

Advanced Cell Biology. Lecture 6

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Outline

Questions and answers

Amino acids

Structure and classification

Nucleic acids

Structure and features



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Previous final question: the answer

Which role in the cell lipids do NOT play?



Previous final question: the answer

Which role in the cell lipids do NOT play?

- ▶ Protein, DNA, RNA synthesis
- ▶ Transport
- ▶ Cellular respiration
- ▶ ~~Making energy~~
- ▶ ~~Exo- / endocytosis~~



Amino acids

Structure and classification

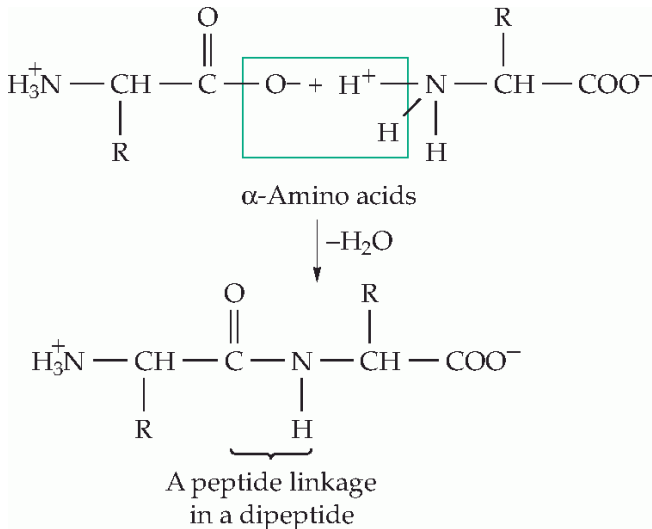


Peptide bonds

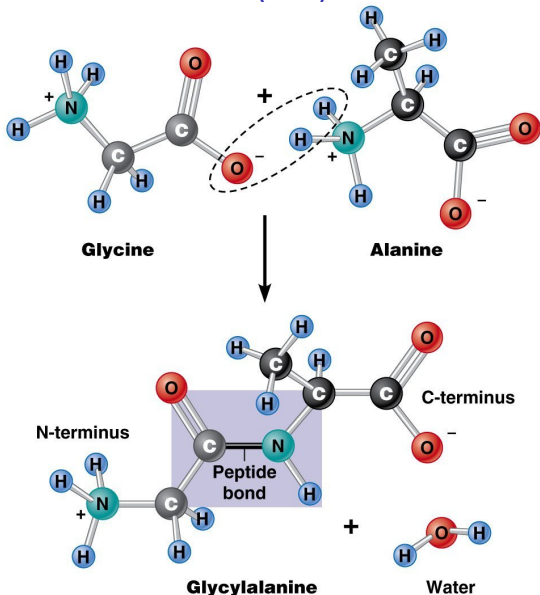
- ▶ Amino acids may group together in peptides via peptide bonds
- ▶ This is **reaction of condensation**, it results also in one water molecule



Reaction of condensation



Reaction of condensation (3D)



Roles

- ▶ Most important: components of peptides and proteins
- ▶ Many are intermediate stages of different biosynthetic processes, e.g.:
 - ▶ *Tryptophan* is a precursor of the neurotransmitter *serotonin*
 - ▶ *Aspartate*, *glycine* and *glutamine* are precursors of nucleotides



Amino acid diversity by groups: glycine

- ▶ Simplest amino acid
- ▶ “R” is simply H in case of glycine

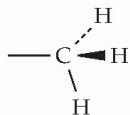


Alkyls

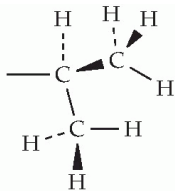
- ▶ Have hydrocarbon groups as radicals
- ▶ Hydrophobic and therefore involving in protein shaping



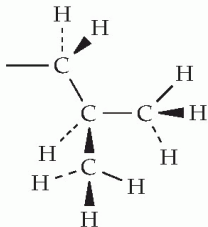
Alkyl amino acids



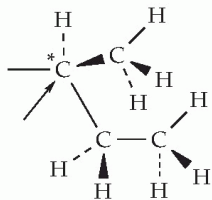
Alanine (Ala, A)



Valine (Val, V)



Leucine (Leu, L)



Isoleucine (Ile, I)

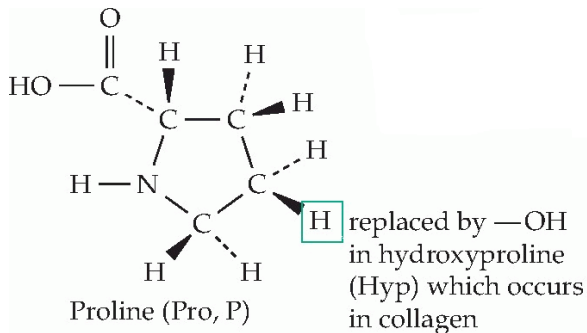


Imines

- ▶ Not an amino acids in a strict sense because there are no α -carbon
- ▶ Molecule is rigid and influence protein folding



Imines

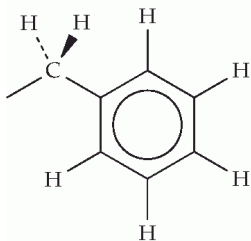


Aromatic

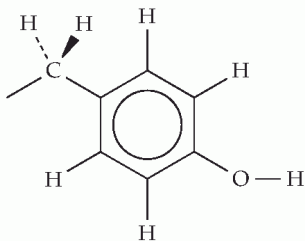
- ▶ Contain benzene groups
- ▶ May form hydrophobic bonds



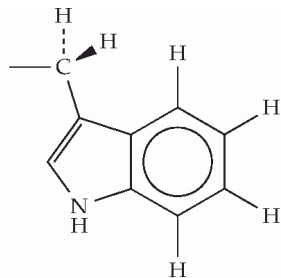
Aromatic amino acids



Phenylalanine (Phe, F)



Tyrosine (Tyr, Y)



Tryptophan (Trp, W)

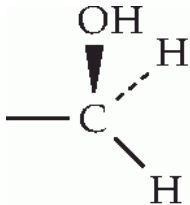


Alcohols

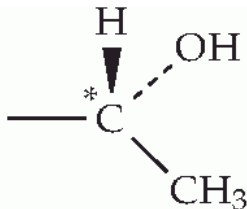
- ▶ -OH group is very weakly acidic
- ▶ May form active centers of some enzyme proteins



Alcohol amino acids



Serine
(Ser, S)



Threonine
(Thr, T)

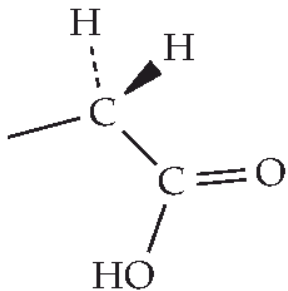


Acidic amino acids

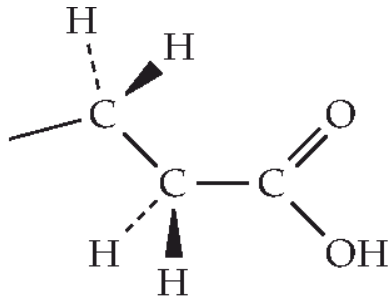
- ▶ Weak acids
- ▶ Provide anionic (–) groups on the surface of proteins



Acidic amino acids



Aspartic acid (Asp, D)



Glutamic acid (Glu, E)

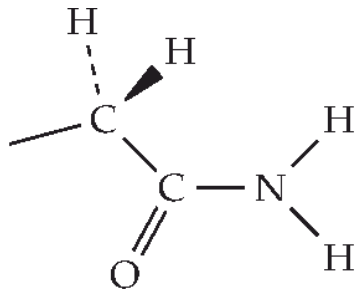


Amidic

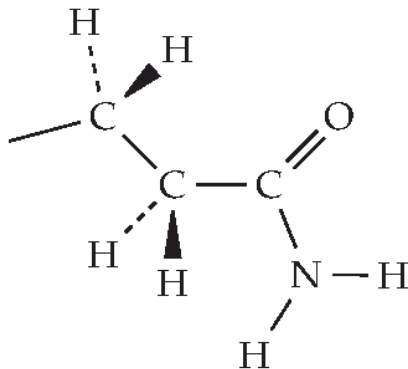
- ▶ Contain amide group –CONH
- ▶ Not acidic, but polar and therefore participate in hydrogen bonding



Amidic amino acids



Asparagine (Asn, N)



Glutamine (Gln, Q)



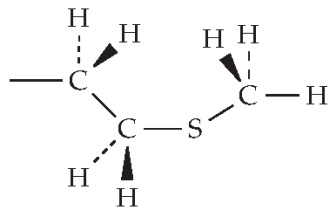
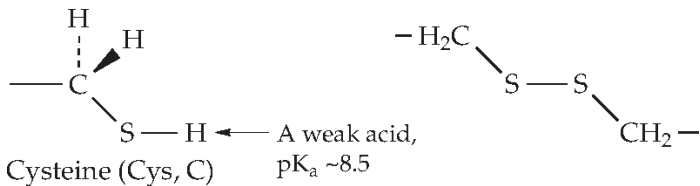
Sulfur-containing

- ▶ Two –SH groups of cysteine may form **disulfide bridge** between different parts of protein molecule

Disulfide bonds movie



Sulfur-containing amino acids



Methionine (Met, M)

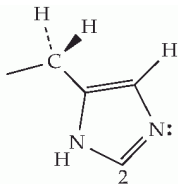


Basic amino acids

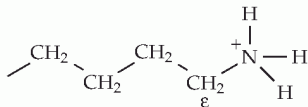
- ▶ Contain different nitrogen basic groups
- ▶ Could be strong bases and therefore binds other molecules to proteins



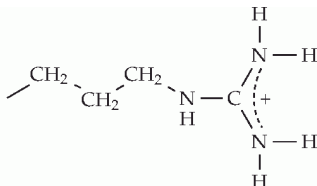
Examples of basic amino acids



Histidine (His, H)



Lysine (Lys, K)



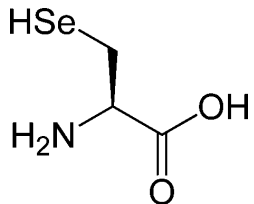
Arginine (Arg, R)

Two extra amino acids

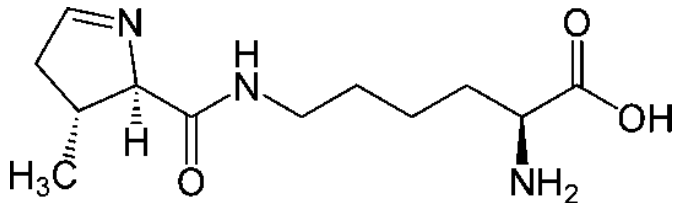
- ▶ **Selenocysteine** is similar to cysteine, but selenium instead of sulfur, forming a selenol group and selenoproteins
- ▶ **Pyrrolysine** is similar to lysine but with additional pyrroline ring, it presents in many proteins of archeobacteria (archaea)
- ▶ They both depend on modified stop codons in RNA (normally, these codons break protein synthesis)



Selenocysteine



Pyrrolysine

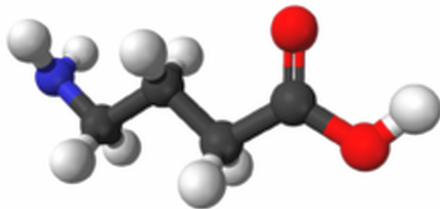
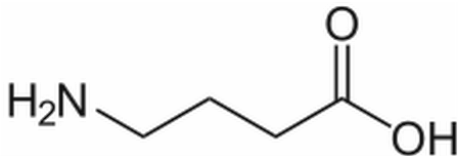


Non-protein amino acids

- ▶ **Taurine** abundant in muscular and brain tissues but its functions still not known
- ▶ **γ -aminobutyric acid (GABA)** is non- α amino acid; it is one of main neurotransmitters in mammalian nervous system



GABA



Nucleic acids

Structure and features



Composition of nucleic acids

- ▶ **Nucleic bases**—heterocycles with nitrogen
- ▶ **Pentose** in cyclic form
- ▶ **Phosphoric acid** H_3PO_4



Phosphate

- ▶ Simply H_3PO_4
- ▶ Normally, fully dissociated (lost 2 hydrogen ions)



Pentose

- ▶ **Deoxyribose** (in DNA)
OR
- ▶ **Ribose** (in RNA)

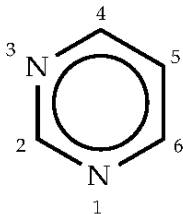


Nucleic bases and nucleosides

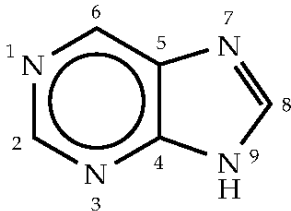
- ▶ **Pyrimidines** (1-cyclic): **uracil/thymine** or **cytosine**
- ▶ **Purines** (2-cyclic + amines): **adenine** or **guanine**
- ▶ *Nucleosides* are nucleic bases + pentoses



Purines and pyrimidines

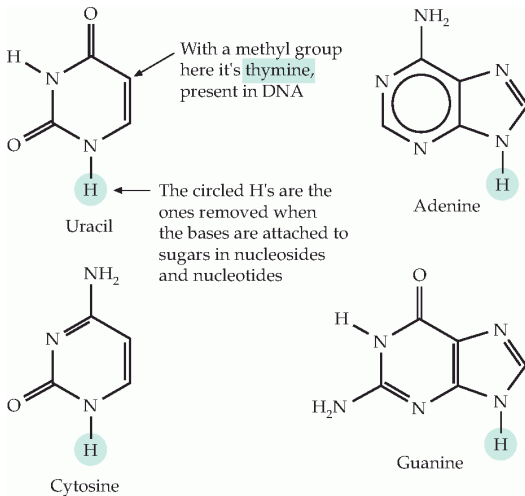


Pyrimidine



Purine

Nucleic bases



Note: all of these molecules are almost perfectly flat!

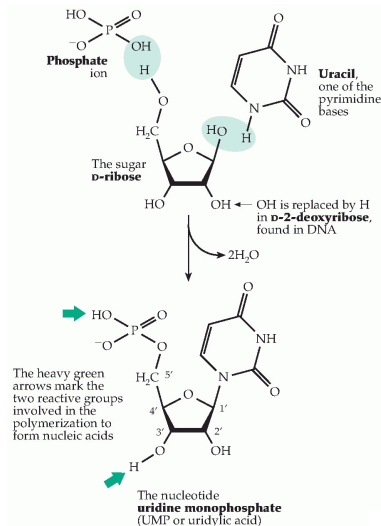


Nucleotide synthesis

- ▶ Double condensation
- ▶ First –OH groups from sugar and phosphoric acid used



Formation of nucleotide

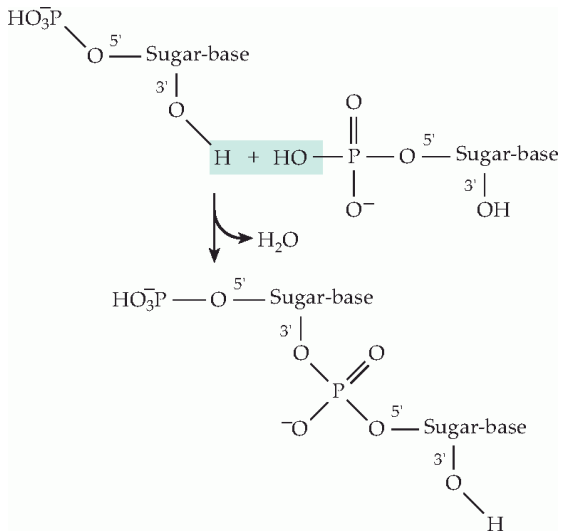


Nucleic acid synthesis

- ▶ Condensation between second free $-OH$ groups of sugar and phosphoric acid
- ▶ Resulted polymer may have almost infinite length



Formation of nucleic acid polymers



DNA and RNA chemistry

- ▶ Deoxyribose vs. ribose
- ▶ Thymine vs. uracil

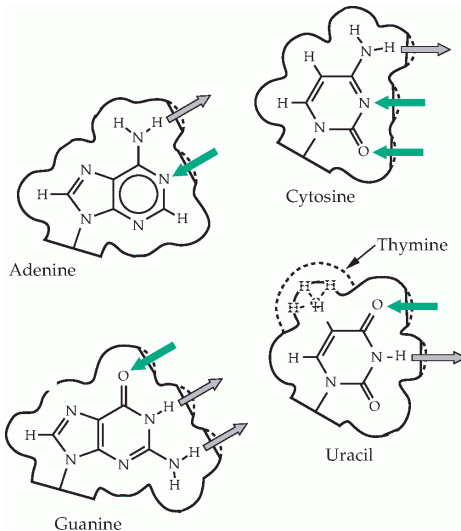


Hydrogen bonds, complementarity and base pairs

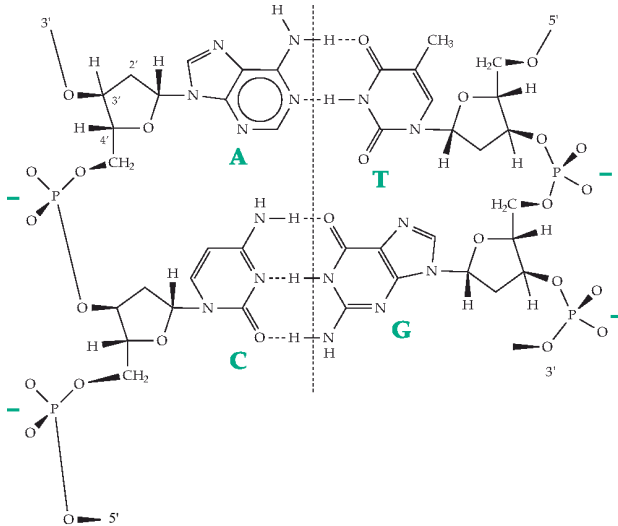
- ▶ 2 hydrogen bonds (one “in”, one “out”): adenine and thymine/uracil
- ▶ 3 hydrogen bonds (one “in”, two “out” in guanine): guanine and cytosine
- ▶ A–T and G–C are base pairs consist of *complementary nucleotides*



Hydrogen bonds between nucleotides



Hydrogen bonds in complementary strands



Final question (3 points)



Final question (3 points)

Write a sequence complementary to **ATTGGAAGC**
Is it from DNA or RNA?



Summary

- ▶ There are 20 (+2) standard amino acids classifying in 9 groups
- ▶ Nucleic acids are composition of purin/pyrimidin base, ribose/deoxyribose and phosphoric acid



For Further Reading



A. Shipunov.

Advanced Cell Biology [Electronic resource].

2011—onwards.

Mode of access:

http://ashipunov.info/shipunov/school/biol_250



B. Alberts et al.

Essential Cell Biology. 3rd edition.

Garland Science, 2009.

Chapter 2: : Molecules in cells, Panels 2–6.

