Drugs from Plants

- There are over a hundred chemical substances that have been derived from plants for use as drugs and medicines. This is by no means a comprehensive list of all of the plants, names of chemicals, or uses for those chemicals, but it should serve as a useful starting point for further research. For your convenience, I have listed the common name of a plant next to its scientific name. Be advised that common names are very imprecise and often assigned to completely different plants, so use the scientific name when looking for additional information concerning a plant.

Drug / Chemical	**Action**	**Plant Source**
Acetyldigoxin	Cardiotonic	Digitalis lanata (Grecian foxglove, woolly foxglove)
Adoniside	Cardiotonic	Adonis vernalis (pheasant's eye, red chamomile)
Aescin	Antiinflammatory	Aesculus hippocastanum (horse chestnut)
Aesculetin	Antidysentery	Frazinus rhychophylla
Agrimophol	Anthelmintic	Agrimonia supatoria
Ajmalicine	Treatment for circulatory disorders	Rauvolfia sepentina
Allantoin	Vulnerary	Several plants
Allyl isothiocyanate	Rubefacient	Brassica nigra (black mustard)
Anabesine	Skeletal muscle relaxant	Anabasis sphylla
Andrographolide	Treatment for baccillary dysentery	Andrographis paniculata
Anisodamine	Anticholinergic	Anisodus tanguticus
Anisodine	Anticholinergic	Anisodus tanguticus
Arecoline	Anthelmintic	Areca catechu (betel nut palm)
Asiaticoside	Vulnerary	Centella asiatica (gotu cola)
Atropine	Anticholinergic	Atropa belladonna (deadly nightshade)
Benzyl benzoate	Scabicide	Several plants
Berberine	Treatment for bacillary dysentery	Berberis vulgaris (common barberry)
Bergenin	Antitussive	Ardisia japonica (marlberry)
Betulinic acid	Anticancerous	Betula alba (common birch)
Borneol	Antipyretic, analgesic, antiinflammatory	Several plants

PLANT HORMONES

plant hormone are specific organic substances produced naturally in higher plants, controlling growth and other physiological functions at the site remote from its place of production.they are known to be active in minute amount.they could be natural (endogenous) or synthetic. The initial biological reactions and changes chemical composition within the plant, thereby influencing developmental processes such as changes in growth pattern which leads to the formation of roots, shoots, leaves, flowers and other structural entities characteristics of plant. About six groups of endogenous plant hormones are known namely

1. Indole-3-acetic acid (IAA) (an auxin)
2. Gibberellic acid (a gibberellins)
3. Zeatin (a cytokinin)
4. Absciscic acid
5. Caffeine acid (a phenolic)
6. Ethylene

Indole-3-acetic acid could be synthesized from the tryptophan follow the processes of deamination followed by decarboxylation or vice-versa.

The compound could be destroyed by the enzyme IAA oxidase. Other synthetic auxins are

- Indole-3-propionic acid
- Indole-3-butyric acid

The biological activities and physiological relevance or importance of this hormones includes:

I. Inhibition of lateral buds
II. Control of leaves abscission
III. Moderate cell enlargement
IV. Promotes cell enlargement
V. Promotes cell division in cambium
VI. Promotes germination at moderate concentration
VII. Induces a highly increased number of vascular strands in roots
VIII. Accelerates flowering
IX. It promotes parthenocarpy
X. Prevents premature dropping of fruits and leaves
XI. Enhances improved fruit settings

GIBBERELLINS: there exist about 40 diferent types of gibberellin which are named as GB_1 to $GB_{40.}$ They contain lactone ring on cyclohexene ring with substituted OH and carboxyl functional groups. The early part of biosynthesis of GB is similar to that of carotenoids and terpenoid: in that, it begins from acetyl coA down to geranylgeranyl phosphate and involves intermediates such as mevalonate and mevalonate-5-phosphatepyrophosphate. However the other steps from geranylgeranyl pyrophosphate to gibberellin biosynthesis differ from those of carotenoids. The summary of gibberellins synthesis is given below

Importance of gibberellins in plant physiology includes:

i. Regulation of sub-apical meristem activities such as stem cell enlargement
ii. Control of fruit growth
iii. Initiation of flowering
iv. Leaf expansion
v. Hyponasty of leaves
vi. Parthenocarphy
vii. Increase the length of hypocotyls and cotyledon

CYTOKININS OR PHYTOKININ OR KINETIN

These hormones contain group of high specificity (purine nuclei) and one lipophilic group without specificity (the furan ring). They have been known to be extracted from tomato juice, coconut milk, immature fruits of Zea mays. They are known to be translocated in the xylem stream as well as basipetal movement in petiole. Their physiological effects include:

i. Delays the breakdown of chlorophyll in detached leaves.
ii. Participates in orderly development of embryo during seed development
iii. It promotes cell division.
iv. Increases the rate of protein synthesis
v. Enhances the breakdown of dormancy of seeds

ABSCISSIC ACID (ABA)

This plant hormones affects plant growth at a relatively low concentration. It posess an asymmetric carbon, hence can exist at (+) or (-) enantiomers. Naturally occurring ABA are usually in (+) form (2-cis-ABA). It can be transformed into 2-trans form in the presence of UV-light ABA is usually manufactured in matured leaves and then move up to the shoot apex through the phloem. Physiological effects of ABA includes:

i. It controls bud dormancy
ii. It initiates flowering
iii. Controls leaves abscission
iv. Regulates opening and closing of stomata
v. Inhibits gibberellins induced enzyme synthesis

PHENOLICS

These are derivatives of phenol molecules and include compounds like cathechol, caffeine/caffeic acid and anthocyanidin. Some of them are powerful fungicidal and bacteriocidal agents. They are known to be able to protect plants from invasion by fungi and bacterial. If a plant is “wounded”, phenolic compounds become concentrated around the damaged tissue(s) andf tend to “seal off” the area from the rest of plant. Large complex of phenolic molecules are frequently found in plant vacuoles or lumen of dead cells. Some insoluble phenolics are waste products of metabolic reactions. The phenolics are known to mediate physiological effects by way of:

i. Inhibiting cell division and cell enlargement
ii. In some cases, they prevent germination of many seeds

ETHYLENE

This is a volatile gas formed by ripening of fruits produce/synthesize high concentration of this compound in the intracellular spaces of the fruit tissue. It can also be produced in other tissue and organs such as leaf, stem, and roots (though at low concentration). Glucose and linoleic acid functions as precursors for the ethylene biosynthesis thus:

Physiological effects of ethylene includes among others:

i. It triggers the ripening of many fruits.
ii. It accelerates the abscission of leaves, stem and flowers
iii. It inhibits stem elongation
iv. It bring about stem swelling
v. Involves in epinasty
vi. It is also involved in flower petal discolouration
vii. It reduces the incidence of pests and diseases

BIOSYNTHESIS OF CAROTENOID

The carotenoids are highly unsaturated hydrocarbon formed from the isoprene units linked end-to-end or their oxygenated derivatives. They are of two main groups namely

(I) Carotenes
(II) Xanthophylls

Both types are water insoluble pigment. The carotenes are purely hydrocarbon in nature whereas the xanthophylls are oxygen-containing derivatives.

They have common biochemical origin which is acetyl coA. They are always/mostly of plant origin but can also be found in animals, since the oxygenated half molecule of α,β and ⍰-carotene is vitamin A commonly found in milk, egg and liver. The most common carotene is β -carotene, which is a C-40 hydrocarbon consisting of a highly branched unsaturated chain containing identical substituted ring structure at each end. Other carotenoids are variance of β -carotene. Enzymatic symmetrical cleavage of _β -carotene by carotenase will yield two molecules of vitamin A. in animal, for instance, this conversion represents a chief natural source of vitamin A.

It should be noted that the alcoholic form of vitamin A (i.e retinol) is essential for the chemical phenomenon of vision. It can be enzymatically converted to the oxidized aldehyde form (retinal) which become complexed with opsin to form active protein which functions as primary photoreceptor of incident light that ultimately transmits information to the nervous system. Biosynthetic pathway for carotenoids and its relationship with the steroids is given below:

Acetyl coA → dimethylallyl → geranylPPO$_4$ → farnesylPO$_4$ → geranylgeranylPPI

→ Phytoene → lycopene → carotenes (α, β, ⍰-carotenes)

HERBICIDES

Pesticides are pest killing agents. They are described as substances intended for preventing, destroying, repelling, mitigating or controlling any pest, including unwanted species of plants or animals or animals during the production, storage, transport, distribution and processing of foods, agriculture products or animal feeds which may be administered to animals for the control of ectoparasites and vector of diseases dangerous to man and animals. They are classified broadly according to their:

(I) Intended use or target organism
(II) Chemical nature
(III) Mode of action

Herbicides are therefore pesticides intended for killing plants or control weeds by interrupting their normal growth. They may either have certain selectivity by chemical property by the way of application in the control of weeds, grasses, or bushes in crop land, rangeland or forest or be a "total herbicide" for use on industrial sites and right-off way locations. They could be systemic or contact in action.

Over 100 types of herbicides are known to exist. All of these falls into a particular class or group which are broadly classified as:

i. Dinitrophenol herbicide
ii. Carboxylic acid herbicide
iii. Bipyridilium herbicide

Examples of dinitrophenol herbicide is 2,4-dinitro-o-cresol otherwise known as Sinox while 2,4-dichlorophenoxy-acetic acid (2,4-D) is an example of carboxylic acid herbicides. The two most important examples of bipyridilium herbicides are diquat and paraquat.

Paraquat ($1,1^{I}$-dimethyl-$4,4^{I}$-bipyridinium dichloride) is otherwise known as methyl viologen is a non-selective herbicide. It is a quartenary herbicide, fast acting, widely used for broadleaf weed control. It is one of the world's worst poisons on earth, thus it has been banned or restricted in some countries.

It is synthesized from pyridine from the reaction of two sodium molecules in anhydrous ammonia and quartenizing a $4,4^{I}$-bipyridyl product with methyl chloride under pressure. It has the chemical structure shown below:

It is non-explosive and non-inflammable in aqueous formulation. It is relatively stable under normal temperature, pressure and pH. Paraquat is corrosive to metals and reacts with strong oxidizers. It is stable in acid or neutral solutions but readily hydrolysed by alkali to its simpler constituents. The most frequently route of exposure to paraquat is either accidentally or intentionally. Its residues have been reported to be found in plants, soil, water and in foods.

First aid measures and managements principle in case of paraquat poisoning includes:

i. Induction of vomiting
ii. Washing of contaminated skin thoroughly with water and soap
iii. Aspiration of gastric content and perform gastric lavage followed by administration of mineral absorbent such as fuller's earth (kaolin), bentonite or activated charcoal in order to remove any unabsorbed PQ remaining in the GIT.
iv. Purgatives such as $MgSO_4$, Mg Citrate, Sorbitol or mannitol may be given.

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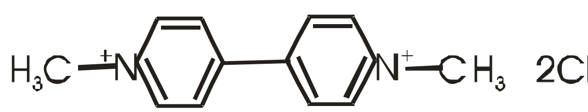
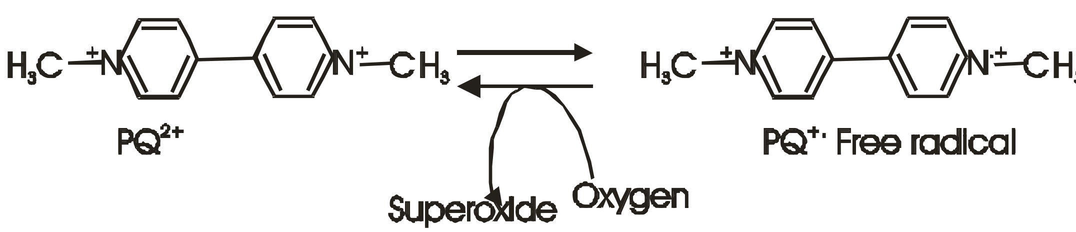
The importance of oxidative stress as a mechanism of PQ toxicity has been demonstrated in ic outcomes of the redox cycling reactions were identified and these includes:

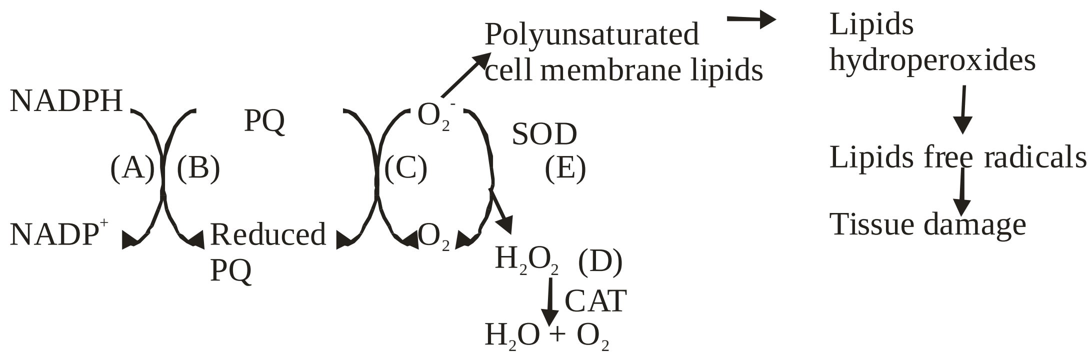
1. Generation of superoxide anion which can lead to the formation of more toxic reactive oxygen such as hydrogen peroxides and hydroxyl radicals.
2. Oxidation of the cellular NADPH, the major source of reducing equivalents for the intracellular reduction PQ, which results in the disruption of important NADPH-requiring biochemical processes.
3. Lipid peroxidation which results in the oxidative degeneration of cellular polyunsaturated fatty acids.



The redox cycle reaction of PQ that causes superoxide production is shown below:



The mechanism of action for the *in vivo* toxicity of paraquat is shown below:



STUDY QUESTIONS

Explain the molecular organization of plant cell.

1. Define photosynthesis.
2. What materials are required for photosynthesis? What is produced?
3. Write the overall reaction for photosynthesis.
4. Describe what happens during the cyclic phosphorylation of photosystem I. How does the transfer of electrons lead to the synthesis of ATP?
5. Describe the reactions of carbon fixation or the Calvin cycle. What enzyme catalyzes the reaction? What are the products of the reaction?