Biochemistry For Medical Students
Lecture 2: Amino Acids II
Types & Properties

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At the end of the lecture students will be able to:

- **Identify nonstandard amino acids.**
- **Define the Ketogenic and glucogenic amino acids.**
- **Describe the Properties and functions of amino acids**

Amino Acid Derivatives of Importance:

Non-standard Amino Acids:

The compounds similar to basic structure of amino acids but do not occur in proteins. Examples of some of those are:

- **β-alanine:** They found in coenzyme A.
- **Ornithine and citrulline:** They are intermediates in urea cycle
- **Thyroxine (T4) and Tri-iodo Thyronine (T3):** Thyroid hormones synthesized from tyrosine.
- **γ-aminobutyric acid (GABA):** A neurotransmitter produced from glutamic acid.
- **β-amino isobutyric acid:** These are end product of pyrimidine metabolism.
- **δ-aminolaevulinic acid (δ-ALA):** These are intermediate in haem synthesis.
- **3, 4-dihydroxy phenyl alanine (DOPA):** A precursor of melanin pigment.

B. D-amino acids: These are non-standard amino acids— Amino acids normally isolated from animal and plants are L-amino acids. But certain D-amino acids are found in bacteria and antibiotics and in brain tissues of animals.

Classification based on metabolism:

Glucogenic and ketogenic amino acids:

Amino acids can be classified as glucogenic, ketogenic, or both, based on which of the intermediates are produced during their catabolism.

A. Glucogenic amino acids

Amino acids whose catabolism yields pyruvate or one of the intermediates of the TCA cycle are termed glucogenic. These intermediates are substrates for gluconeogenesis and, therefore, can give rise to the net synthesis of glucose in the liver and kidney.

B. Ketogenic amino acids:

Amino acids whose catabolism yields either acetoacetate or one of its precursors (acetyl CoA or acetoacetyl CoA) are termed ketogenic . Acetoacetate is one of the ketone bodies, which also include 3-hydroxybutyrate and acetone . Leucine and lysine are the only exclusively ketogenic amino acids found in proteins.

C. Glucogenic & Ketogenic amino acids:

Isoleucine, Phenylalanine, Tyrosine, Threonine and Tryptophan are partially ketogenic and partially glucogenic.

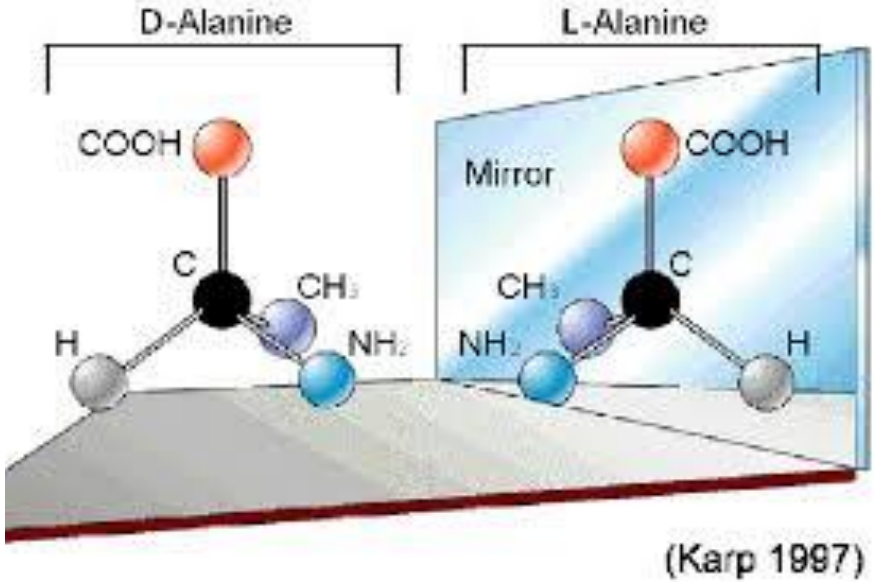
- **(remembered by: the "PITTT" or "FITTT", and includes all the aromatic amino acids) Phenylalanine (abbreviated Phe or F ; based on their respective pronunciations)**

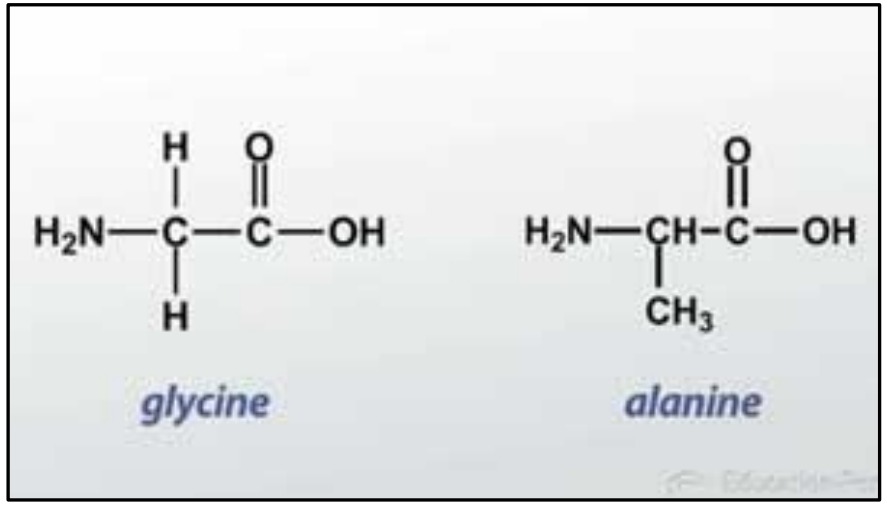
Glycogenic , Ketogenic And Both Kitogenic And Glucogenic Amino Acids Classification

Glucogenic		Both Glucogenic and ketogenic	ketogenic
Alanine	Arginine	Isoleucine	Leucine
Asparagine	Aspartate	Phenylalanine	Lysine
Cysteine	Glutamate	Trptophan	
Glutamine	Glycine	Tyrosine	
Histidine	Methionine	Threonine	
Proline	Serine		
Threonine	Valine		

Optical properties of amino acids.

The α-carbon of each amino acid is attached to four different chemical groups and is, therefore, a chiral or optically active carbon atom. Glycine is the exception because its α-carbon has two hydrogen substituents and, therefore, is optically inactive.





Amino acids that have an asymmetric center at the α-carbon can exist in two forms, D and L that are mirror images of each other.

The two forms in each pair are termed stereoisomers, optical isomers, or enantiomers. All amino acids found in proteins are of the L-configuration. D-amino acids are found in some antibiotics and in plant and bacterial cell walls.

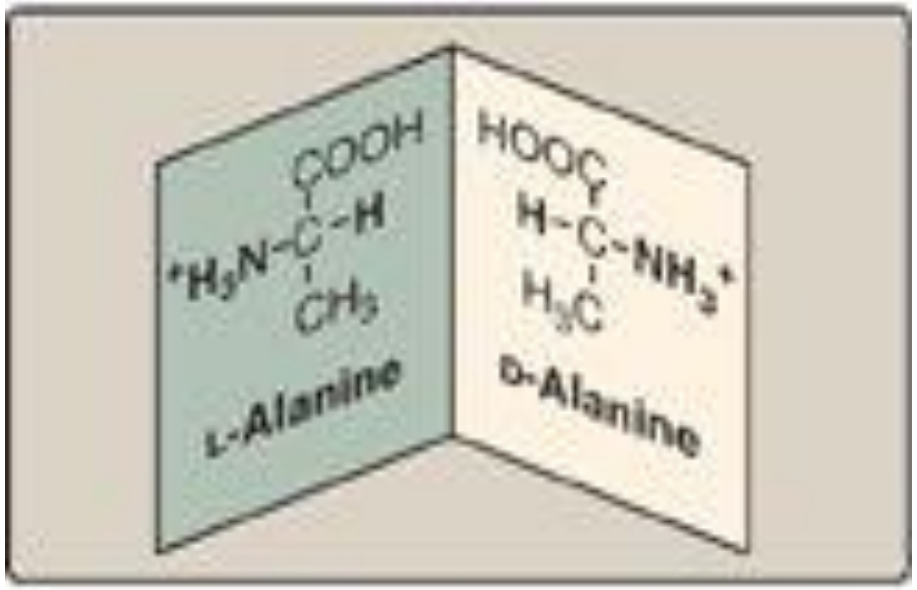


Figure 8: D and L forms of alanine are mirror images.

Acidic and basic properties of amino acids:

- **Amino acids in aqueous solution contain weakly acidic α-carboxyl groups and weakly basic α-amino groups. In addition, each of the acidic and basic amino acids contains an ionizable group in its side chain.**
- **Thus, both free amino acids and some amino acids combined in peptide linkages can act as buffers.**
- **Recall that acids may be defined as proton donors and bases as proton acceptors. Acids (or bases) described as "weak" ionize to only a limited extent.**
- **Substances, such as amino acids, that can act either as an acid or a base are defined as amphoteric, and are referred to as ampholytes (amphoteric electrolytes).**

Functions of Amino Acids:

(a) Some amino acids are converted to carbohydrates as **glucogenic amino acids**.

(b) Specific amino acids give rise to specialized products, e.g.

- **Tyrosine** forms hormones such as **thyroid hormones**, (T3, T4), **epinephrine** and **norepinephrine** and a pigment called **melanin**.
- **Tryptophan** can synthesize a vitamin called **niacin**.
- **Serotonin is formed from tryptophan.**

Summary:

- **Each amino acid has an α-carboxyl group and a primary α-amino group**

- **At physiologic pH, the α-carboxyl group is dissociated, forming the negatively charged carboxylate ion ($-COO^-$), and the α-amino group is protonated ($-NH_3^{+)}$.**

- **Each amino acid also contains one of 20 distinctive side chains attached to the α-carbon atom. The chemical nature of this R group determines the function of an amino acid in a protein and provides the basis for classification of the amino acids as nonpolar, polar, acidic (polar negative), or basic (polar positive).**

- **All free amino acids, plus charged amino acids in peptide chains, can serve as buffers. The α-carbon of each amino acid (except glycine) is attached to four different chemical groups and is, therefore, a chiral or optically active carbon atom. The L-form of amino acids is found in proteins synthesized by the human body.**

Assessments and evaluation:

Try to answer these questions?

1. **What are glucogenic and ketogenic amino acids?**
2. **What is the optical activity for amino acid?**
3. **Why glycine is optically inactive?**
4. **What is the importance of amino acids?**

Good Luck

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