

# Metabolic Pathways in Higher Plants and Their Determination

## Metabolites and Their Types

### What Are Metabolites?

- Metabolites are small molecules involved in metabolism, essential for energy production, growth, repair, and various cellular functions.
- They are intermediates or end products of metabolic pathways.

### Types of Metabolites

#### 1. Primary Metabolites

- Involved in basic processes like growth and energy production.
- **Examples:** Glucose, amino acids, ATP, fatty acids.

#### 2. Secondary Metabolites

- Non-essential for growth but important for defense, signaling, and adaptation.
- **Examples:** Alkaloids (nicotine), terpenoids (menthol), flavonoids, antibiotics (erythromycin).

### Primary Metabolism

- Primary metabolism involves pathways essential for life, such as **photosynthesis**, **respiration**, and the biosynthesis of carbohydrates, amino acids, and lipids.

#### Key Processes:

##### 1. Photosynthesis:

- Converts light energy into chemical energy, forming sugars from carbon dioxide and water.

##### 2. Respiration:

- Breaks down sugars to release energy for cellular processes.

##### 3. Biosynthetic Routes:

- **Carbohydrate Synthesis:** Produces sugars via the Calvin Cycle.
- **Amino Acid Metabolism:** Forms the building blocks for proteins.
- **Lipid Synthesis:** Builds cell membranes and energy-storing molecules.

### Secondary Metabolism

- Secondary metabolites are derived from primary metabolic pathways and include diverse classes of compounds such as **alkaloids**, **terpenoids**, and **phenolics**.
- **Biosynthetic Origins:**

- **Phenylpropanoids:** Derived from the amino acid phenylalanine.
- **Terpenoids:** Derived from isoprene units originating in carbohydrate metabolism.
- **Alkaloids:** Derived from amino acids and other primary metabolic intermediates.

## **Determination of Metabolic Pathways**

- Understanding metabolic pathways requires experimental techniques that map out the biosynthesis and function of metabolites:

### **Key Techniques:**

#### **1. Biochemical Techniques:**

- Enzyme isolation, in vitro assays, and substrate feeding experiments to identify enzymatic steps in pathways.

#### **2. Radioisotope Labeling:**

- Introducing radioactive isotopes (e.g., **<sup>14</sup>C** or **<sup>3</sup>H**) into precursors to track the movement of atoms through metabolic routes.

#### **3. Analytical Methods:**

- Techniques like chromatography, mass spectrometry, and NMR are used to identify and quantify metabolites.

#### **4. Molecular Biology Tools:**

- Genetic manipulation, gene expression profiling, and mutant analysis to study enzyme roles and regulatory networks.

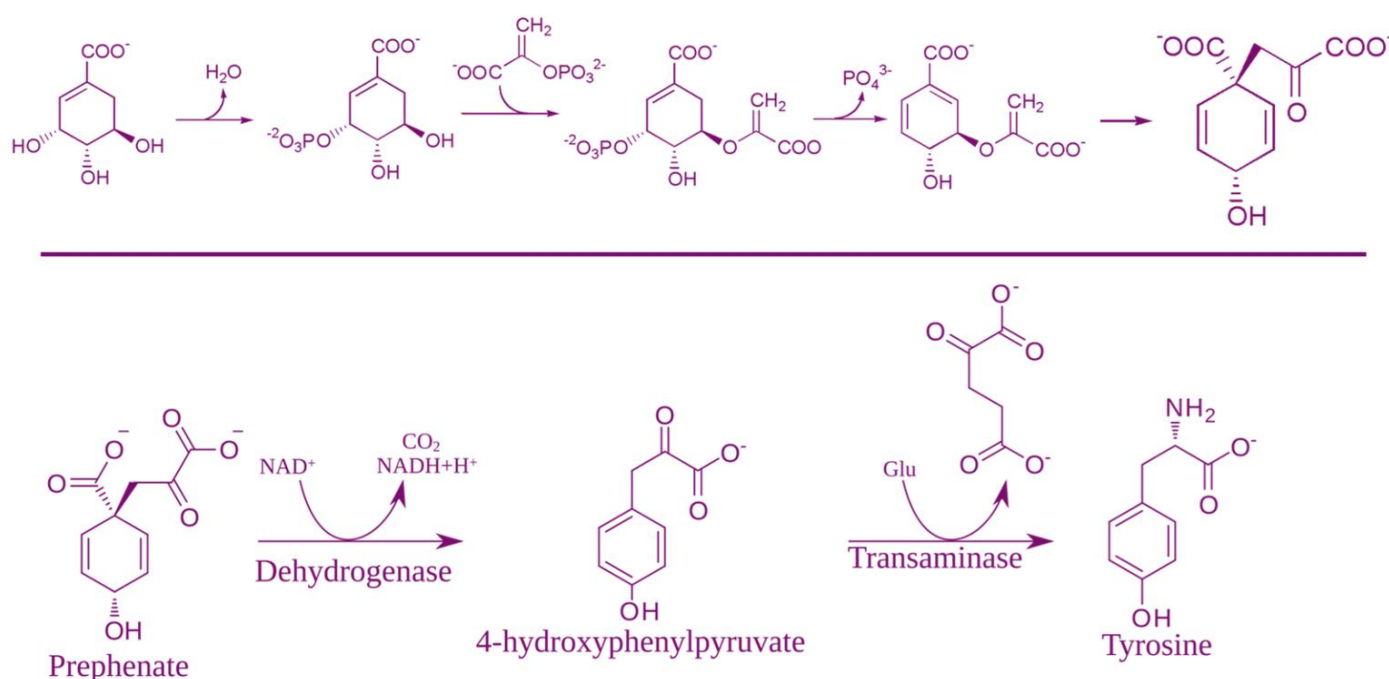
# Basic Metabolic Pathways and Formation of Secondary Metabolites

## Shikimic Acid Pathway

### Overview

- The Shikimic acid pathway is a central biosynthetic route responsible for the production of aromatic amino acids (phenylalanine, tyrosine, tryptophan) and various aromatic secondary metabolites.
- It is not present in animals, making it a major target for herbicides and antimicrobial agents.

### Key Steps



### 1. Formation of Shikimic Acid

- **Starting materials:**
  - **Phosphoenolpyruvate (PEP):** Derived from glycolysis.
  - **Erythrose-4-phosphate:** Derived from the pentose phosphate pathway.
- These precursors undergo condensation and multiple enzymatic reactions to form shikimic acid.

### 2. Formation of Chorismate

- Shikimic acid is phosphorylated to form shikimate-3-phosphate, which is then converted to chorismate.
- Chorismate is a crucial branching point leading to the biosynthesis of aromatic amino acids and other secondary metabolites.

### 3. Aromatic Amino Acid Biosynthesis



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