Q. Differences between Primary Metabolites and Secondary Metabolites

Answer:

Basis for Comparison	Primary Metabolites	Secondary Metabolites
Definition	Primary metabolites are the compounds that are directly involved in the metabolic pathways of an organism necessary for its growth, development, and reproduction.	Secondary metabolites are the organic compounds that are produced by various organisms that are not directly involved in the growth, development, or reproduction of the organism but are essential in the ecological and other activities.
Also termed	Primary metabolites are also termed as central metabolites.	Secondary metabolites are also termed as specialized metabolites.
Growth phase	Primary metabolites are produced during the growth phase of the organism.	Secondary metabolites are produced during the stationary phase of the organism.
	This phase of growth is also termed as 'trophophase'.	This phase of growth is also termed as 'idiophase'.

Quantity	Primary metabolites are produced in large quantities.	Secondary metabolites are produced in small quantities.
Extraction	It is easier to extract primary metabolites.	It is difficult to extract secondary metabolites.
Specificity	Primary metabolites are not species-specific and thus might be identical in some organisms.	Secondary metabolites are species-specific and thus are different in different organisms.
Involved in	Primary metabolites are involved in the growth, development, and reproduction of organisms.	Secondary metabolites are involved in ecological functions and species interactions.
Structural component	Primary metabolites might form the molecular structure in organisms.	Secondary metabolites are not a part of the molecular structure of the organism
Importance	Primary metabolites are used in various industries for different purposes.	Secondary metabolites are used in various biotechnological procedures

		for the formation of drugs and other compounds.
Defensive action	Primary metabolites are not active in the defense mechanism.	Secondary metabolites are active against foreign invaders and might be involved as a defense mechanism.
Examples	Examples of primary metabolites include proteins, enzymes, carbohydrates, lipids, vitamins, ethanol, lactic acid, butanol, etc.	Some examples of secondary metabolites include steroids, essential oils, phenolics, alkaloids, pigments, antibiotics, etc.

Q. Primary Metabolites and Secondary Metabolites

- Primary metabolites are the compounds that are directly involved in the metabolic pathways of an organism necessary for its growth, development, and reproduction.
- These metabolites are associated with the physiological processes occurring in the organism.
- Primary metabolites are produced in the organism during the growth phase, as a result of the growth mechanism.
- The growth phase associated with the production of primary metabolites is termed as ‘trophophase’.

- The production of primary metabolites is initiated when the nutrients necessary for the body are available in the medium.
- These are found in most cells throughout the body and are also termed central metabolites.
- Primary metabolites are crucial for various metabolic activities as some act as a substrate for these processes, while others act as catalysts.
- Some primary metabolites like amino acids are common throughout the organisms, whereas some are restricted to some cells or some organisms.
- Even though primary metabolites play an essential role in the growth and development of an individual, these do not have pharmacological actions or effects against other factors.
- The production of primary metabolites usually occurs at a high rate as these are constantly required for the body. These can also be extracted easily through simple extraction procedures.
- Primary metabolites are divided into two groups; primary essential metabolites and primary metabolic end products.
- Primary essential metabolites include compounds like proteins and carbohydrates that make up the structural and physiological organization of the organism. In contrast, primary metabolic end products include products like lactic acid and ethanol that are the end products of various metabolic pathways.
- Examples: proteins, enzymes, carbohydrates, lipids, vitamins, ethanol, lactic acid, butanol, etc.

Secondary Metabolites:

Plants produce thousands types of chemicals. Some of the organic compounds like carbohydrates, fats, proteins, nucleic acids, chlorophylls, hemes are required for their basic metabolic processes and found throughout the plant kingdom.

These organic compounds are called primary metabolites or biomolecules. These are produced in large quantities and can easily be extracted from the plants.

Many plants, fungi and microbes of certain genera and families synthesize a number of organic compounds which are not involved in primary metabolism (photosynthesis, respiration, and protein and lipid metabolism) and seem to have no direct function in growth and development of plants. Such compounds are called secondary metabolites (secondary plant products or natural products).

These compounds are accessory rather than central to the functioning of the plants in which they are found. These compounds are produced in small quantities and their extraction from the plant is difficult and expensive.

They accumulate in small quantities only in specific parts of plants. These are derivatives of primary metabolites. By the cultivation of plant cells in culture media, secondary metabolites can be produced on large scale.

Types of Secondary Metabolites:

These secondary metabolites are highly numerous in number, chemically diverse in nature and belong to three groups.

1. Isoprenoids or Terpenes, e.g., rubber, steroids, essential oils, carotenoid pigments.

2. Nitrogen containing compounds, e.g., alkaloids, glucosinolates, glycosides, non-protein amino acids.

3. Phenolic compounds, e.g., lignin, tannins, coumarins, aflatoxins, flavonoids (anthocyanins).

Characteristics of secondary metabolites:

1. Secondary metabolites are specifically produced by selected few microorganisms.

2. They are not essential for the growth and reproduction of organisms from which they are produced.

3. Environmental factors influence the production of secondary metabolites.

4. Some microorganisms produce secondary metabolites as a group of compounds (usually structurally related) instead of a single one e.g. about 35 anthracyclines are produced by a single strain of Streptomyces.

5. The biosynthetic pathways for most secondary metabolites are not clearly established.

6. The regulation of the formation of secondary metabolites is more complex and differs from that of primary metabolites.

Q. A brief account on phytochrome.

Answer: Phytochrome is a pigment present in small amounts in all plants. Under short- day conditions, an interruption of the dark period with light (specifically red light) causes an intramolecular shift in phytochrome that brings about flowering in long-day plants and prevents flowering in short-day plants.

- **Characteristics of Phytochrome:**

The cytoplasmic pigment system phytochrome now identified as a protein and partially purified, which is sensitive to red light.

This pigment can exist in two forms, one that absorbs red light (Pr) and one that absorbs far- red light (Pfr). Red light converts Pr to Pfr, but this form is unstable and is gradually converted back to the Pr form.

Phytochrome is active in the Pfr form and thus the responses are produced by red light. In relation to flowering, reactions promoted by Pfr interfere with the dark reaction that promotes flowering in short-day plants and inhibits the flowering of long-day plants.

Since it is the length of the dark period that is critical, and therefore, it is supposed that the reversion of Pfr to Pr determines the critical length of the dark period. The reversion takes place only about four hours in the dark.

Apart from photoperiodic phenomena, many other light effects upon plants are exerted through the phytochrome system. The germination of lettuce seeds for example, required a light stimulus, and this is effected by red light and reversed by far-red light. Stem elongation and leaf expansion could be influenced by red light, and the effect of etiolation could be checked by exposure to red light.

Phytochrome is a protein with chromophoric (pigment) groups. The molecular weight of phytochrome is about 60,000 with three chromophores per molecule. The chromophore pigment is closely similar but not identical to the chromophore of c-phycocyanin, an algal (blue alga) chromoprotein.

It is believed that phytochrome is also involved in other photo-periodically controlled processes such as tuber and bulk formation, and dormancy.

About the functioning of the phytochrome, it has been suggested that it may operate by influencing membrane permeability in the cells, not only of the plasma membrane but also of those of the nucleus and the mitochondria, thus influencing the metabolism of cells.

Though the discovery of phytochrome has made a very significant contribution towards explaining the first step in the mechanism of flowering, yet much experimentation is required, so that the substances specifically causing the transition of the apical meristems from the vegetative to the flowering conditions could be isolated and their mode of action determined.

Q. Short notes on Phototropins.

Answer: Phototropins are blue-light receptors that mediate phototropism and chloroplasts movements in plants. In late 1980s, it was found that blue-light stimulated phosphorylation of a 120 kDa protein located on plasmamembrane of actively growing regions of etiolated seedlings. These regions were also most responsive to phototropic stimulus. Extensive biochemical and physiological studies showed this protein to be a kinase autophosphorylating in blue-light and which could be the photoreceptor for phototropism.

Phototropin is also a flavoprotein with two flavin mononucleotide (FMN) chromophores. The protein has a carboxy-terminal domain with a serine/threonine kinase activity. In the amino-terminal half, there are two domains called LOV domains (of about 100 amino acids each) to which are attached the chromophores. (LOV domains are so called because they are characteristics of microbial proteins which regulate response to light, oxygen and voltage).

Recent spectroscopic studies done by Swartz et al, 2000) have shown that in dark, FMN molecules remain non covalently bound to LOV domains, but on irradiations with blue-light they become covalently bound to cysteine residues of the apoprotein through a sulphur atom forming a cysteine- flavin covalent adduct. The reaction is reversed in dark. A second gene called phot 2 has also been isolated from Arabidopsis which is related to phot 1. It is believed that phototropic response involves both phot 1 and phot 2.

- **Mechanism of action of phototropins:**

The mechanism of action of phototropins is not clear. It has been observed that blue-light causes a transient increase in cytosolic calcium concentration and there are indications that phototropin signalling chain may partly involve regulation of cytoplasmic calcium concentration.