Lecture-1

Metabolic pathways in higher plants and their determination

Presented By;-

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Contents

Metabolic pathway

Definition;- A **metabolic pathway** is a series of enzyme-catalyzed biochemical reactions in which one compound is converted into another through a sequence of intermediates. These pathways are essential for the growth, development, survival, and reproduction of living organisms.

Examples

- Glycolysis
- Citric Acid (TCA) Cycle
- Shikimic Acid Pathway
- Acetate–Malonate Pathway
- Mevalonate Pathway

Primary Metabolites

Definition;- Primary metabolites are compounds that are directly involved in the normal growth, development, and reproduction of plants. They are produced during the active growth phase and are essential for life.

Examples

- Carbohydrates (Glucose, Starch)
- Proteins
- Amino acids
- Lipids
- Nucleic acids
- Organic acids

Importance

- Provide energy.
- Form structural components of cells.
- Serve as precursors for secondary metabolites.
- Support plant growth and development.

Secondary Metabolites

Definition;-Secondary metabolites are organic compounds that are not directly required for the growth and reproduction of plants but play important roles in defense, adaptation, and ecological interactions.

Examples

- Alkaloids (Morphine, Quinine)
- Glycosides (Digoxin)
- Flavonoids (Quercetin)
- Tannins
- Terpenoids (Menthol, Artemisinin)
- Volatile oils
- Resins

Importance

- Protect plants against insects and pathogens.
- Attract pollinators.
- Provide medicinal properties.
- Used in pharmaceuticals, cosmetics, and food industries.

Shikimic Acid Pathway

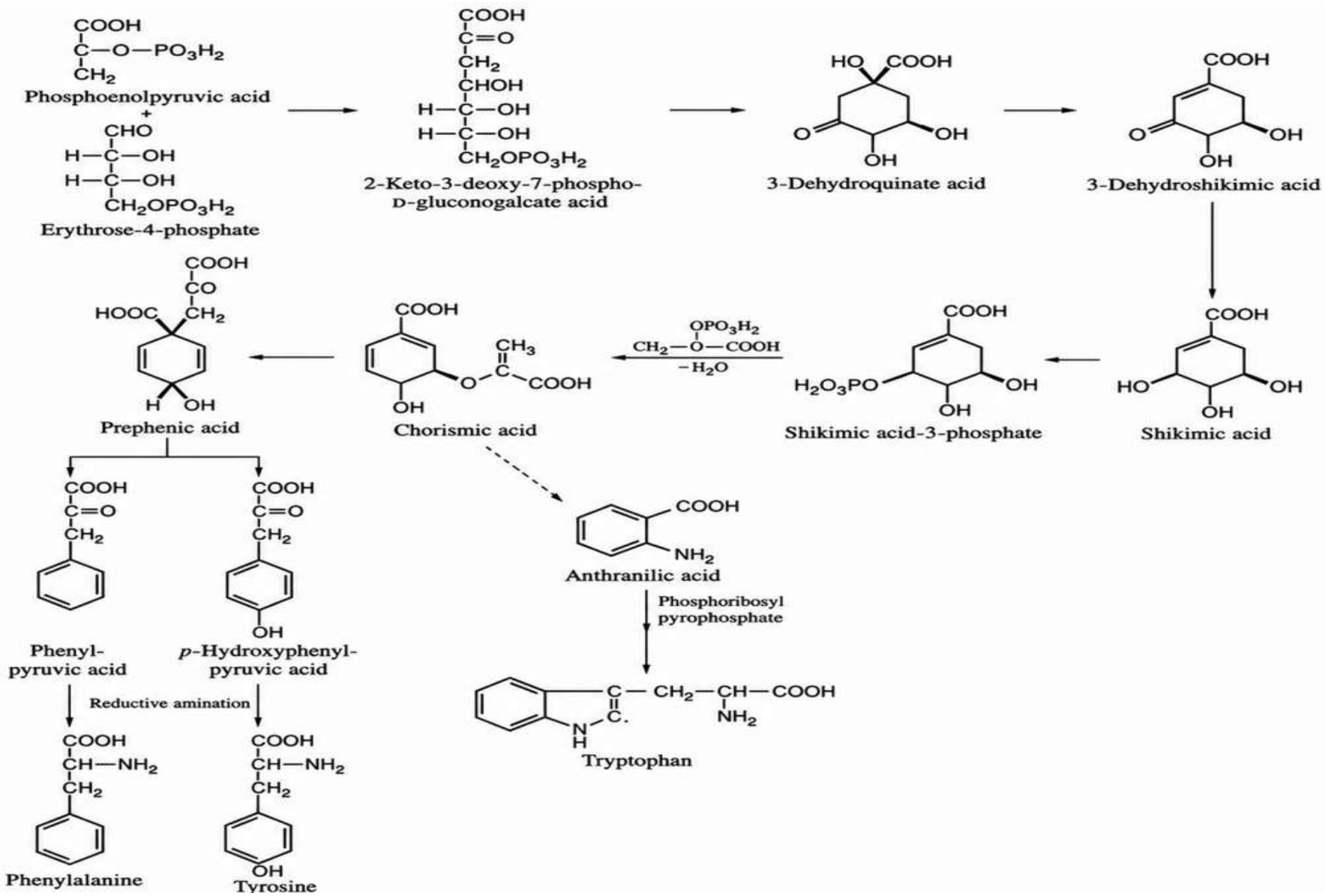
The **shikimic acid pathway** is a **seven-step** metabolic route used by bacteria, fungi, and plants to synthesize the aromatic amino acids phenylalanine, tyrosine, and tryptophan.

Because humans lack this pathway, we cannot synthesize these essential amino acids, making them vital dietary requirements.

Pathway Steps

1. **Condensation**: Phosphoenolpyruvic acid and Erythrose-4-phosphate combine.
2. **First Intermediate**: They form 2-Keto-3-deoxy-7-phospho-D-gluconoheptonic acid.
3. **Cyclization**: This linear molecule cyclizes into 3-Dehydroquinic acid.
4. **Dehydration**: 3-Dehydroquinic acid loses water to form 3-Dehydroshikimic acid.
5. **Reduction**: 3-Dehydroshikimic acid is reduced to Shikimic acid.
6. **Phosphorylation**: Shikimic acid receives a phosphate to become Shikimic acid-3-phosphate.
7. **Chorismate Formation**: Reaction with a second phosphoenolpyruvate yields Chorismic acid.

Once chorismate is formed, it acts as a central branch point. It is further processed into the essential amino acids **phenylalanine**, **tyrosine**, and **tryptophan**, and serves as a starting material for various secondary metabolites like flavonoids and lignin.


Phosphoenolpyruvic acid
Erythrose-4-phosphate
2-Keto-3-deoxy-7-phospho-D-gluconogalcate acid
3-Dehydroquinate acid
3-Dehydroshikimic acid
Shikimic acid
Shikimic acid-3-phosphate
Chorismic acid
Prephenic acid
Phenyl-pyruvic acid
p-Hydroxyphenyl-pyruvic acid
Reductive amination
Phenylalanine
Tyrosine
Anthranilic acid
Phosphoribosyl pyrophosphate
Tryptophan

Significance of the Shikimic Acid Pathway

1. **Produces aromatic amino acids** (phenylalanine, tyrosine, and tryptophan), which are precursors of many bioactive compounds.
2. **Synthesizes important secondary metabolites** such as flavonoids, phenolic compounds, tannins, coumarins, lignin, and some alkaloids.
3. **Provides medicinally active phytochemicals** with antioxidant, anti-inflammatory, antimicrobial, anticancer, and cardioprotective properties.
4. **Plays a key role in pharmacognosy** by aiding the identification, authentication, and quality control of medicinal plants and herbal drugs.
5. **Has pharmaceutical importance** because shikimic acid is used as a starting material for the industrial synthesis of the antiviral drug Oseltamivir.

Acetate pathways

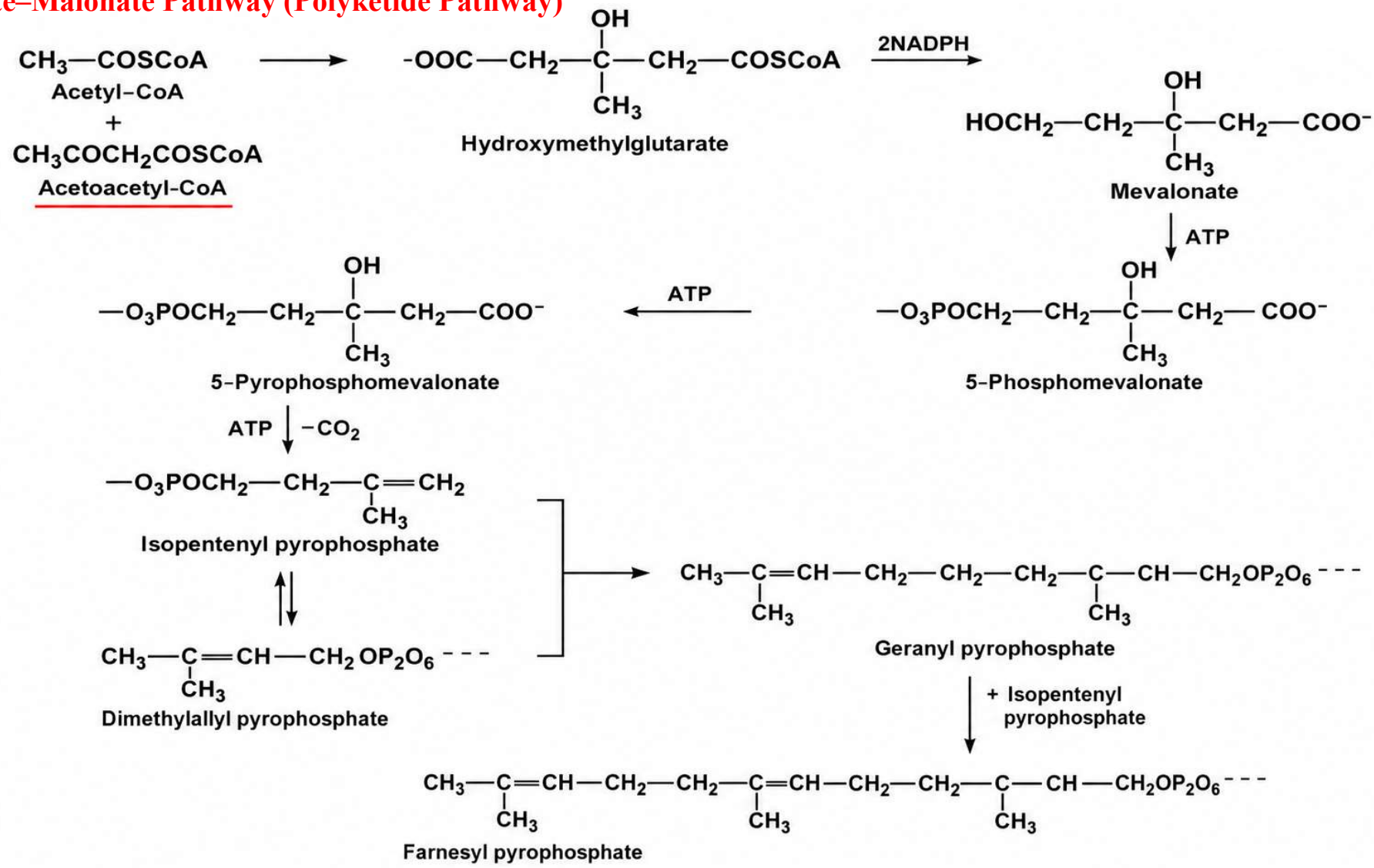
Definition;- The Acetate pathway is a major biosynthetic pathway in plants, fungi, and microorganisms. It produces many important **secondary metabolites** by using **acetyl-CoA** as the starting material and **malonyl-CoA** as the chain-extending unit.

In pharmacognosy, this pathway is important because it forms several medicinally active natural products used as drugs or lead compounds.

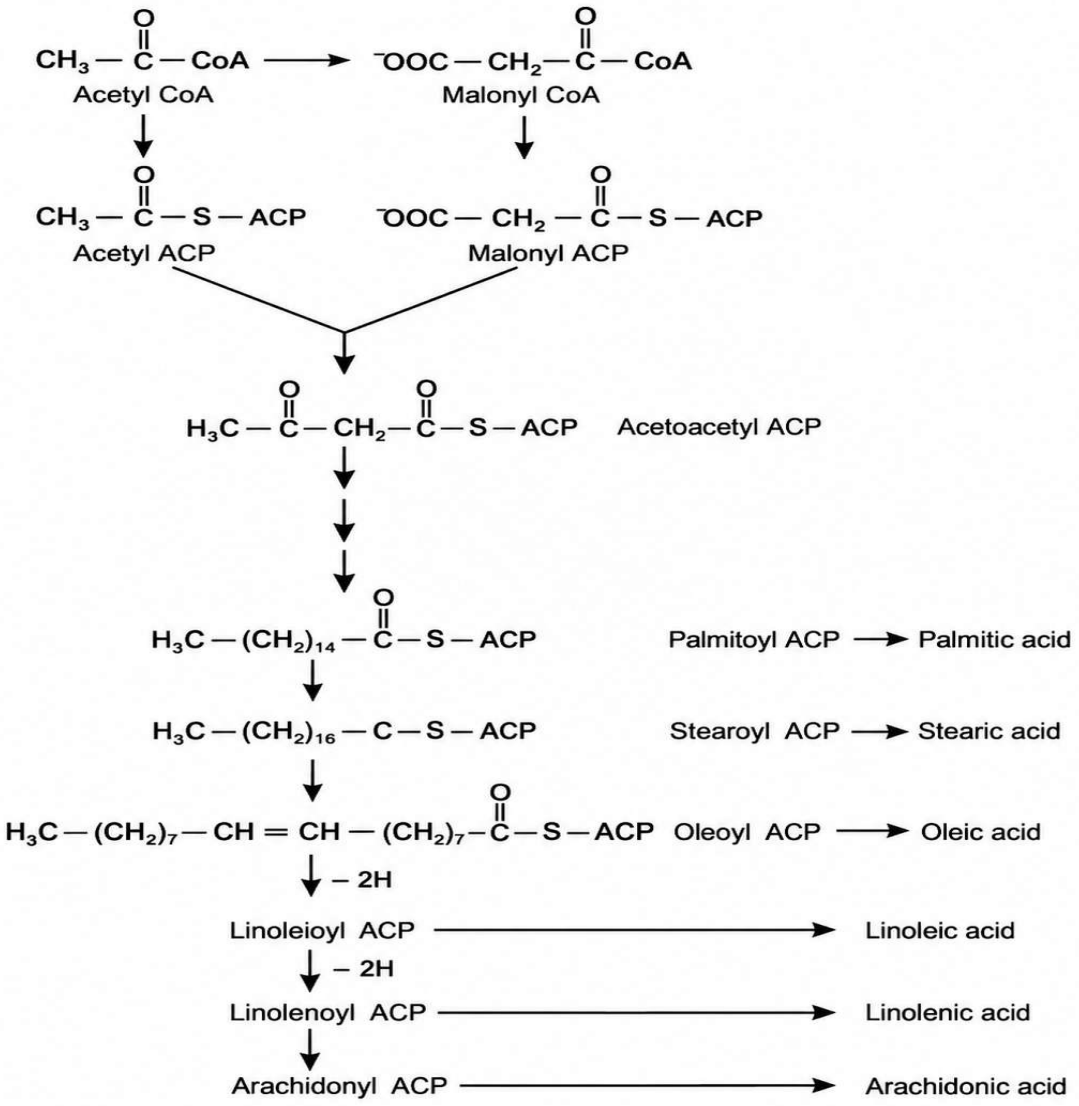
Types of Acetate Pathway;-

1. **Acetate–Malonate Pathway (Polyketide Pathway)**
2. **Acetate–Mevalonate Pathway (Isoprenoid Pathway)**

1. Acetate–Malonate Pathway (Polyketide Pathway)



2. Acetate–Mevalonate Pathway (Isoprenoid Pathway)



Significance Of Acetate Pathway

1. **Terpenoid Synthesis:** It utilizes the acetate-mevalonate pathway to generate isoprenoids like essential oils (menthol, camphor) and anti-malarial drugs (artemisinin).
2. **Steroid & Saponin Production:** It produces squalene, the direct precursor for vital medicinal compounds like cardiac glycosides, steroidal saponins, and steroid hormones.
3. **Polyketide & Antibiotic Formation:** Through the **acetate-malonate pathway**, it synthesizes complex polyketides, which are critical for yielding antibiotics (tetracycline), antifungals (griseofulvin), and anticancer drugs (doxorubicin).
4. **Fatty Acid Generation:** It is responsible for the synthesis of fixed oils, fats, and waxes used as pharmaceutical excipients, drug delivery vehicles, and nutritional supplements.
5. **Biogenetic Classification:** Understanding this pathway allows pharmacognosists to classify active constituents, trace their taxonomic origins, and artificially recreate active pharmaceutical ingredients (APIs) in the lab.

Thank you