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MEDICINAL PLANT

STAGE (THIRD)

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SECONDARY METABOLISM

By

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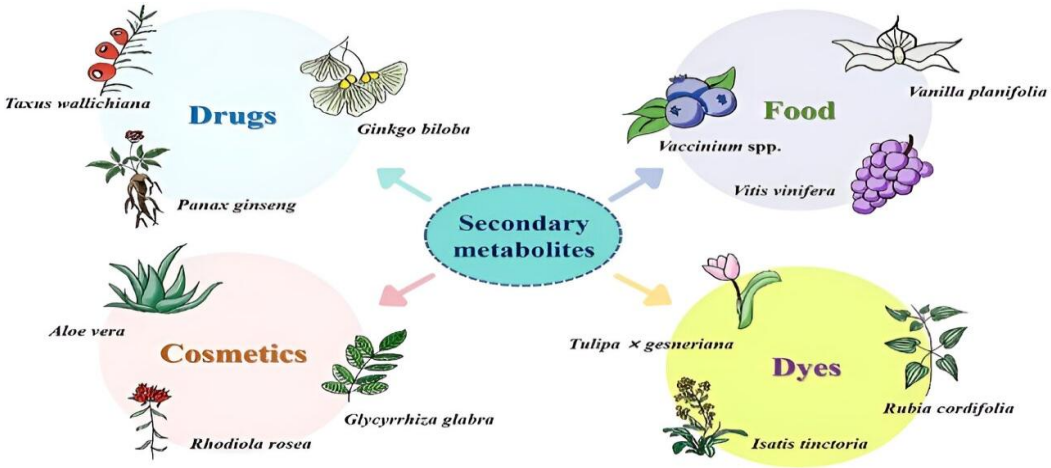


Secondary metabolism

In all organisms, there are two types of metabolism which synthesize complex molecules from simple molecules with the help of catalysts. These metabolisms are called primary and secondary metabolism.

Primary metabolism,

also known as basic metabolism, is very significant for organisms, because the compounds produced in primary metabolic pathways are used in vital functions. While primary metabolites play roles in development and growth functions, compounds synthesized in secondary metabolism do not enter into these types of reactions.

However, Secondary metabolites compounds have important functions including interactions between organisms and their environments. These secondary metabolites are often necessary so that organisms can survive in their ecosystem.

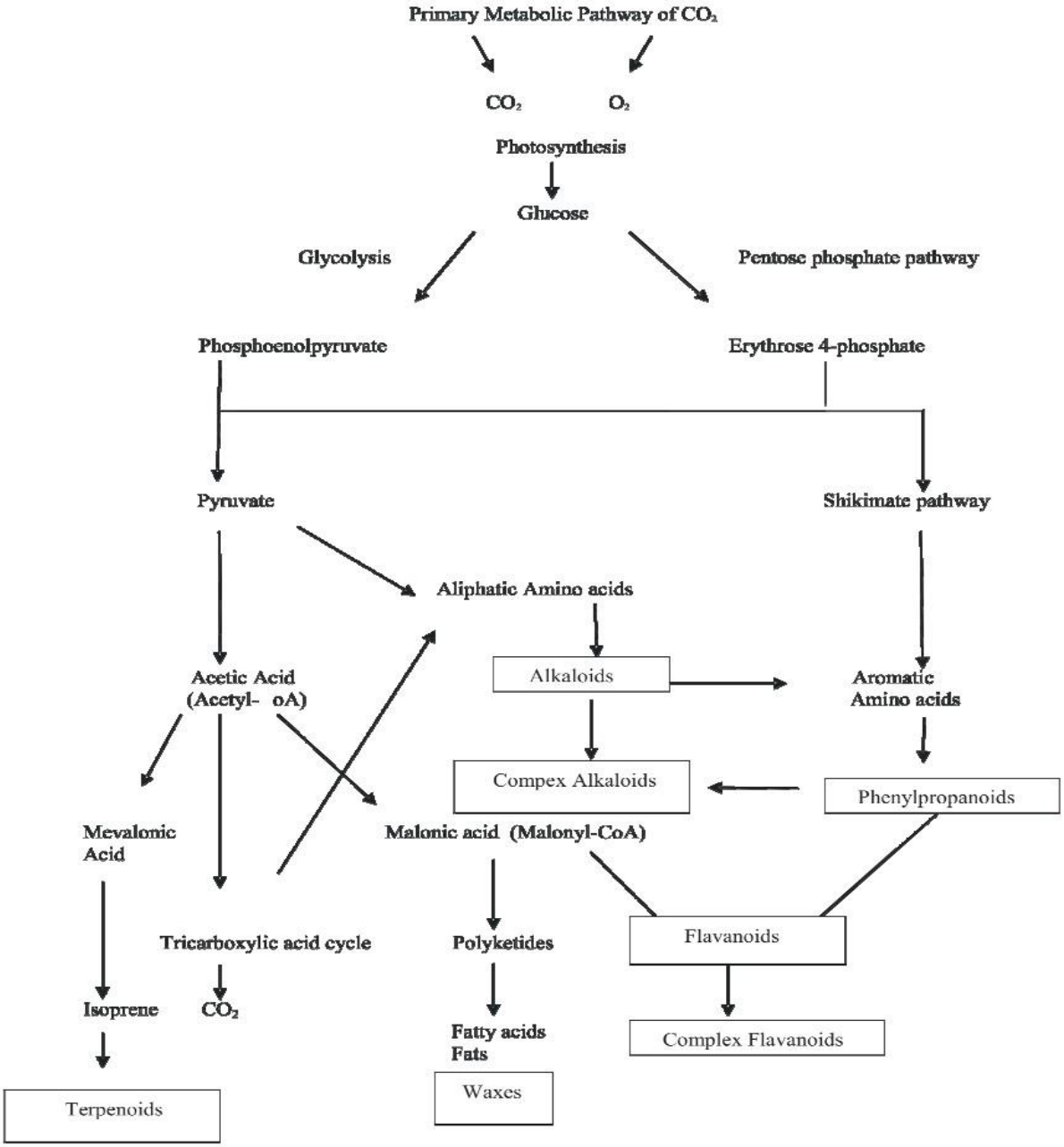
In the primary metabolic pathway of carbon, different compounds, such as pyruvate and acetylCoA produced in intermediate steps, used as precursors to produce secondary metabolites. For example, the glucose generated by photosynthesis converted to pyruvate by glycolysis. The pruvate can converted into aliphatic amino acids, which are precursors for alkaloid production. Alternatively, the pruvate can be used to make acetyl-CoA which have a role in flavonoid, terpenoid and wax production. If Malonic acid produced by acetyl-CoA, this product can give flavanoids or waxes according to two different pathways. However, if acetyl-CoA turns into mevalonic acid, this product can be utilized as an intermediate compound to synthesize terpenoids. The ecological functions affect plant survival profoundly, and it reasonable to adopt the less pejorative term “plant natural products” to describe secondary plant metabolites that act primarily on other species.

Plant primary metabolites	***Plant Secondary metabolites (Plant natural products)***
1. Organic compounds produced in the plant kingdom	1. Organic compounds produced in plant kingdom
2. Have metabolic functions essential for plant growth and development	2. Don’t have apparent functions involved in plant growth and development
3. Produced in every plant	3. Produced in different plant families, in specific groups of plant families or in specific tissues, cells or developmental stages throughout plant development.
4. Include carbohydrates, amino acids, nucleotides, fatty acids, steroids and lipids	4. Include terpenoids, special nitrogen metabolite (including, non-protein amino acids, amines, cyanogenic glycosides, glucosinolates, and alkaloids), and phenolics.

Functions of Secondary Metabolites in Plant

When the pathways of secondary metabolism are studied, it is seen that synthesis of secondary metabolites is very costly for plants and other organisms which have secondary metabolism. 'Costly' means that secondary metabolism requires high concentrations of ATP. Because high levels of ATP are needed during secondary metabolite production.

The functions of secondary metabolites reveals. In plants, these metabolic compounds have ecological functions for plants and other organisms related to plants.



Relationships between primary metabolic pathways and secondary metabolic pathways. Secondary metabolites are shown in boxes.

The functions of secondary metabolites in plants.

1- Secondary metabolites protect plants against microbial pathogens and viruses.

Secondary metabolites used as antibiotics against pathogens; they are active at all times, because these components are part of the constitutive defence mechanism and are usually localized in the cell wall or in the vacuole. However, in the inducible defense system, defence compounds formed after infection by the pathogen.

These responses include the production of different secondary metabolites such as steroid glycol alkaloids. Moreover, secondary metabolic compounds serve as signal agents during infection. When a plant infected by a pathogen, it can become resistant against the pathogen that infected the plant. This defense system called systemic acquired resistance (SAR). SAR generally induced by secondary metabolites such as salicylic acid.

2- Plants having secondary metabolites are also to protected aganist herbivores.

A part from defense functions against pathogens, protect plants from herbivores because of their toxicity effects. Plants also use toxic secondary metabolites to compete with other individuals of the same or different species. This type of toxic compound called an ‘allelopathic substance, For instance, two plants which share the same territory, will compete for insufficient water or nutrients. Under these conditions, allelopathic substances play an important role.

3- Moreover, secondary compounds provide a defence system against abiotic environmental stresses.

Moreover, plants have to defend themselves against abiotic stresses such as temperature, light level and water level. These abiotic stresses cause oxidative stress in plants.

4- Some secondary metabolites attract insects for pollination and seed dispersal. In addition, they used for interactions between plants and symbiotic microorganisms. In addition to these functions, some secondary metabolites serve to attract insects or animals for pollination and seed dispersal. Generally, secondary metabolites serve as flower pigments, scent, taste compounds, and attract other organisms. For example, terpenes and aromatic compounds known as attractive compounds because of their volatility. In addition, flavonoids used as colour pigments in flower petals to attract the attention of insects or animals.

5- Furthermore, these compounds are important in a plant’s relations with other plants.

6- Another function of secondary compounds is to give signals for symbiotic interaction .These metabolites serve as signal agents to provide communication between a host plant and symbiotic microorganisms. The interaction between Agro-bacterium or Rhizobium and a plant given as an example of symbiotic interaction. For instance, some phenolic compounds derived from flavanoids used to attract Rhizobium bacteria to plant roots for formation of nodules. Importance of Plant Secondary Metabolites for Humans

In recent years, it have been found that secondary metabolites can have antioxidant, anticarcinogenic, anti-inflammatory, antiallergenic, and antimicrobial effects on human health. Because of these functions, they have been attractive for medicine and used as drugs. Therefore, some secondary metabolites called **natural drugs**.

1- One of their most important functions is an antioxidant function. Most secondary metabolites such as **flavanoids, beta-carotene, and lycopenes** have antioxidant functions. This function protects humans from oxidative stress. It known that oxidative stress damages humans because of **ROS** (reactive oxygen species). Generally free radicals which are a kind of ROS, can interact with lipids, proteins, low-density lipoproteins, and DNA. When free radicals join one of these biomolecules such as a lipid, some modifications in the biomolecule occur due to the unpaired electrons of ROS.

the antioxidant and also anticancer genic functions of secondary metabolites, these compounds are:

1- **Phenolic antioxidants** can used in cancer therapy due to their functions.

2- Generally, **polyphenols** have an important role as **anti-inflammatory, antimicrobial**, and antibacterial compounds in medicine. The most polyphenols,

3- **Flavopiridol** used in medicine as an **anticancer**. Especially, flavone found to be inhibitory to respiratory syncytial virus.

4- In addition, other phenolic acids inhibit some different viruses, bacteria and fungi.

5- Indicated that alkaloids used to inhibit the HIV virus.

Table 1. Shows some other secondary metabolites that used in medicine.

PSM	Major Sources	Therapeutic application
Tannin	vascular woody plants ferns	Anticancer applications Cardioprotective effects Antimicrobial effects
Saponin	higher plants some marine animals	Anticancer applications Immunomodulatory applications Cardioprotective effects Antidiabetic effects Analgesic Anti-inflammatory effects
Mimosine	*Leucaena leucocephala* *Mimosa pudica*	Anticancer applications Anti-inflammatory effects
Phytoestrogens	leguminous forage seeds foods	Anticancer effects Prevention of prostate cancer Prevention of colon cancer Cardioprotective effects

Major Classes of Secondary Metabolites

Plants generally classified according to the secondary metabolites, which they produce. This classification called 'chemotaxonomy'. However, secondary metabolites classified according to their carbon skeletal type or biosynthetic organs. Generally, classification of secondary metabolites based on carbon skeletal type.

Table 2. Shows the major classifications of plant secondary metabolites with examples of compounds in each class.

Major class of SM	Subunite of SM
Terpenoids	Hemiterpenes
	Monoterpenes
	Sesquiterpenes
	Diterpenes
	Triterpenes
	Tetraterpenes
	Polyterpenes
	Meroterpenes
Phenolics	Phenolic acids
	Lignin
	Lignan
	Flavanoids
	Coumarins
	Furanocoumarins
	Stilbenes
	Tannin
Nitrogen and sulfur containing	Glucosinolates
Nitrogen containing	Alkaloids
	Glycoalkaloids