several allelochemicals can be reduced by organic matter, ion exchange capacity, inorganic ions, and mineral reactive surfaces

- Allelochemicals incorporated into soil may be transformed when movement happens and they are metabolized by soil microbes

- Soil pH affects availability of soil nutrients and hence plant growth

- Phenolic compounds may reduce soil pH due to soil acidification

What are Allelochemicals?

- The allelopathic compounds present in some plants are mostly secondary metabolites, including phenolics, terpenoids, and alkaloids

- There are many crops that produce allelochemicals during their growth, such as sorghum, wheat, alfalfa, barley, corn, asparagus, coffee, tea, tobacco, and sunflower

- These allelopathic crops can produce allelochemicals during decomposition of their plant residues, such as roots and leaves

Phenolic acids as allelochemicals

- Phenolic acids are a class of most important common secondary metabolites which are found in plants and act as allelochemicals in natural ecosystems
- Phenolic acids originate from the shikimic acid and acetic acid metabolic pathways in plants
- Phenolic acids consist of a hydroxyl group bonded to an aromatic hydrocarbon group

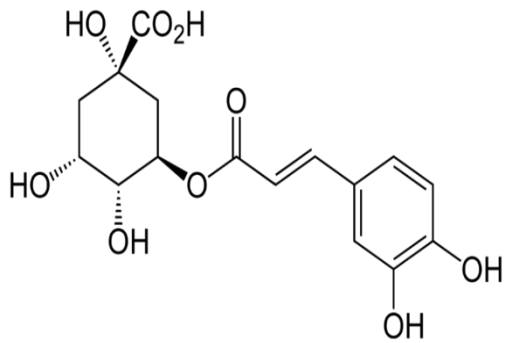
- Phenolic compounds are one of the big groups of plant metabolites which have numerous important functions in some plant species

- The primary structures of phenolic acids are benzoic acids and derivatives of cinnamic acids
- Most of the phenolic acids which have already been identified as allelochemicals are extracted from plant parts, such as shoots and roots

- Many years ago, de Candolle (1830) noticed suppressive effects of root exudates on the neighbouring plants
- It was difficult to determine if phenolic compounds were involved in this effect and if so, which ones.
- After 1980s there was a revolution: numerous methods such as column chromatography on silica, ion exchange chromatography were developed which enabled phenolics to be found and extracted from plants

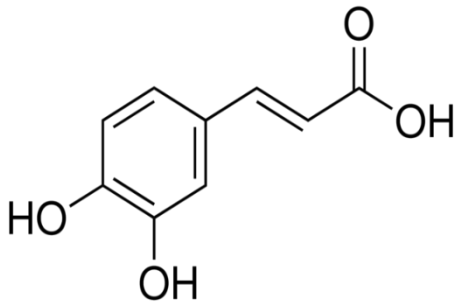
1. Chlorogrnic acid

- Chlorogenic acid is produced by a combination of caffeic acid and quinic acid and usually appears in high concentration in comparison with other phenolic acids in many fruits, vegetable, and field crop plants.
- Chlorogenic acid plays an essential role as a dietary antioxidant and it is the main polyphenolic acid.
- Example: *Imperata cylindrica*



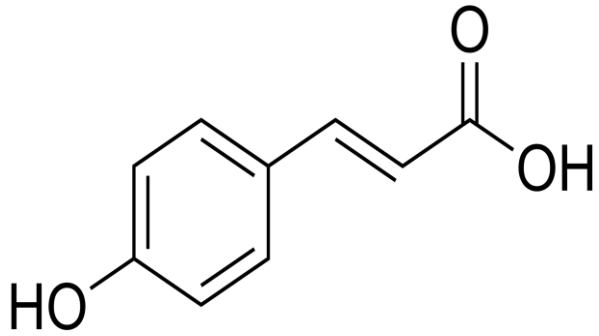
2. Caffeic acid

- Caffeic acid is a well-known important phenolic substance found from plants and is one of pivotal intermediates of plants which belongs to hydroxycinnamic acid derivatives
- Caffeic acid plays an essential role in inhibiting seed germination and seedling growth of some plants
- Example: Sunflower plants



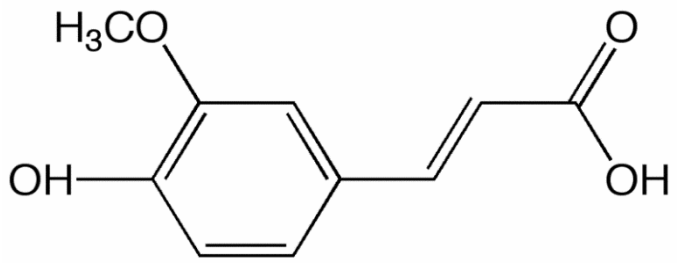
3. P-coumaric acid

- P-coumaric acid is a phenolic acid which is a derivative hydroxyl of cinnamic acid
- It is one of the main phenolic acids which is counted as a plant inhibitor and appears in rhizome and leaf extracts
- P-coumaric acid plays an essential role in inhibition of seed germination and seedling growth of wheat
- Example: Walnut leaf



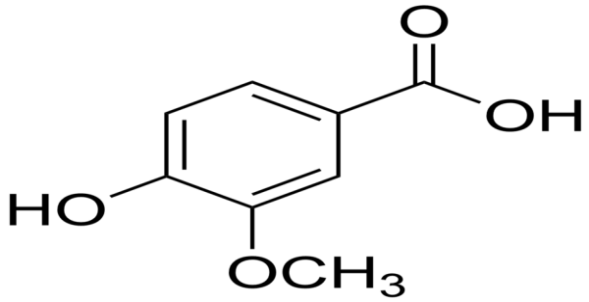
4. Ferulic acid

- Ferulic acid is also a well-known hydroxyl cinnamic acid derivative which is largely distributed in the plant kingdom.
- Ferulic acid causes stress in plant roots and influences several physiological and biochemical effects i.e. utilization of water, foliar expansion, root enlargement, photosynthesis process, ion uptake, and respiration
- Example : Sunflower



5. Vanillic acid

- Vanillic acid is a natural hydroxycinnamic acid derivative in plants
- Vanillic acid may act as a big allelopathic component that appears plant-selective activity as examined on seed germination of watermelon.
- Example: Sunflower



Mode of action of allelochemical compounds

- Opportunities to use natural phytotoxins in weed management are increased by elucidation (clarification) of the mode of action of allelochemicals.

- There are no standard methods for studying their mechanism of action but research teams have studied and developed approaches.

- For example, analysing allelochemical structures and activity, may give clues as to mechanisms of action.

- When allelochemicals affect root growth, the mitosis (cell cycle) can be analysed by using onion roots to study the allelopathic impacts on root cell division

- Allelochemicals often affect the photosynthesis process.

- For instance, *Sorghum bicolor* is able to release an allelochemical compound, sorgoleone- that inhibits photosynthesis by influencing photosystem.

- Weed seed production might be decreased because of the negative impacts from allelochemicals on the photosystem process

- The mechanism of action of allelochemicals on respiration has also been examined.
- They may affect mitochondrial respiration and inhibit O2 uptake.
- For example, sunflower leaf aqueous extracts inhibit mustard seed germination by minimizing the rate of seed respiration in the first three days of germination.

- This may be due to the influence of allelochemicals from the sunflower leaves.

- Allelochemicals may reduce plant growth by inhibition of mitosis and mitochondrial activity.

- Potential allelopathic compounds are usually verified by testing their effects on seed germination of susceptible plant species.
- Inhibition of, or delays to seed germination of certain species by some plants that have allelopathic potential such as, **wheat, sunflower, rye, sorghum,** have been reported.

1. Sugar Content

- Sugars are hydrocarbon organic compounds which are produced during photosynthesis and play an essential role in providing energy in respiration.
- Sucrose is condensed to form starch which is a longer term energy store.
- Sugars also play a crucial role in the structure of plant cell walls
- **Allelochemicals** may exert an effect by influencing sugar metabolism in susceptible plants

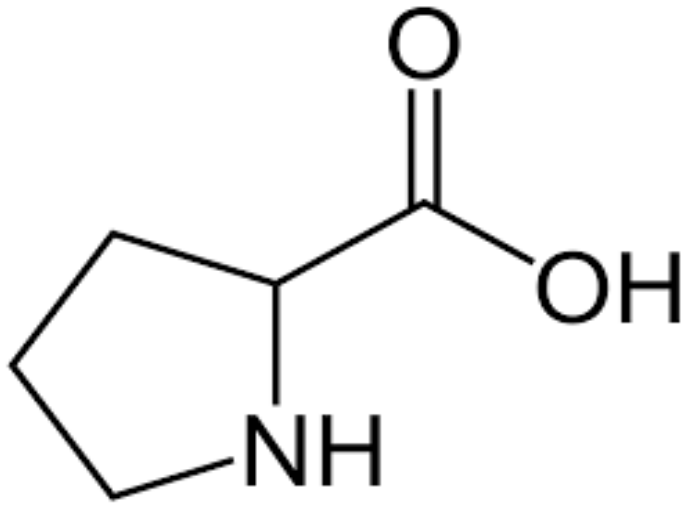
2. Protein content

- Proteins are the most multilateral macromolecules in living systems and serve important functions as they are essential in all biological processes.
- Allelochemicals interfere with enzymes or proteins that eventually influences the growth and metabolism of plant systems.

3.Proline content

- Proline is defined as one of the osmoprotective molecules.
- It protects organisms from **stress** and its capable of accumulating in various organisms such as, invertebrates, bacteria, fungi and plants through water stress and salinity.
- Proline, also called L-proline, is an unusual non-essential amino acid.

- The amino acid proline is a very common compatible osmolytes in biotic and abiotic plants .
- Proline has also been recognised as a general stress indicator.
- Therefore, the content of this amino acid in plants may be indicative of allelopathic effects.

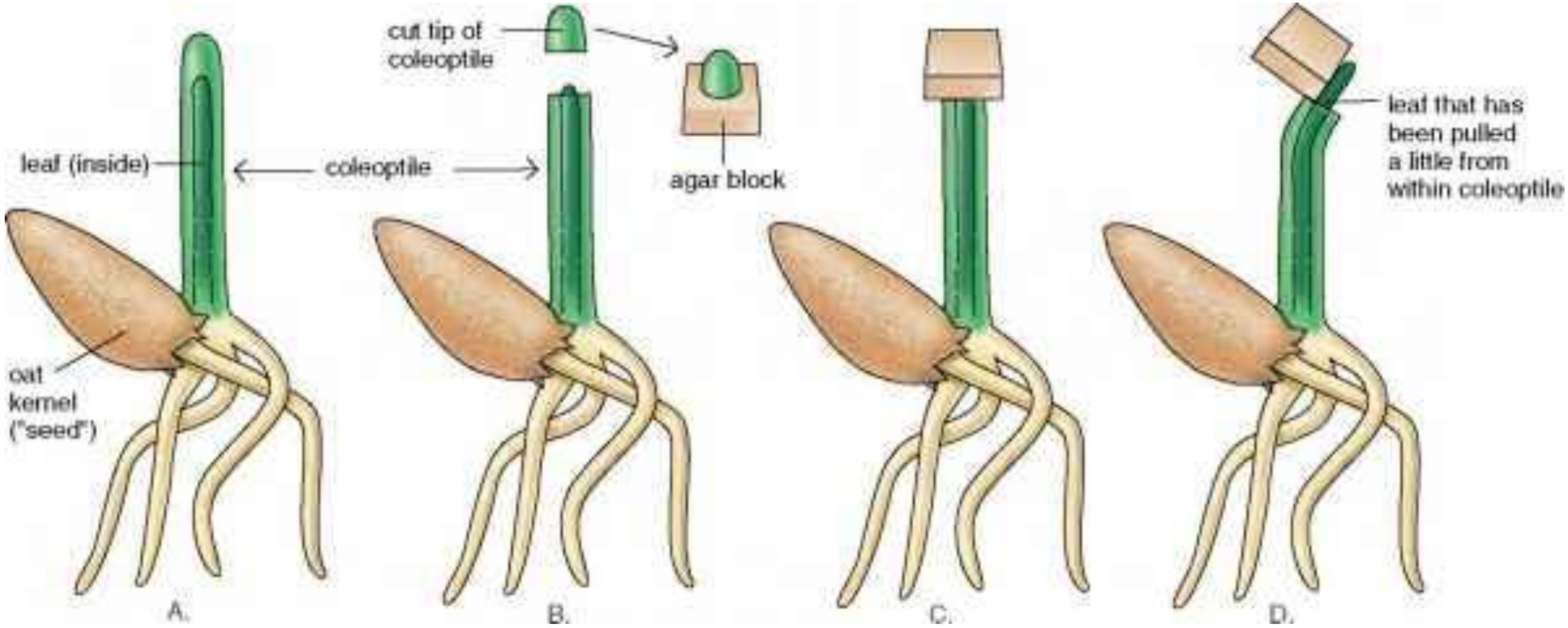


4. DNA content

- Allelochemicals are associated with the inhibition of cell division through effects on mitosis, chromatin organization, DNA physical and chemical properties
- Mitotic processes play an important role in cell growth and division.
- When the cell division process is disturbed e.g. during germination of seeds, seedlings grow slowly or die

5. Plant hormones

- The term "hormone" was first mentioned in plant physiology by Fitting.
- He reported that orchid pollinia contains some materials that causes swelling.
- In 1926, Went worked on isolation of material from coleoptile tips that encouraged cell elongation of coleoptiles: he called this material **auxin**

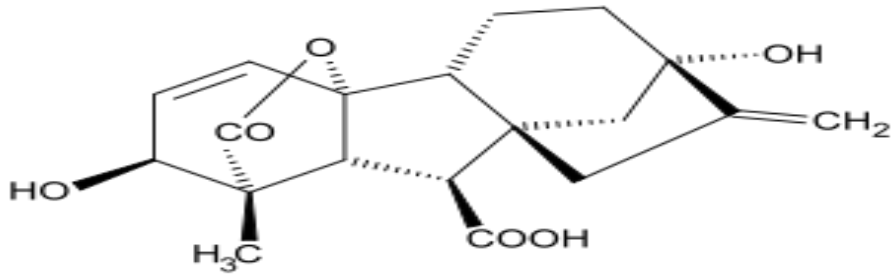

cut tip of coleoptile
leaf (inside)
coleoptile
agar block
leaf that has been pulled a little from within coleoptile
oat kernel ("seed")
A.
B.
C.
D.

- Higher concentrations of auxin stimulates cell division that can helps photosynthesis process.
- The regulation of auxin can be changed by the levels of Indole Acetic Acid or depends on the sensitivity of plant tissues
- Allelochemical effects on plant growth are implicated in production and control of phytohormone levels.
- This involvement could represent an essential factor affecting regulation of numerous metabolic processes which control plant growth

- Phytohormones, are chemical compounds which are produced by plants and can be the main internal factors to control plant growth and development.
- Plant hormones play an essential role in regulation of life cycle events in plants.
- For instance, plant hormones regulate cell division and extension, seed germination and seed dormancy, flowering and fruiting.

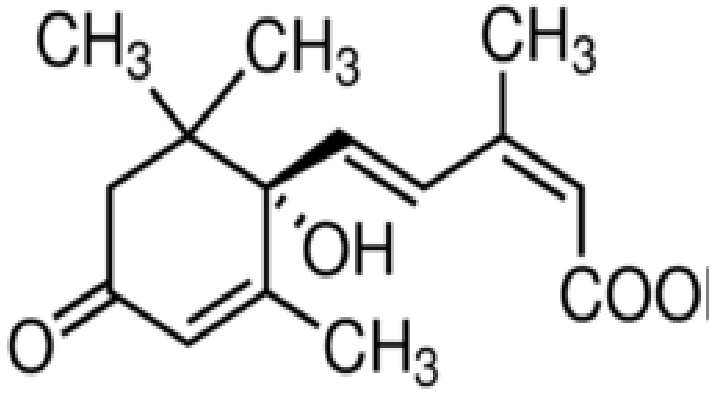
- Plant hormones occur and are effcetive at a very low compared with other chemical compounds.
- High performance liquid chromatography (HPLC) is the most effective method for identification and determination of plant hormones and few studies have described the methodology and results.

- **Gibberellins** (GA) were first isolated by Kuarasawa in 1926 from the fungus *Gibberella fujikora* and he observed that when plants were infected with it, their stems elongated.
- The material was called gibberellin.
- Some physiological influences of gibberellins include stem elongation by stimulating cell division, seed dormancy break and flowering.



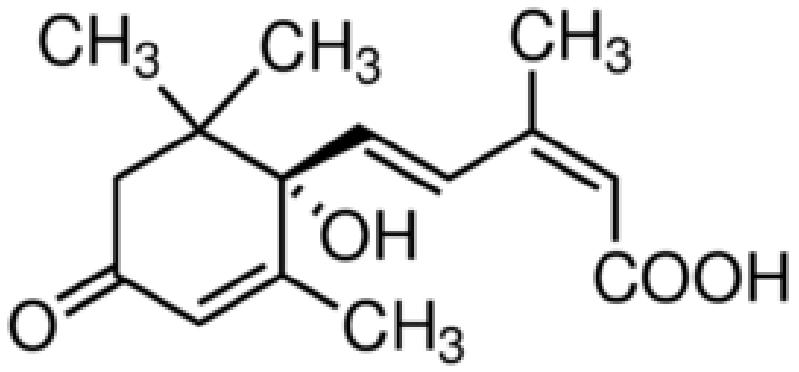
- **Abscisic acid (ABA)** was separated and identified from cotton bolls as biologicaly active in 1960.

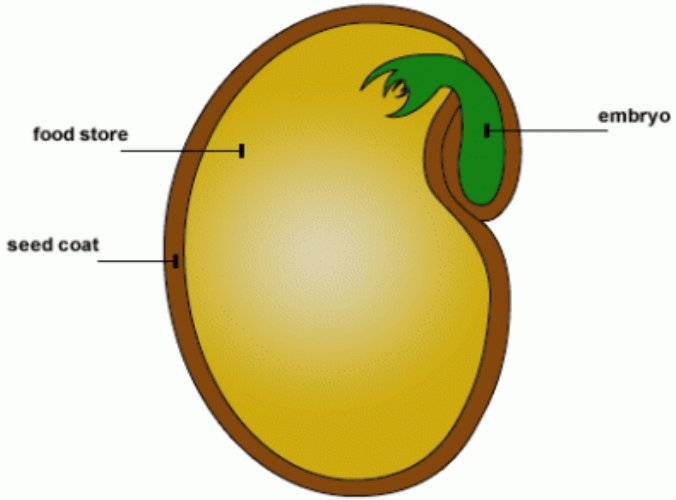
- This phytohormone plays an essential role in many aspects of plant growth, such as seed germination , seed dormancy, and plant stress responses, for example drought and osmotic stress.



- ABA, is considered to be a plant growth inhibitor because of the inhibitory effect of exogenously applied ABA on seed germination and growth when used in bioassays.
- Neverthless, it has been showed that endogenous abscisic acid may play an important role in promoting plant

- ABA also regulates the final phases of somatic (body) embryo development and embryo quality through enhancing tolerance to desiccation (drying) and prevents germination





6.Chlorophyll content

- The term of chlorophyll is a Greek hybrid word , “ Chloros ”, which means “green” and “phyllos” means “leaves”,.
- It was first mentioned in 1818 about pigments extracted from plant leaves with using organic solvents.
- Chlorophyll was identified as pigments by using spectroscopy method and techniques of solvent partition.

- Chlorophylls are the main drivers of the photosynthesis process which absorb light and transfer energy.
- The efficiency of photosynthesis process is based on the concentrations of chlorophyll in plant tissues.
- Functions occur during photosynthesis process which are by the solar energy CO_2 and can be driven into carbohydrates and gives the basic energy for the global ecosystem.
- $6CO_2 + 6H_2O + \text{light energy} = C_6H_{12}O_6 + 6O_2$.

- Chlorophylls absorb light energy and they transfer light energy to excitation energy as well as high quantum efficiency to the reaction centre.
- Therefore, chlorophylls perform primary separation throughout photosynthetic membrane.

- During 19th century chlorophylls a, b, and c were recognized and in 1943 chlorophyll c was recognized

- Phenolic acids have allelopathic inhibitory effect on plant growth via influencing photosynthesis process and chlorophyll content

Chemical structure of Chlorophyll a and b