

Lecture : 1

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Slide Sheet



Medical Committee
The University of Jordan

Biochemistry

cybernetics
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enzymology
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Mousa Suboh

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Biochemistry Lec #1 –Dr. Nafith AbuTarboush– (30.6.2014)

Amino Acids 1

Campbell and Farrell's Biochemistry, Chapter 3 (pp.66-76)

Introduction: Biochemistry is two courses; one is structural biochemistry and the other is concerned about metabolism

This course is all about the structure and macromolecules; proteins, carbohydrates, lipids and nucleic acids and in the last two weeks of the course we will talk about special part of proteins which is the enzymes

In the first semester of the coming year we will start talking about the metabolism ...

First we'll start with the proteins and their structure

Protein word comes from a Greek word "proteios" which means primary, primary means important and essential

If you measure the dry body weight (without water) you'll find that 50% of that weight is proteins which means that they are of a great importance

Proteins serve a wide range of different functions such as:

1. Work as enzymes; biological catalysts that speed up the chemical reactions in human body
2. Defense mechanism like antibodies
3. Carriers like hemoglobin that carries oxygen
4. Receptors and chemical messengers
5. Support and structural purposes like collagen
6. Signal transduction

What makes them serve this wide range of different functions?

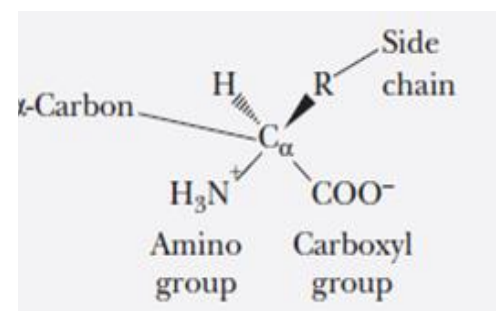
The difference is the structure of the proteins (structural difference leads to functional difference)

What makes such structural differences? What are the structures of proteins?

They are polymers of amino acids. Proteins differ from each other by the number of amino acids that construct them and in the arrangement of these amino acids.

The structure of amino acids (structural features of amino acids):

Alpha carbon is connected to an acidic group which the carboxyl group, basic group which is the amino group, hydrogen and R group. The R group is different in different amino acids (side chain).



All amino acids share this basic structure; alpha carbon connected to carboxyl group, amino group, H and R group which differs from one amino acid to another.

We classify amino acids relatively to the R group, and we classify the R group according to its polarity; polar or nonpolar amino acids. Polar amino acids are also classified as charged or uncharged amino acids. Any structure to be polar it should have oxygen, nitrogen or sulfur (note!, They are strong electronegative atoms).

The carbons which are in the side chain are named alphabetically according to the Greek letters (alpha (α), beta (β), gamma (γ), delta (δ), epsilon (ϵ), zeta...)

The terminal carbon atom is referred to as the omega (ω) carbon

The fatty acids; Omega-3, Omega-6 and Omega-9, are named according to the principal in organic chemistry; the last carbon is named in the chain is called omega. In Omega-3 there are 3 carbons from the omega carbon, in omega-6 there are 6 carbons from the omega carbon and in omega-9 there are 9 carbons from the omega carbon, then you'll find the double bond.

The alpha carbon is surrounded by four groups, and these four groups are not on the same plane, they are distributed three dimensionally (3D).

These 3D structures are optically active compounds that can rotate polarized light to the left or the right, and according to that they will be named L(left) or D(right) structures (like R and S in organic chemistry (clockwise and counter-clockwise)).

Chirality of molecules is different than chirality of atoms.

There should be a chiral center if the molecule is chiral; the chiral center gives the chirality to the molecule "at least one chiral center", but if there was more than one chiral center they may cancel each other which makes the molecule achiral.

The chiral carbon in the amino acids is the **alpha carbon**.

The molecule to be chiral, it must be able to be divided from the axis (vertically or horizontally), if it gives two equal parts then it's achiral (does not have a plane of symmetry) .

When the R group in the amino acid is hydrogen then it's achiral, and this applies only to one amino acid.

All amino acids **except** Glycine are chiral; the alpha carbon is a chiral center (surrounded by four different groups) and gives chirality to the amino acid.

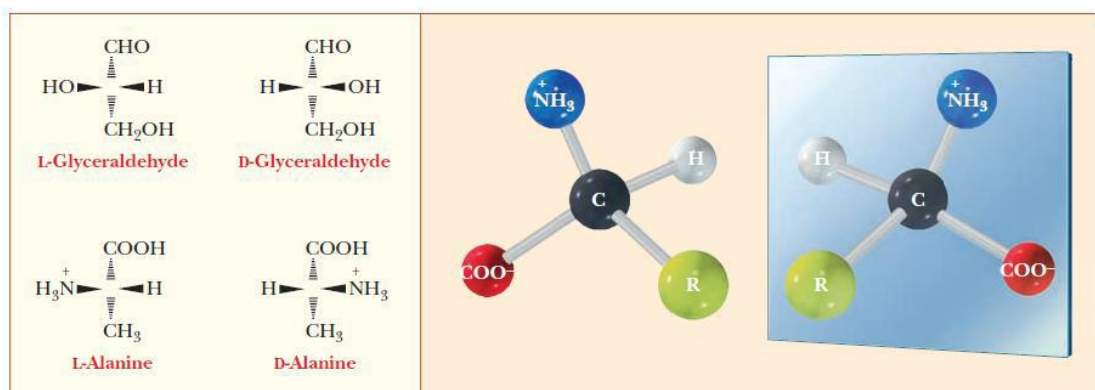
Chirality is important because it restricts whether the amino acid is D or L.

It's important to have D and L amino acids to get a bigger variety in functions.

If the structure of a molecule differs even spatially this will lead to different functions.

To hold the surgical tools the right way you should wear the gloves the right way; the left hand in the left glove and the right hand in the right glove, and this is the way enzymes and amino acids work and this is why it's important to know whether the amino acid is D or L, because there are some enzymes that only work with D amino acids and others only work with L amino acids (more specificity).

Looking at the picture below we conclude that:



If two molecules have the same number of atoms, they are isomers

If the isomers have the same atomic connectivity, but differ spatially, they are stereoisomers

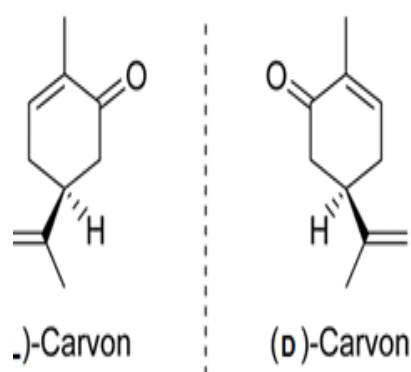
If the stereoisomers are mirror images of each other, they are enantiomers

If a molecule is exposed to a straight light and the light deviates to the right then it's D, to the Left it's L.

Note that ! All amino acids that occur in proteins naturally are L form.

The most important thing to know is that the difference in orientation (in rotating the polarized light) which makes the D or L (Dextro → right handed, Levo → Left handed) affects the function.

This example is to show that the orientation affects the function; these two compounds only differ spatially but they are functioning totally in a different manner. The (L)-Carvon is found in the spearmint and gives it the color, smell and taste, while the (D)-Carvon is found in the caraway and gives it the smell and taste.



Aspartame is the sweeter that is found in extra chewing gum and diet soda drinks. It's used to sweeten the tea and any other drink for diabetes patients. Aspartame is made up of two amino acids not sugars, and the two amino acids should be of the L type; if one them is D or both it would give a bitter taste.

Amino acids are much more than 20. But there are 20 encoded by the genetic code.

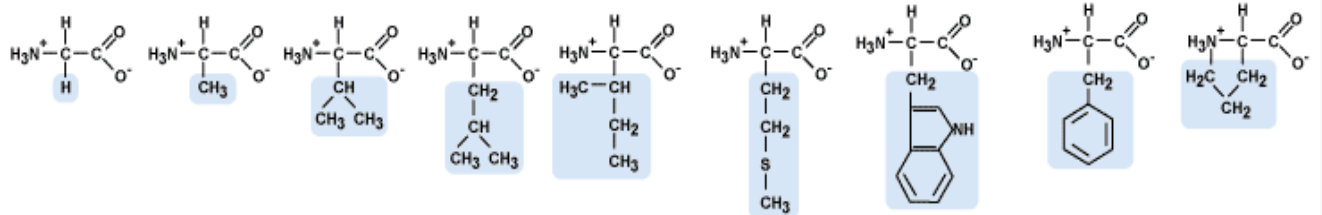
The amino acids that will get synthesized in proteins are the 20 encoded by the genetic code.

We must know the names, 3-letter code but the 1-letter code of these 20 amino acids is not required:

The 20 amino acids

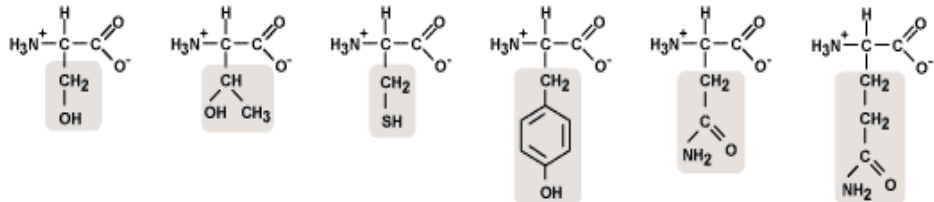
Abbreviation	Amino acid	Abbreviation	Amino acid
Ala	Alanine	Leu	Leucine
Arg	Arginine	Lys	Lysine
Asp	Aspartic acid	Met	Methionine
Asn	Asparagine	Phe	Phenylalanine
Cys	Cysteine	Pro	Proline
Gln	Glutamine	Ser	Serine
Glu	Glutamic acid	Thr	Threonine
Gly	Glycine	Trp	Tryptophan
His	Histidine	Tyr	Tyrosine
Ile	Isoleucine	Val	Valine

NONPOLAR



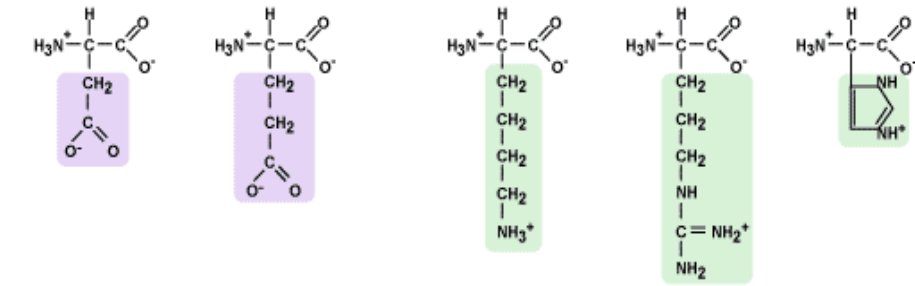
Glycine (Gly) Alanine (Ala) Valine (Val) Leucine (Leu) Isoleucine (Ile) Methionine (Met) Tryptophan (Trp) Phenylalanine (Phe) Proline (Pro)

POLAR



Serine (Ser) Threonine (Thr) Cysteine (Cys) Tyrosine (Tyr) Asparagine (Asn) Glutamine (Gln)

Electrically Charged



Acidic

Aspartic Acid (Asp) Glutamic Acid (Glu)

Basic

Lysine (Lys) Arginine (Arg) Histidine (His)

If we classified them according to the polarity of the side chain, they will be whether polar, non-polar, and the polar charged or uncharged, and the charged positive or negative.

We should know this classification:

Non-polar	Polar	Charged (positive)	Charged (negative)
Alanine	Serine	Lysine	Glutamate
Valine	Threonine	Arginine	Aspartate
Leucine	Glutamine	Histidine	
Isoleucine	Asparagine		
Methionine	Cysteine		
Tryptophan	Tyrosine		
Phenylalanine			
Proline			
Glycine			

The charged amino acids:

Glutamate, Aspartate, Lysine, Arginine and Histidine.

Aspartic acid has an acidic group. Glutamic acid has also an acidic group. They differ from each other in the number of carbons in the side chain; the glutamate has an extra carbon.

The aspartic acid comes before the glutamic acid alphabetically and it's smaller.

Lysine, arginine and histidine

The 20 amino acids

Abbreviation	Amino acid	Abbreviation	Amino acid
Ala	Alanine	Leu	Leucine
Arg	Arginine	Lys	Lysine
Asp	Aspartic acid	Met	Methionine
Asn	Asparagine	Phe	Phenylalanine
Cys	Cysteine	Pro	Proline
Gln	Glutamine	Ser	Serine
Glu	Glutamic acid	Thr	Threonine
Gly	Glycine	Trp	Tryptophan
His	Histidine	Tyr	Tyrosine
Ile	Isoleucine	Val	Valine

Histidine has a quinary ring in its side chain and it's positively charged.

Lysine has one amino group in the side chain.

Arginine has a guanidino group. It's an important group made up from one carbon connected to 3 nitrogens. It's a very strong basic group used to make plastic and explosives.

If we remove the O and the negative charge from the aspartic acid and glutamic acid we'll get C=O which is the carbonyl group. And if we connect the carbonyl to nitrogen we will get an amide group.

Aspartic acid → Asparagine (Polar, Uncharged)

Glutamic acid → Glutamine (Polar, Uncharged)

The polar, uncharged amino acids:

Asparagine, Glutamine, Serine, Threonine, Cysteine and Tyrosine.

Any polar structure must have N, O, or S

There are 3 amino acids having a hydroxyl group on their side chain; serine, threonine and tyrosine.

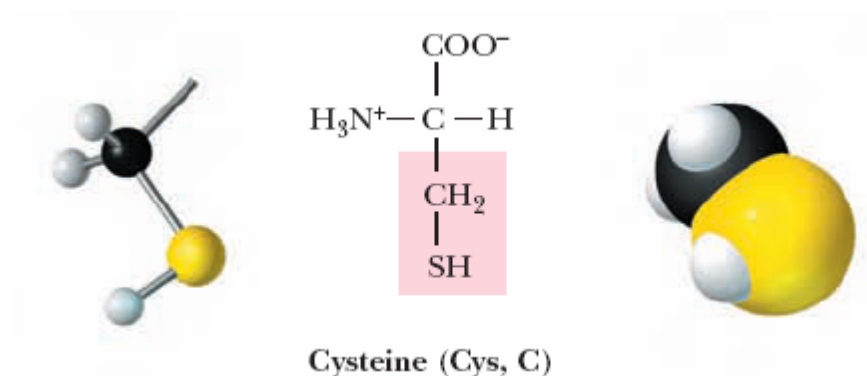
In serine, **one** carbon connected to the hydroxyl group in the side chain.

In threonine, **two** carbons connected to the hydroxyl group in the side chain.

In tyrosine, benzene ring connected to the hydroxyl group in the side chain.

- When we remove the OH it becomes nonpolar.

Cysteine contains sulfur, when the sulfur is terminal it's called a thiol group. The thiol group is reactive, it can make bonds.



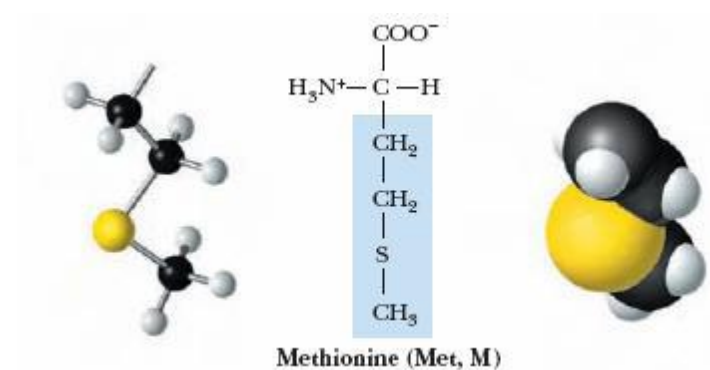
If the sulfur is connected to another carbon (no bond with H) it won't be reactive, and the amino acid will be nonpolar.

The nonpolar, uncharged amino acids:

Glycine, Alanine, Valine, Proline, Leucine, Isoleucine, Methionine, Tryptophan and Phenylalanine.

If the benzene ring is not connected to a hydroxyl group then it's phenylalanine.

If the sulfur is connected to two carbons it's nonpolar and called methionine.



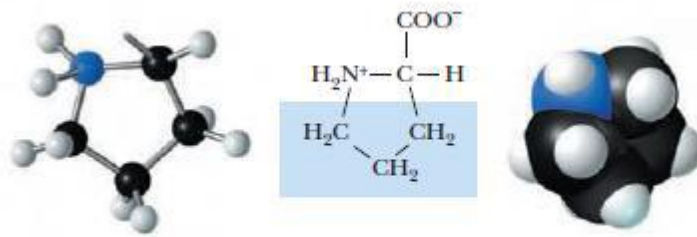
Tryptophan is a nonpolar amino acid; it's identified by the two rings in the side chain which is called Indole ring structure.

- You should be able to identify the amino acid when you look at its structure.

Note ☺ ... Tryptophan is the largest amino acid while Glycine is the smallest.

Proline **contains imino** group

It is already a chain then it is wrapped to make another covalent bond between the branch and the amino group of the amino acid, that makes the "N" of the NH_3^+ group 2° N.



Proline (Pro, P)

It is a rigid amino acid; it is a ring structure, bonded and tightly wrapped, so it's not a flexible amino acid