Advanced Cell Biology. Lecture 6

Alexey Shipunov

Minot State University

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Outline

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Questions and answers

Amino acids

Structure and classification

Nucleic acids

Structure and features

Previous final question: the answer

Which role in the cell lipids do NOT play?

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Which role in the cell lipids do NOT play?

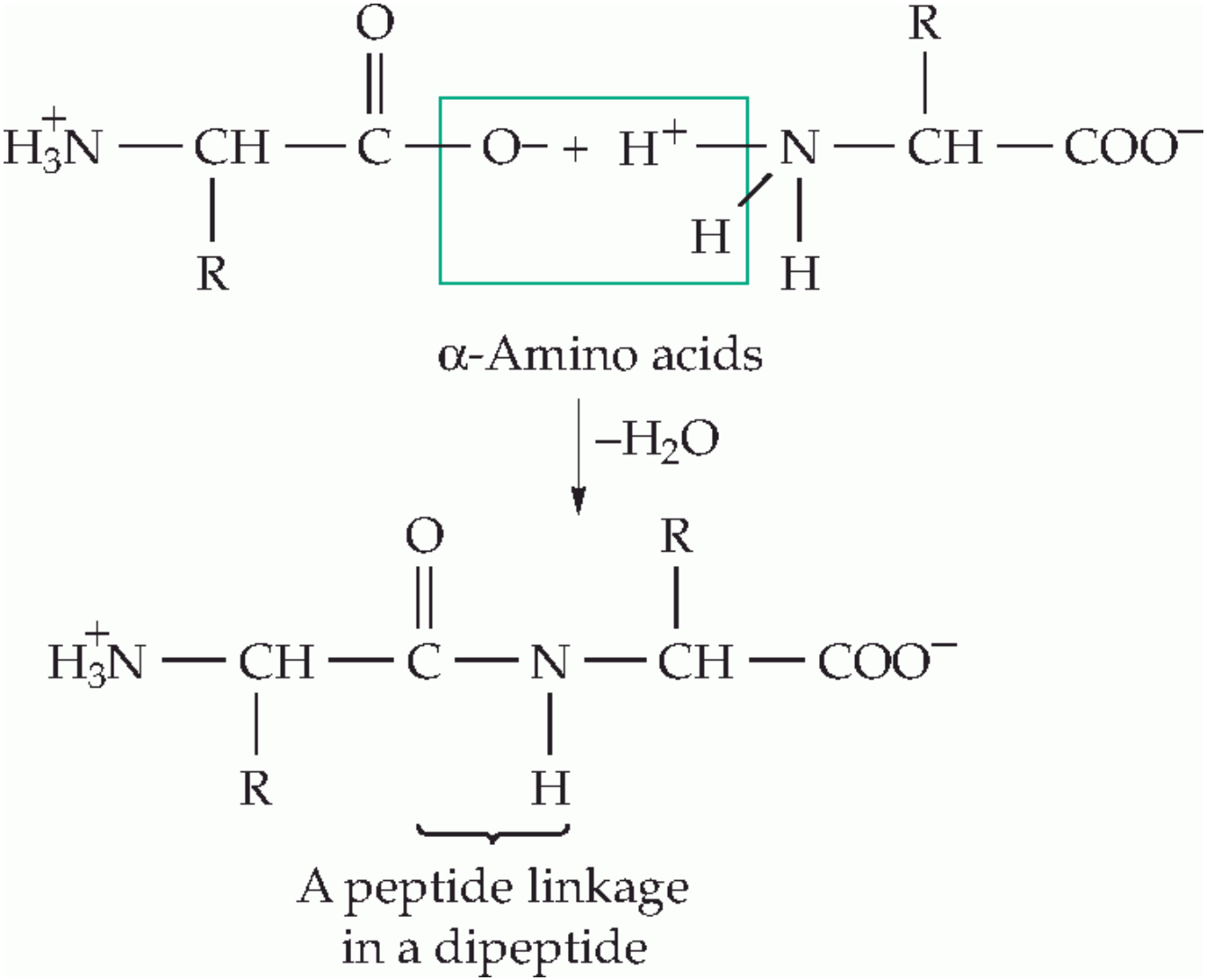
- Protein, DNA, RNA synthesis
- Transport
- Cellular respiration
- ~~Making energy~~
- ~~Exo- / endocytosis~~

Amino acids
Structure and classification

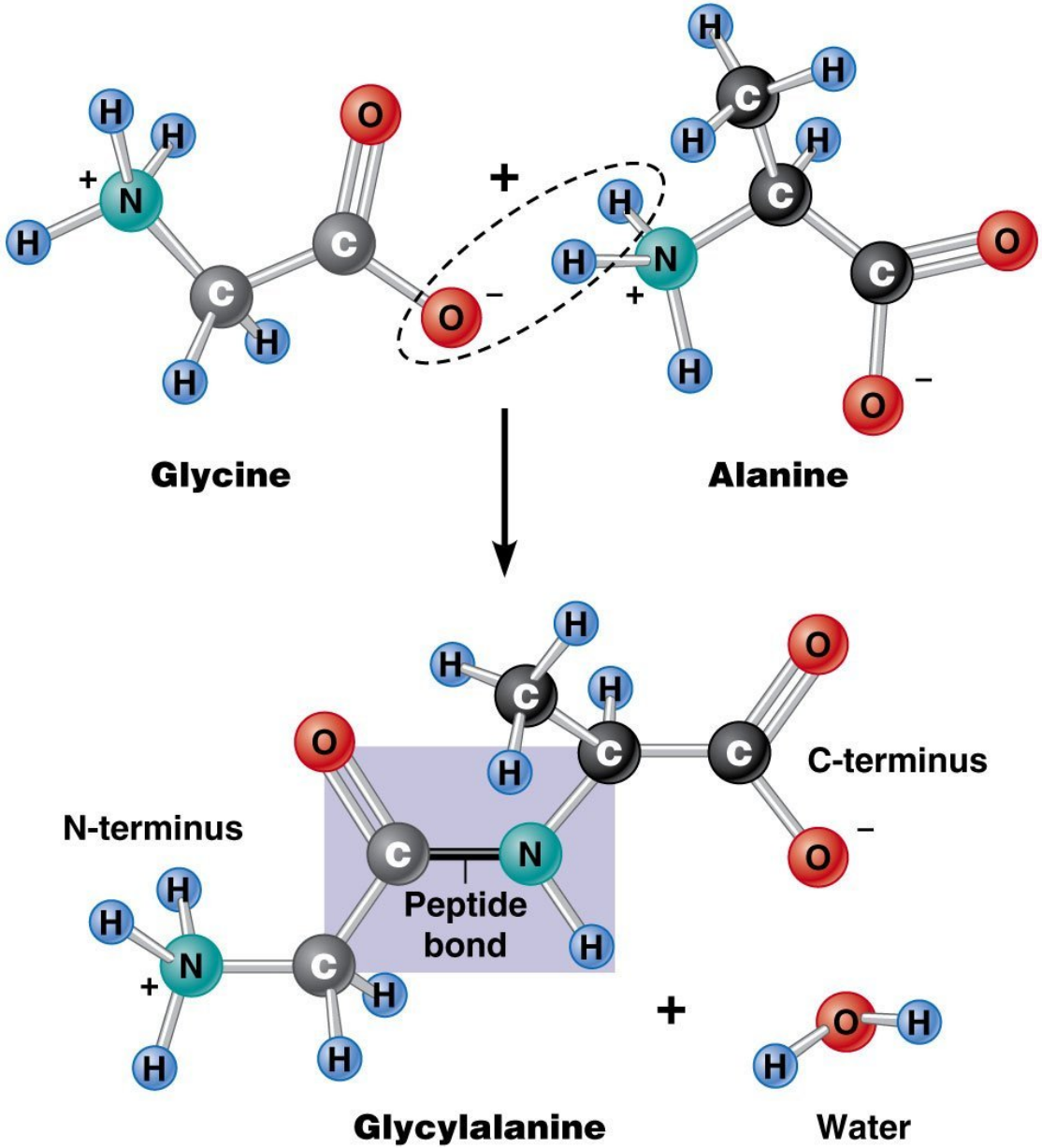
Peptide bonds

- 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

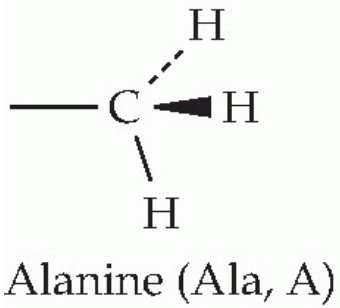
Amino acid diversity by groups: glycine

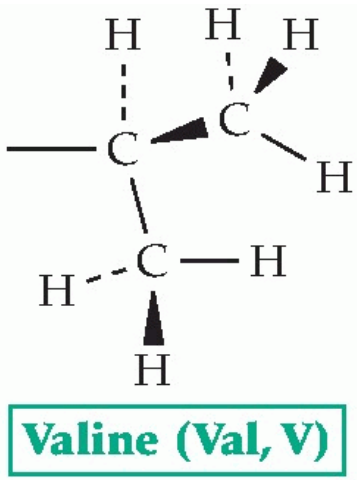
- Simplest amino acid
- “R” is simply H in case of glycine

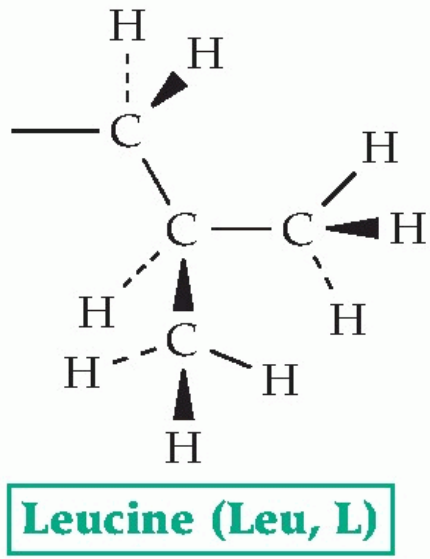
Alkyls

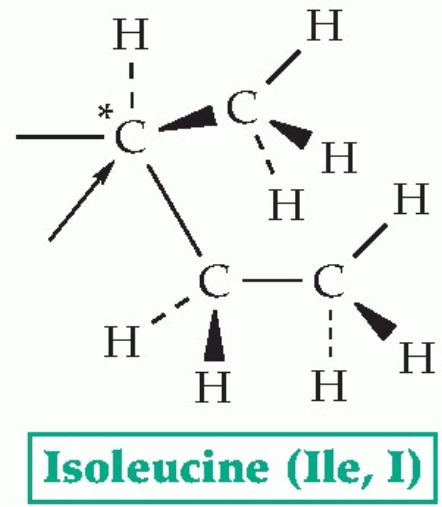
- Have hydrocarbon groups as radicals
- Hydrophobic and therefore involving in protein shaping

Alkyl amino acids





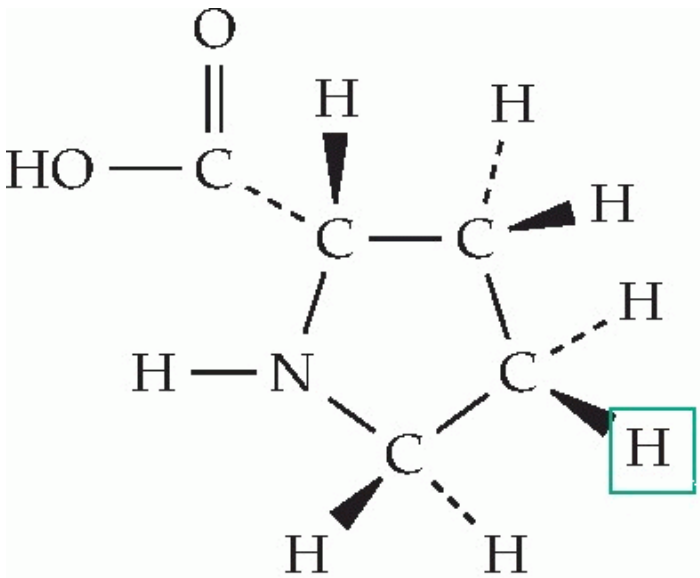




Imines

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

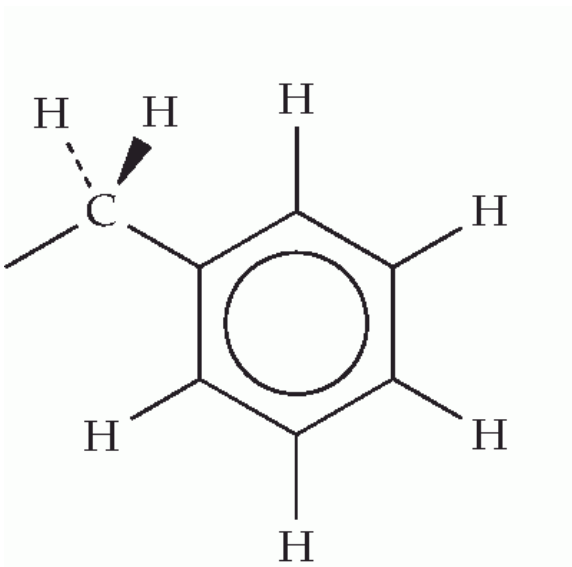
Imines


O
HO
C
H
H
C
C
H
H
H
N
C
C
H
H
H
H replaced by —OH in hydroxyproline (Hyp) which occurs in collagen
Proline (Pro, P)

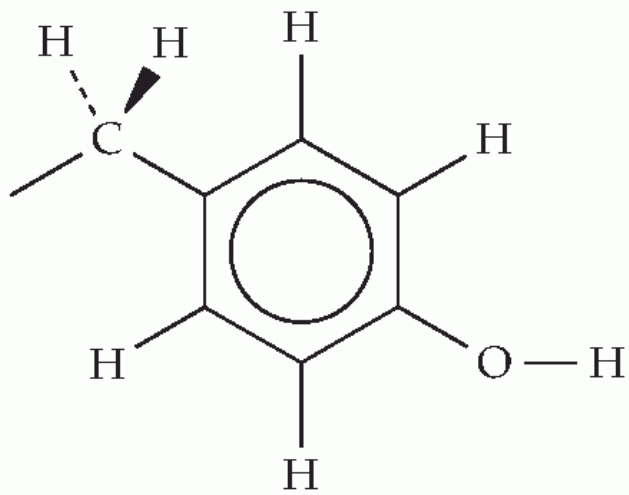
Aromatic

- Contain benzene groups
- May form hydrophobic bonds

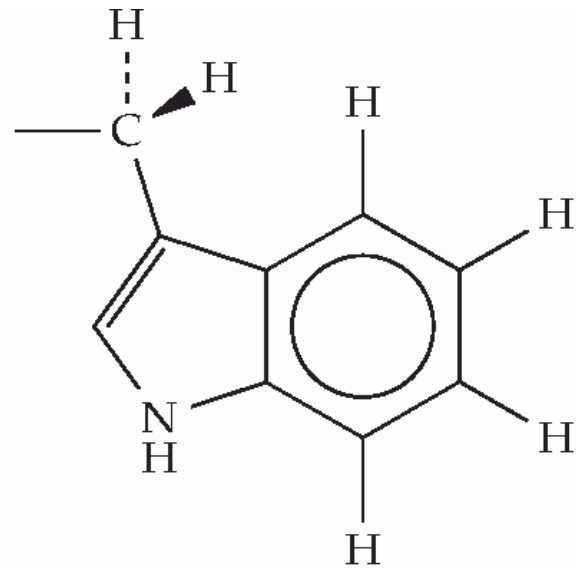
Aromatic amino acids



Phenylalanine (Phe, F)



Tyrosine (Tyr, Y)

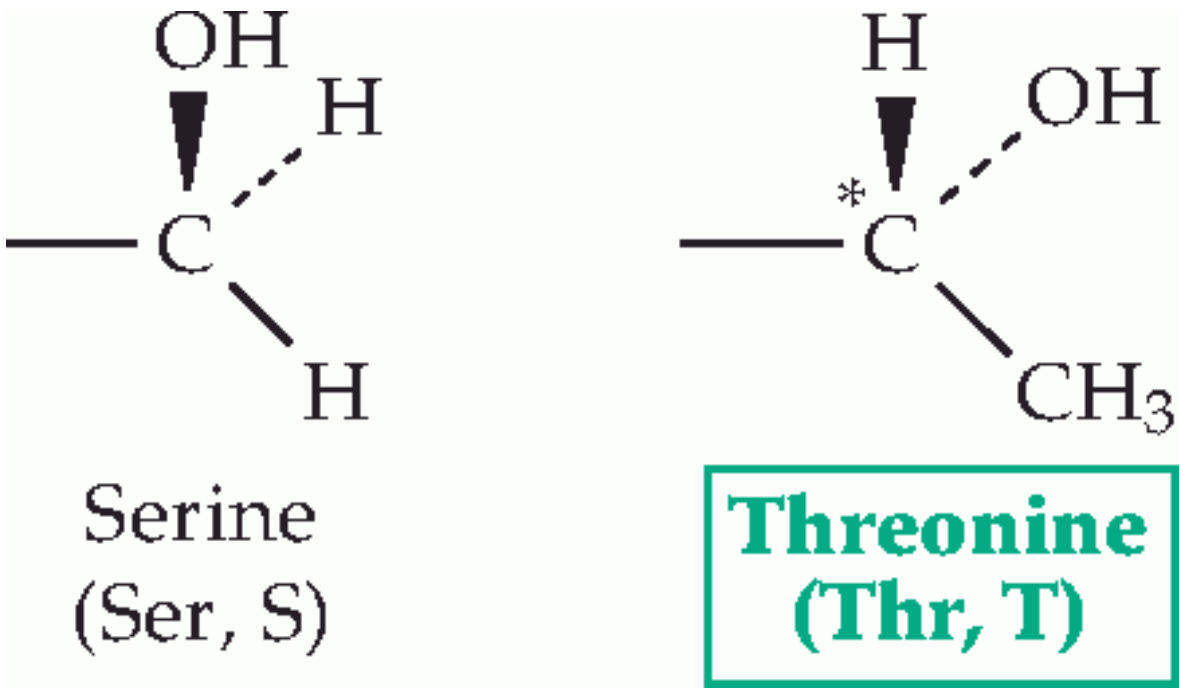


Tryptophan (Trp, W)

Alcohols

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

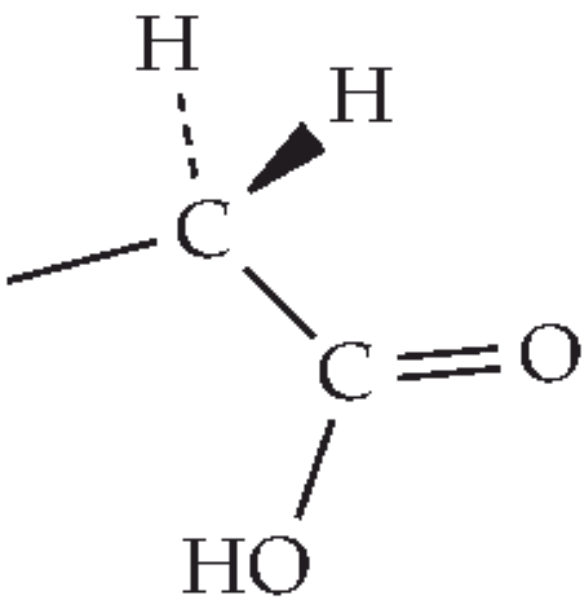
Alcohol amino acids



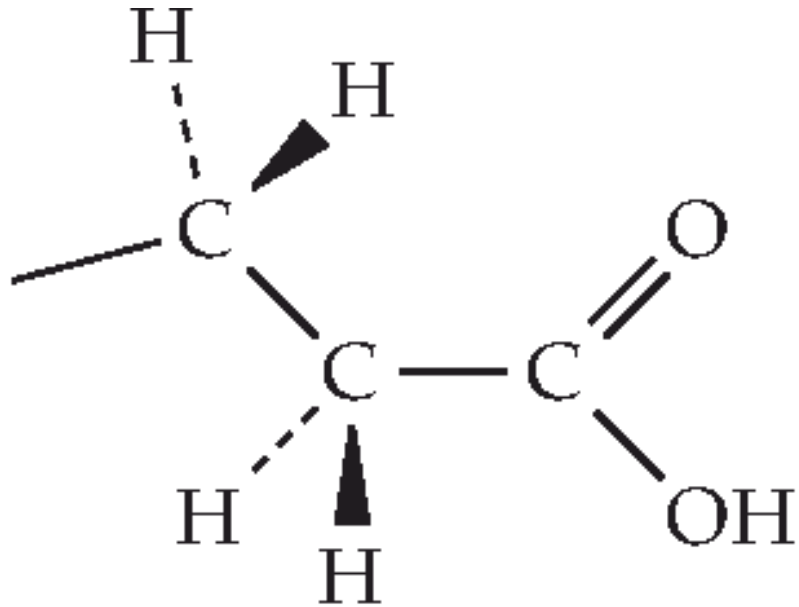
Acidic amino acids

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

Acidic amino acids



Aspartic acid (Asp, D)

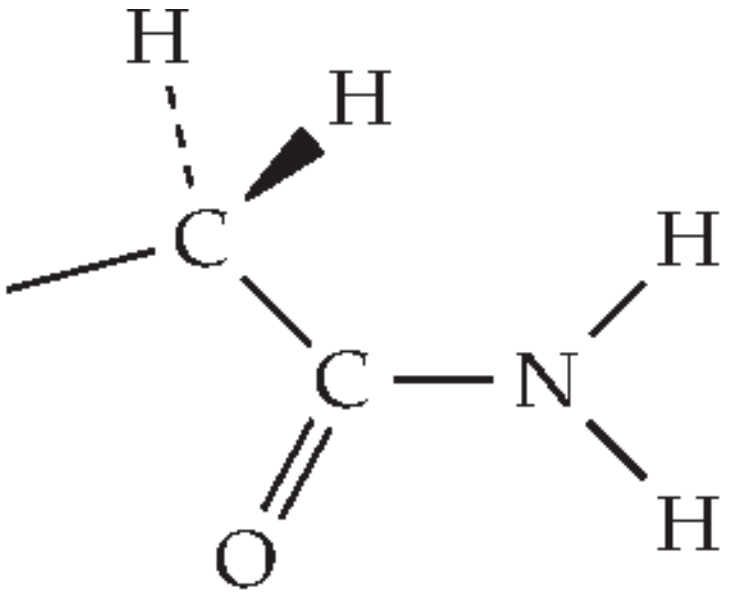


Glutamic acid (Glu, E)

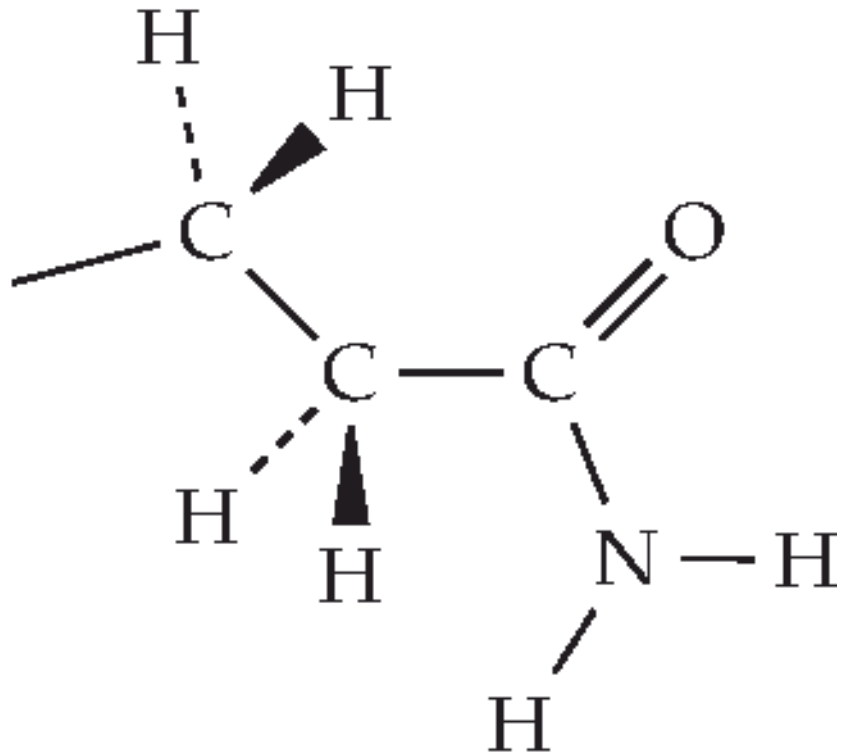
Amidic

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

Amidic amino acids



Asparagine (Asn, N)



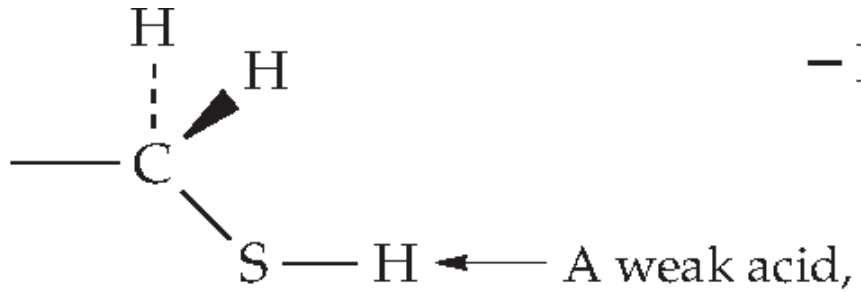
Glutamine (Gln, Q)

Sulfur-containing

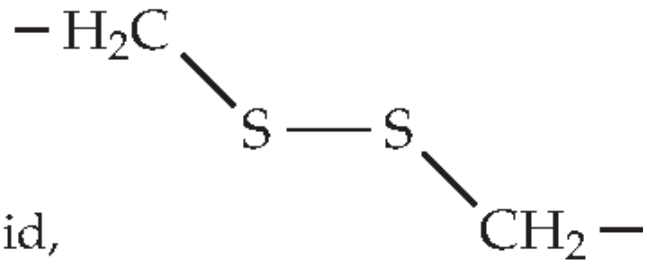
- Two –SH groups of cysteine may form **disulfide bridge** between different parts of protein molecule

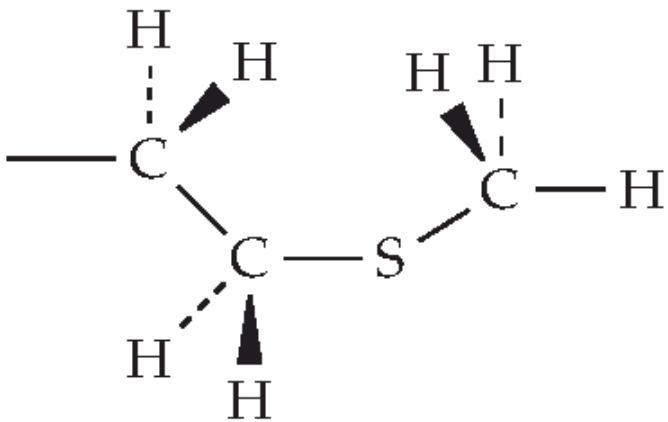
Disulfide bonds movie

Sulfur-containing amino acids



Cysteine (Cys, C)



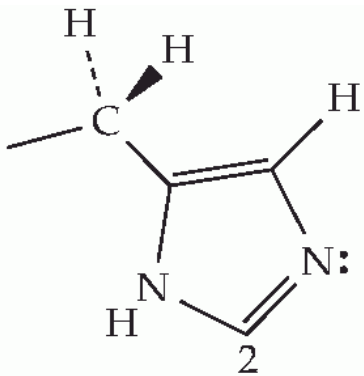


Methionine (Met, M)

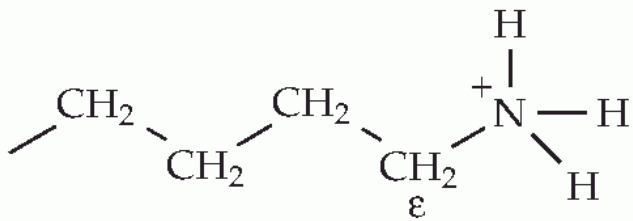
Basic amino acids

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

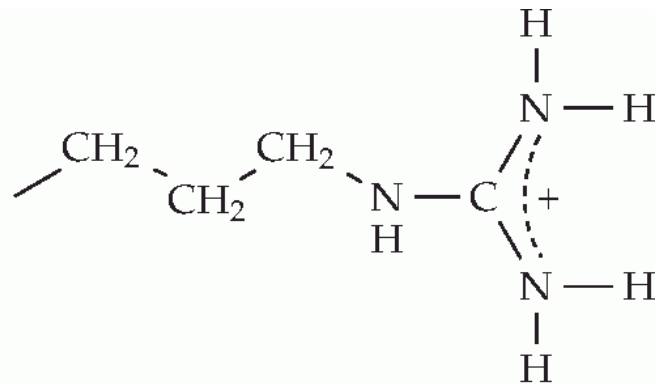
Examples of basic amino acids



Histidine (His, H)



Lysine (Lys, K)

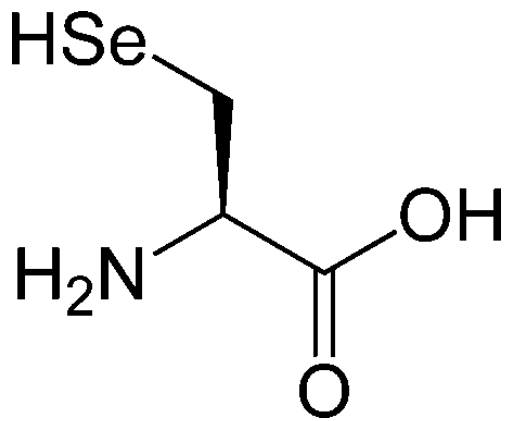


Arginine (Arg, R)

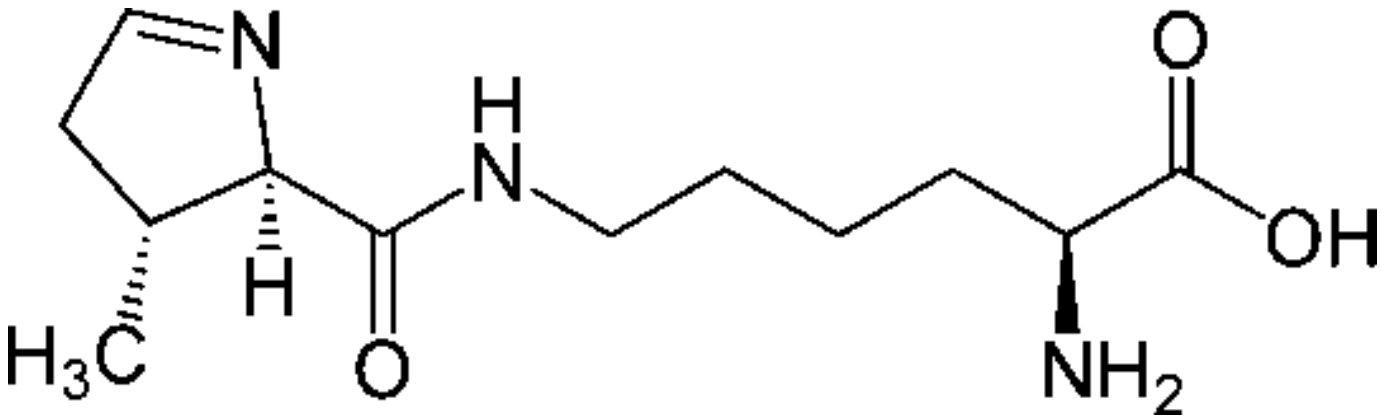
Two extra amino acids

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

Selenocysteine



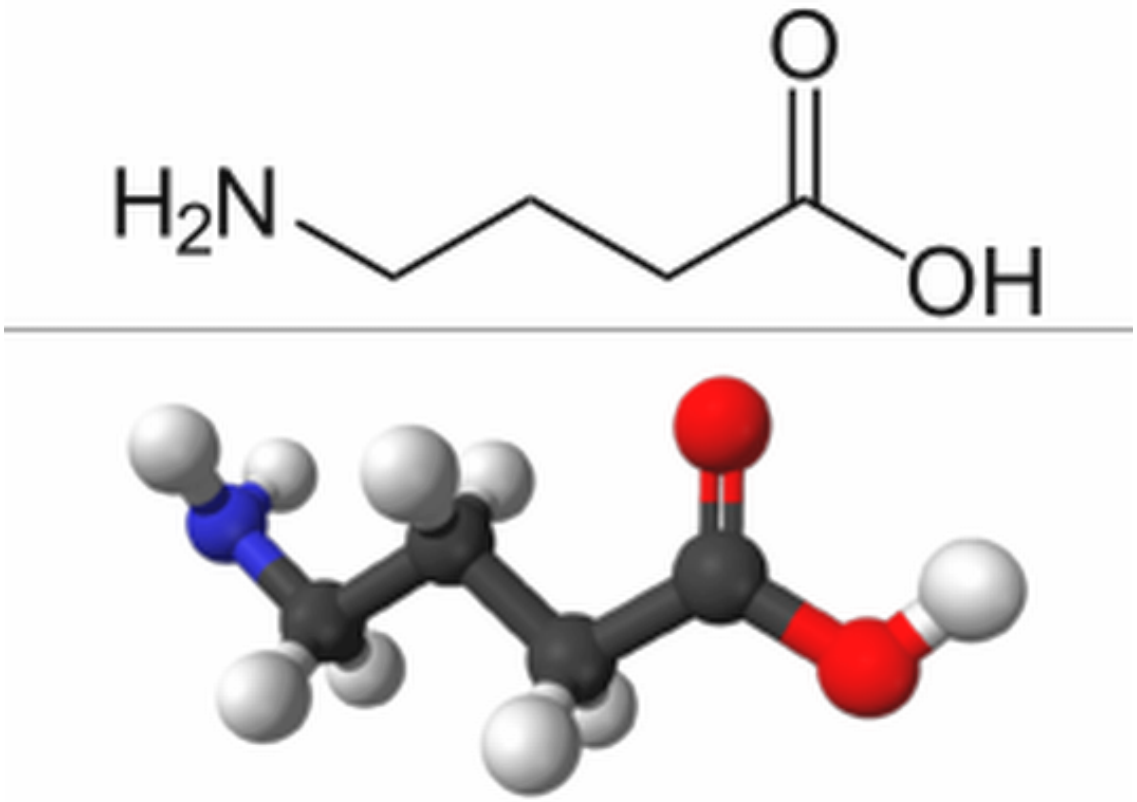
Pyrrolysine



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)

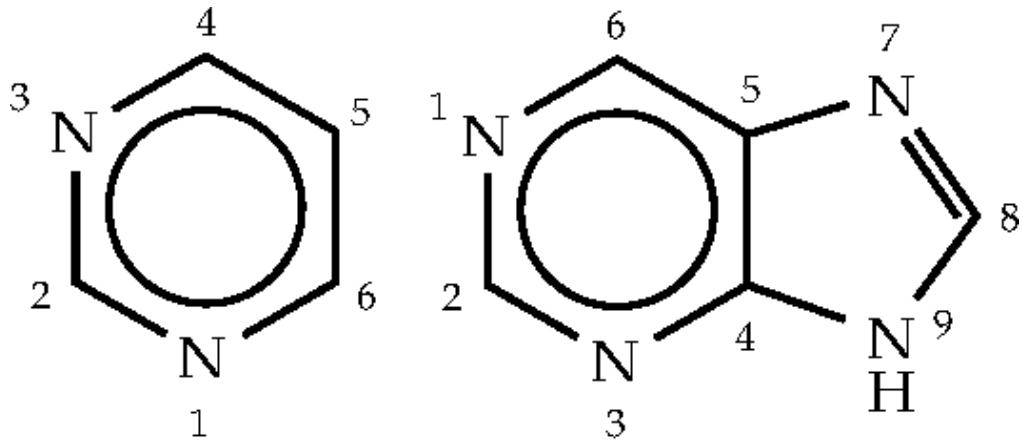
Pentose

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

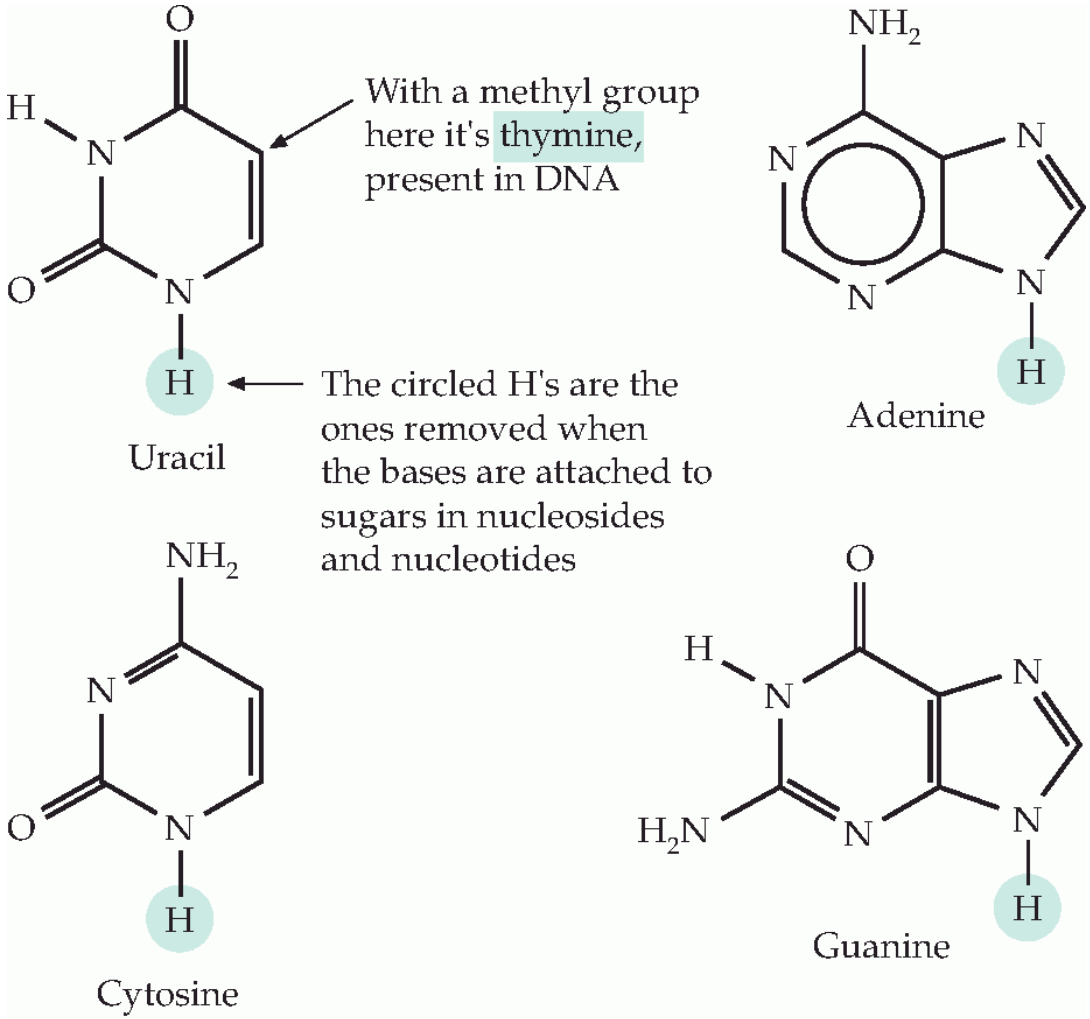
Nucleic bases and nucleosides

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

Purines and pyrimidines



Nucleic bases

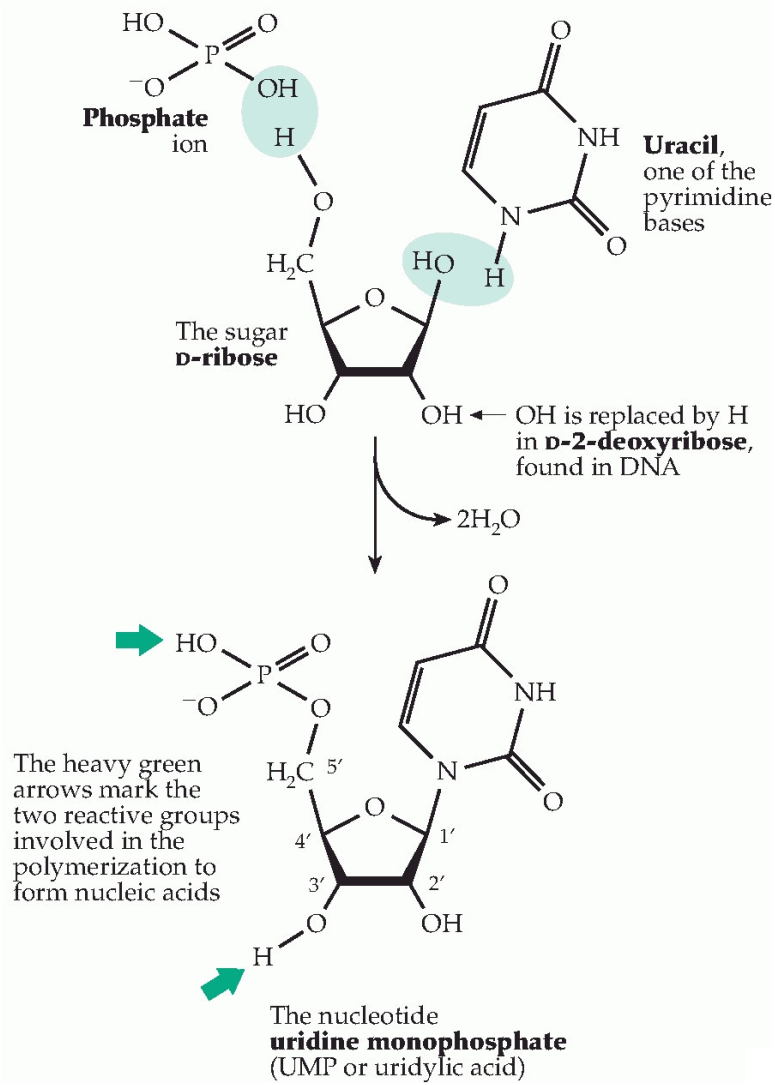


Note: all of these molecules are almost perfectly flat!

Nucleotide synthesis

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

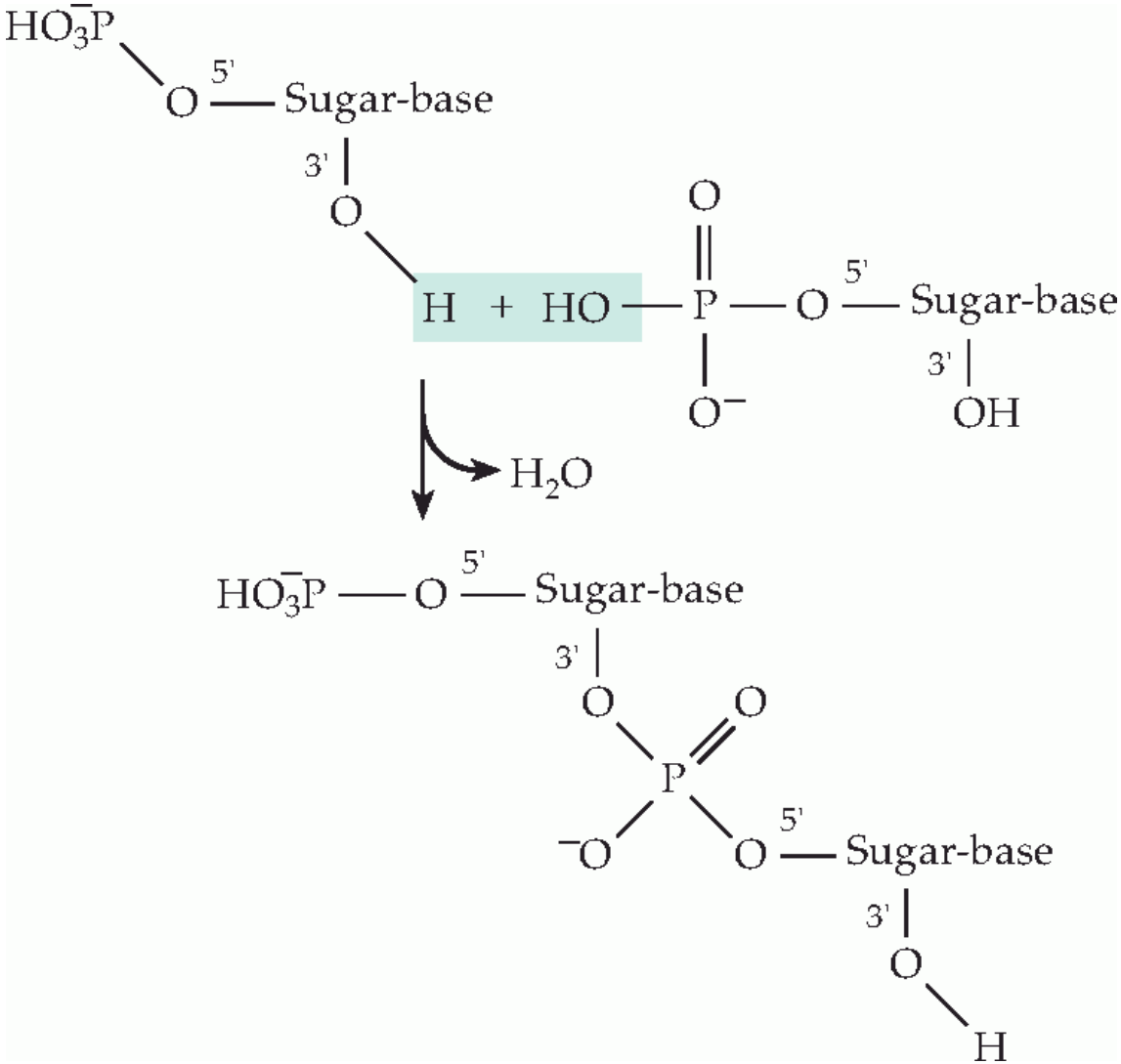
Formation of nucleotide



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



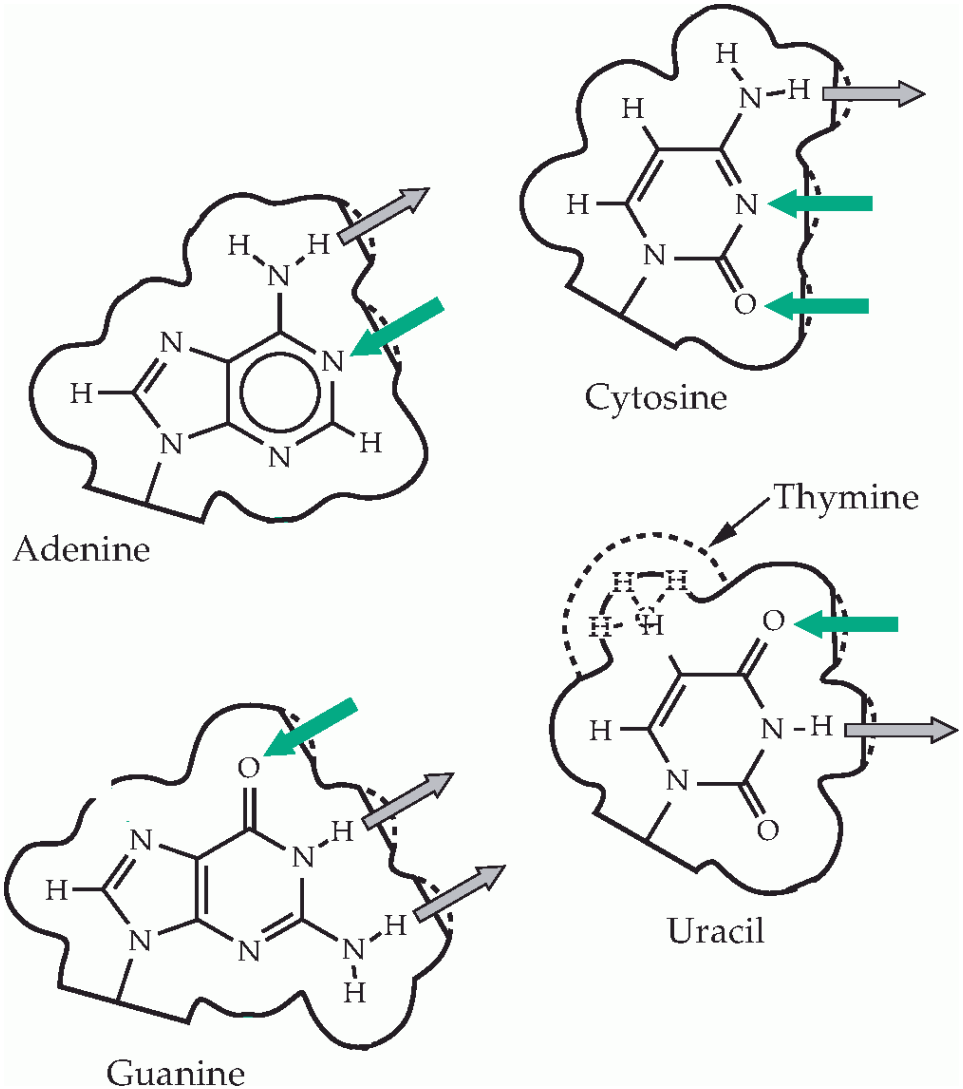
DNA and RNA chemistry

- Deoxyribose vs. ribose
- Thymine vs. uracil

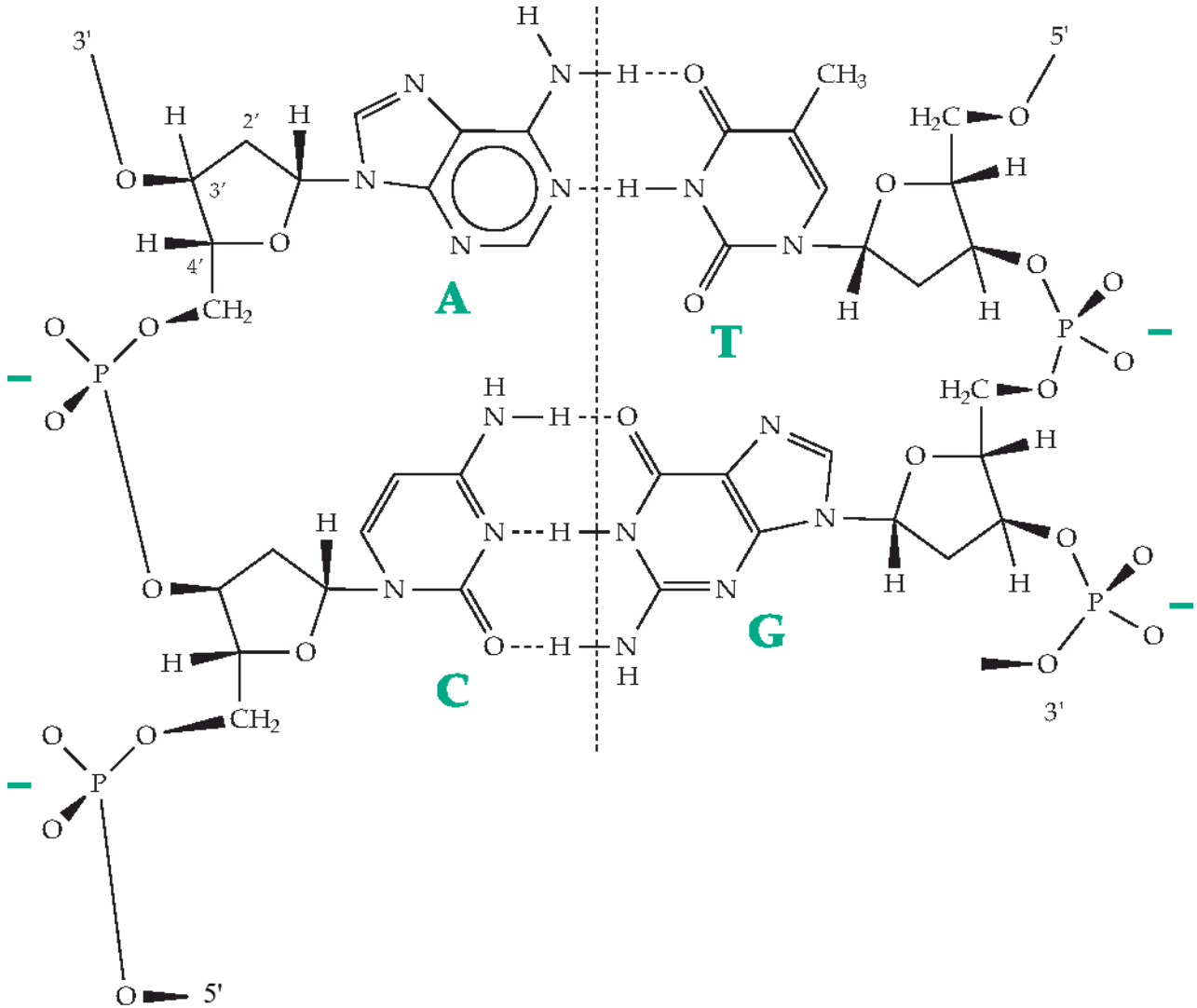
Hydrogen bonds, complementarity and base pairs

- 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.