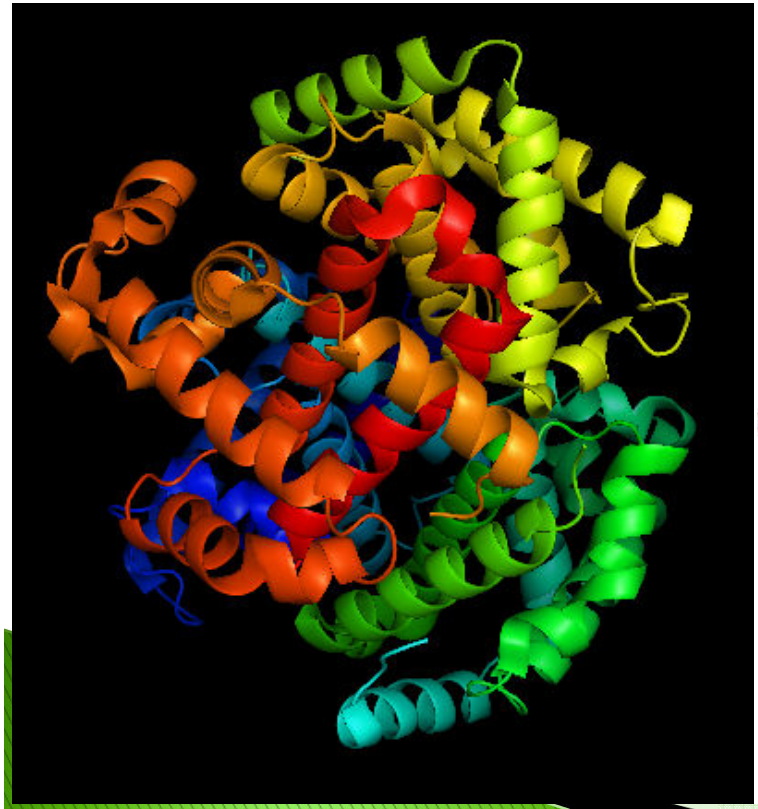
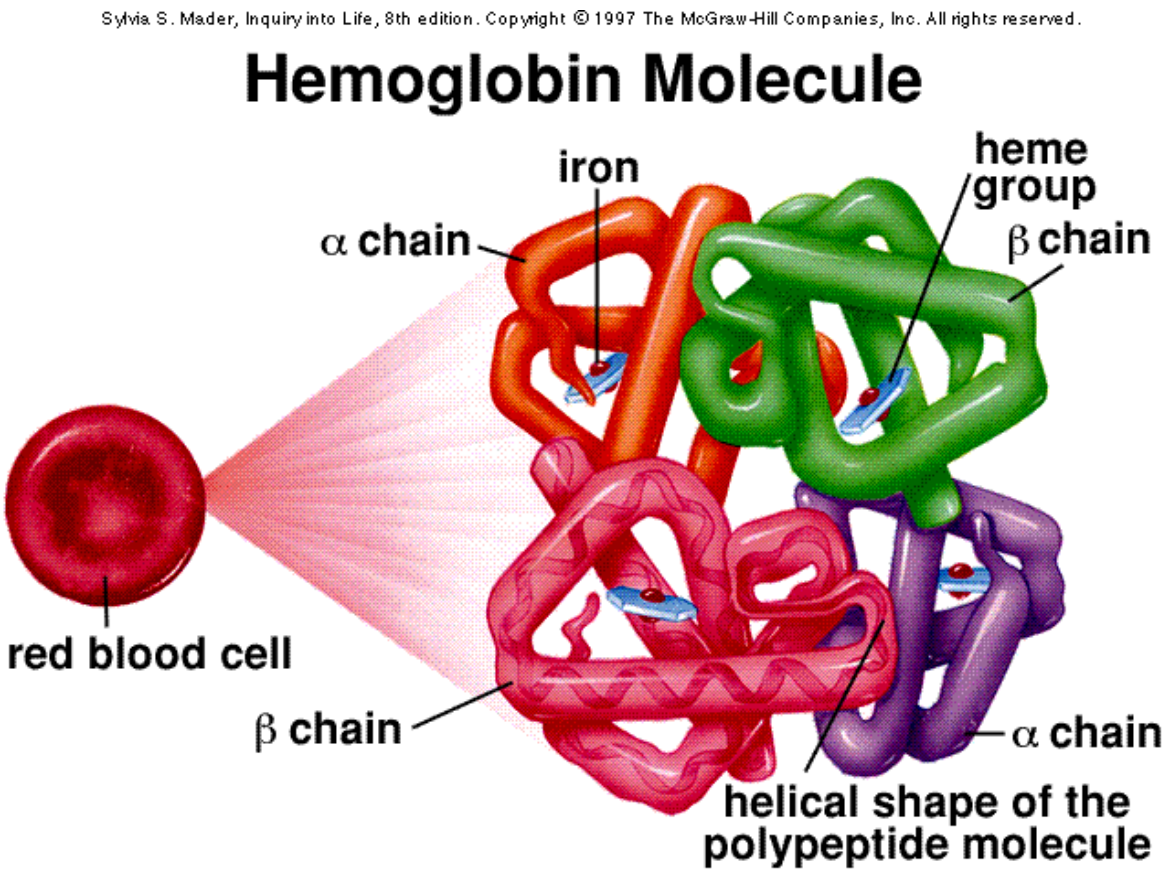
Proteins and Nucleic Acids

Proteins

- Large variety of structures= wide range of functions
  - Unique shapes!



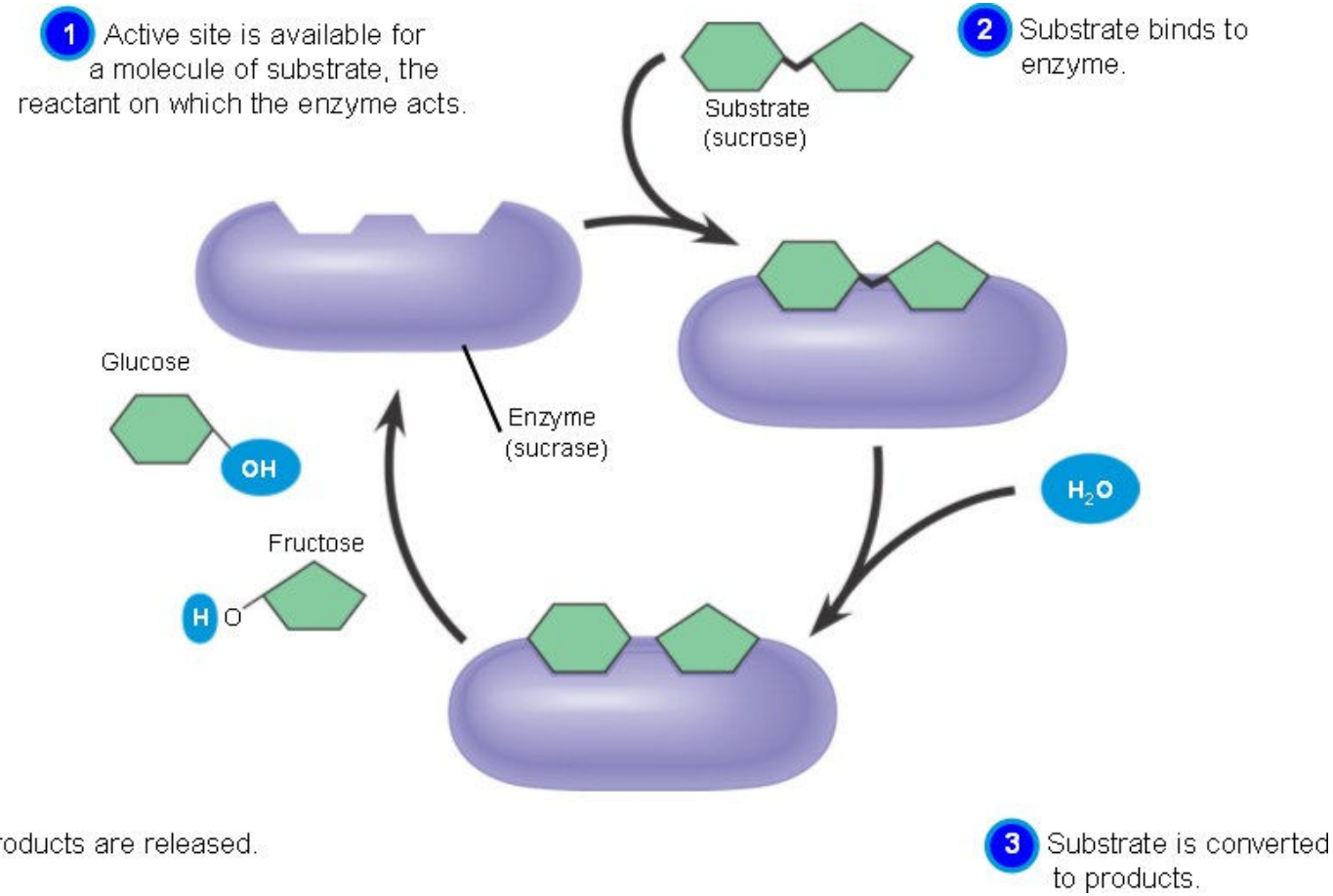


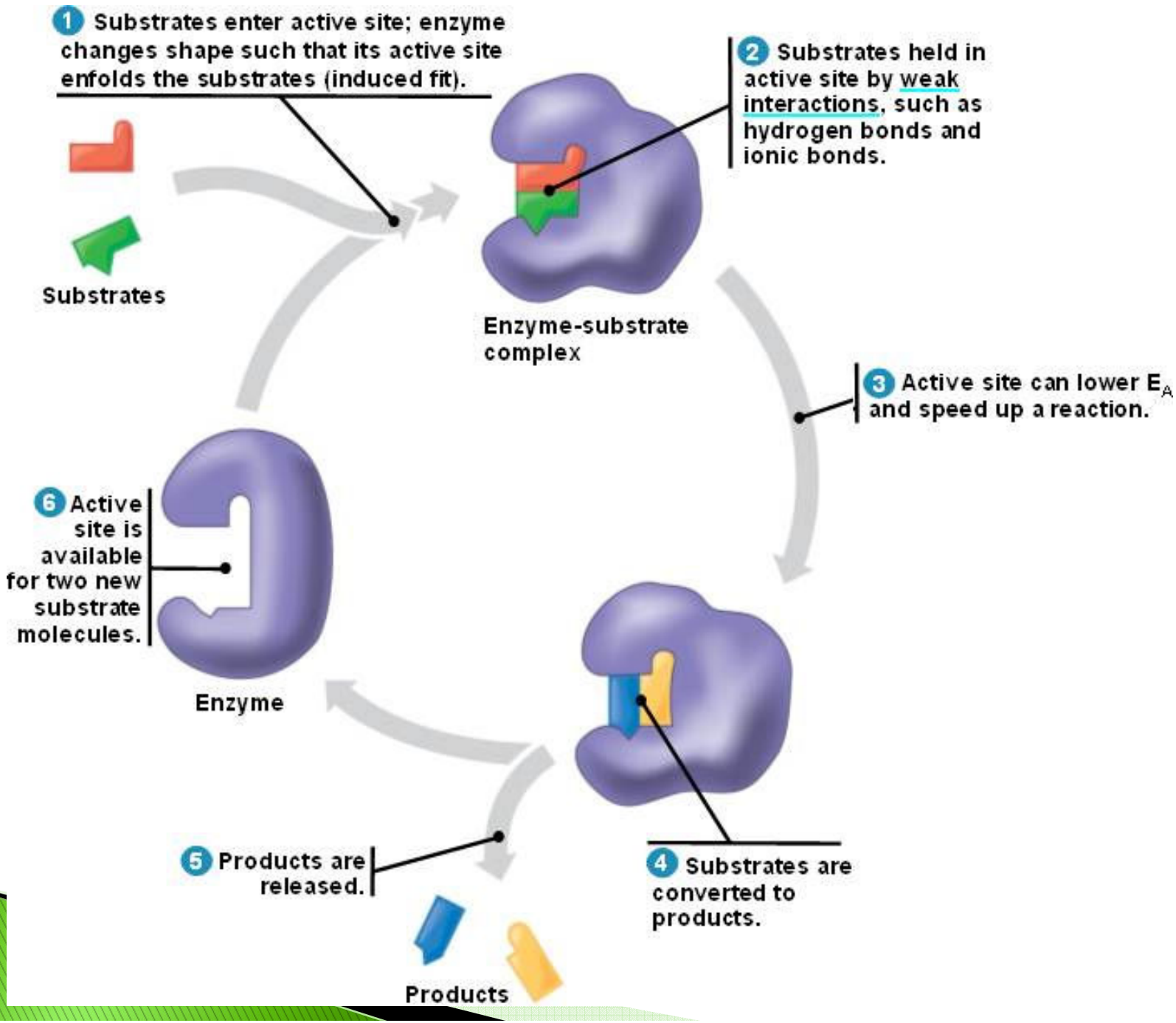
Protein functions

- Enzymes (speed up chemical reactions)
- Structural support (collagen, elastin)
- Storage (seeds)
- Transport (hemoglobin)
- Cellular communication (neurotransmitters)
- Movement (actin and myosin)
- Defense (antibodies)
- In short, they are involved everywhere!

Enzymes

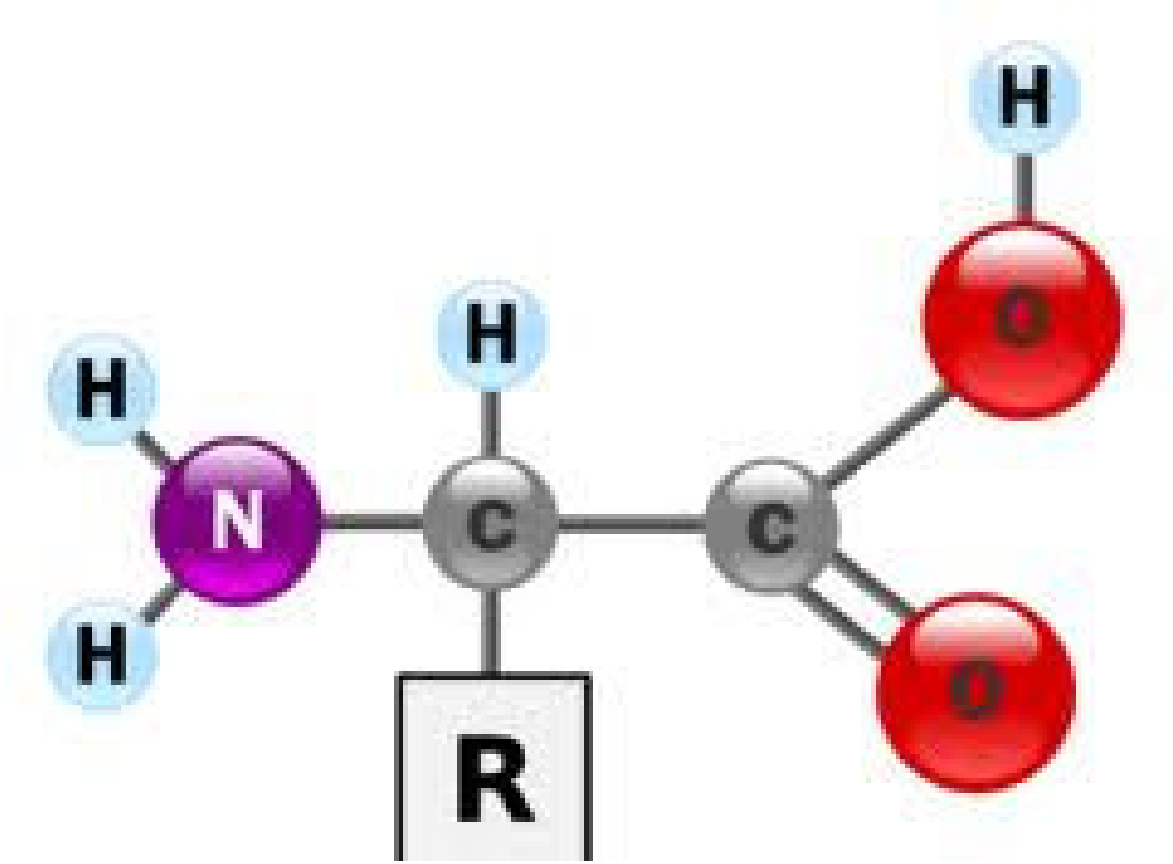
- Regulators of metabolism
- Act as a catalyst – speed up reactions
- Not consumed in the reaction




1 Substrates enter active site; enzyme changes shape such that its active site enfolds the substrates (induced fit).
Substrates
2 Substrates held in active site by weak interactions, such as hydrogen bonds and ionic bonds.
Enzyme-substrate complex
3 Active site can lower E_A and speed up a reaction.
4 Substrates are converted to products.
5 Products are released.
Products
6 Active site is available for two new substrate molecules.
Enzyme

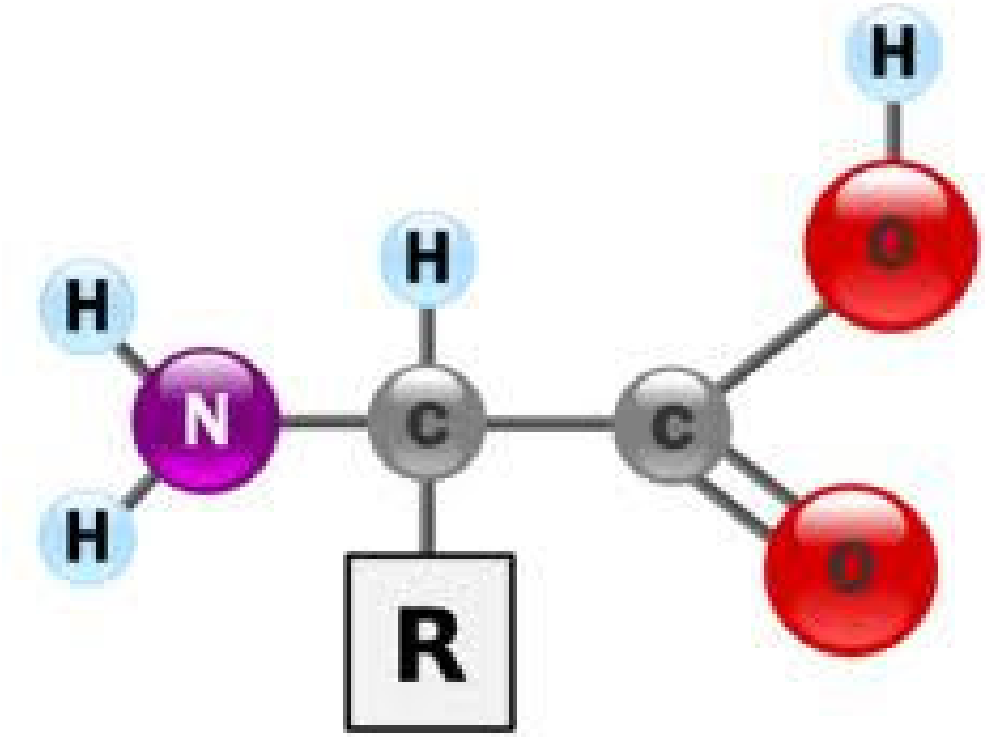
Protein Basics

- Proteins are made from amino acids (monomer)
  - 20 different types of AA, each with a different R group



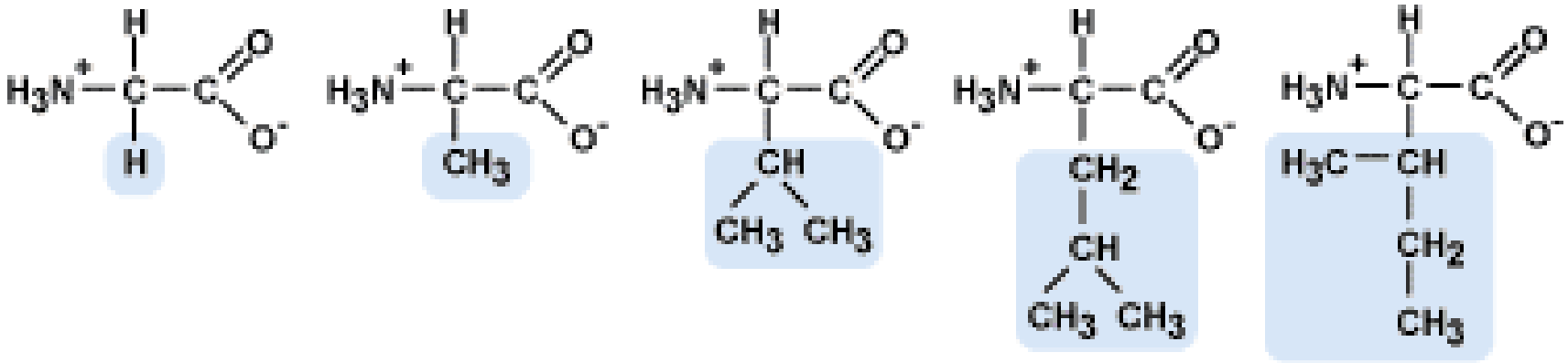
Components of an amino acid

- What are the key elements that you see?
- Amino functional group
- R groups- side chain
  - How will the R group affect the amino acid?

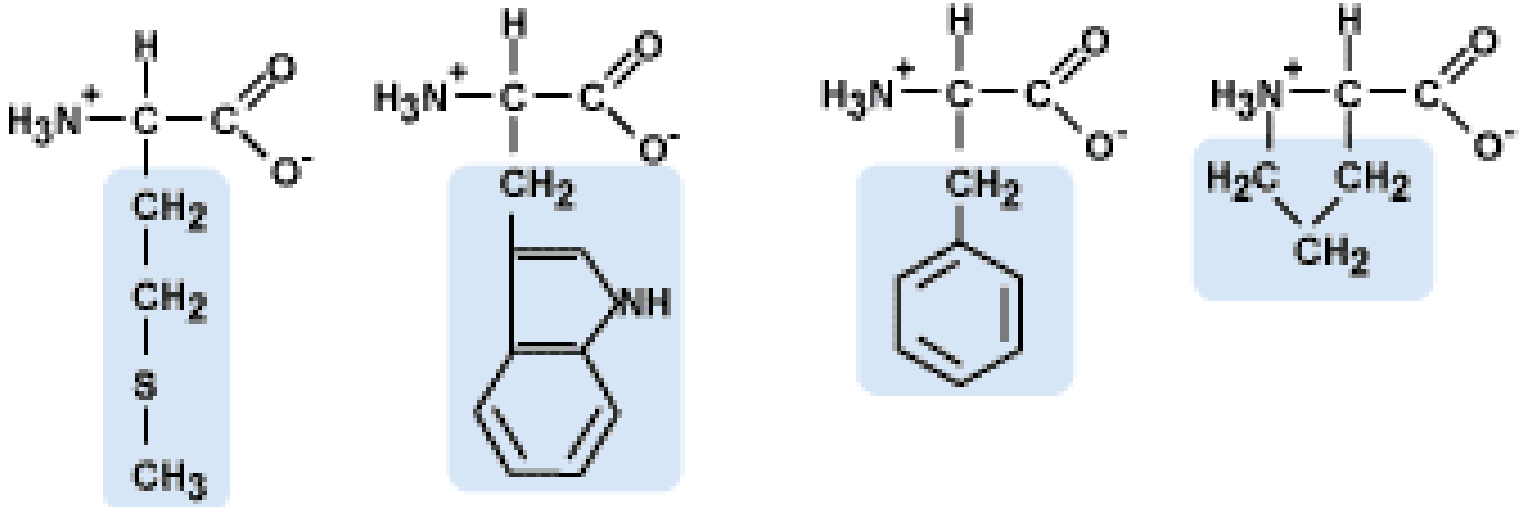


Amino Acids- Hydrophobic

NONPOLAR



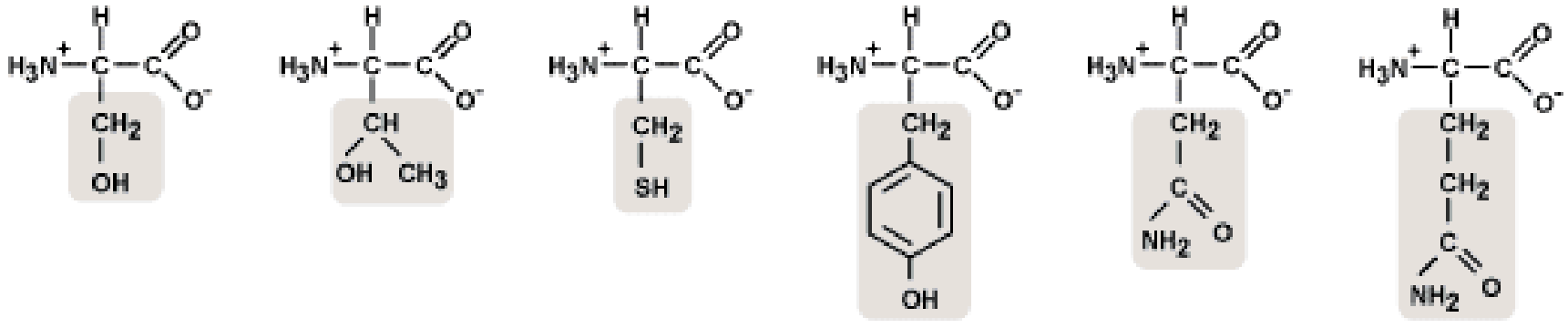
Glycine (Gly) Alanine (Ala) Valine (Val) Leucine (Leu) Isoleucine (Ile)



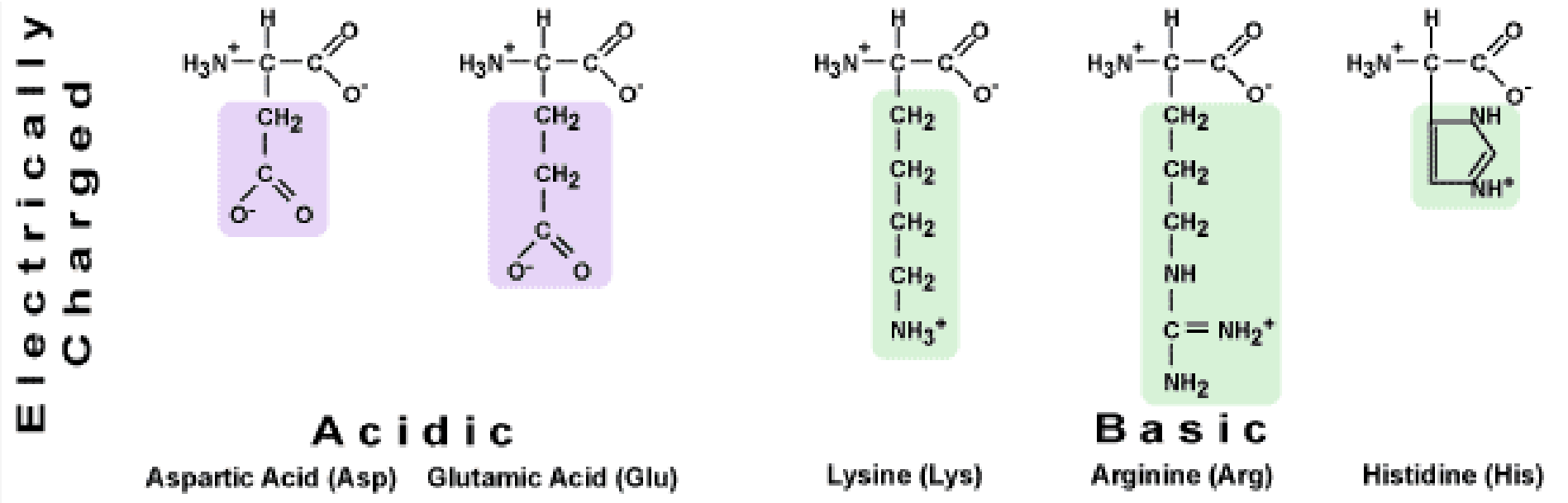
Methionine (Met) Tryptophan (Trp) Phenylalanine (Phe) Proline (Pro)

Amino Acids- Hydrophilic

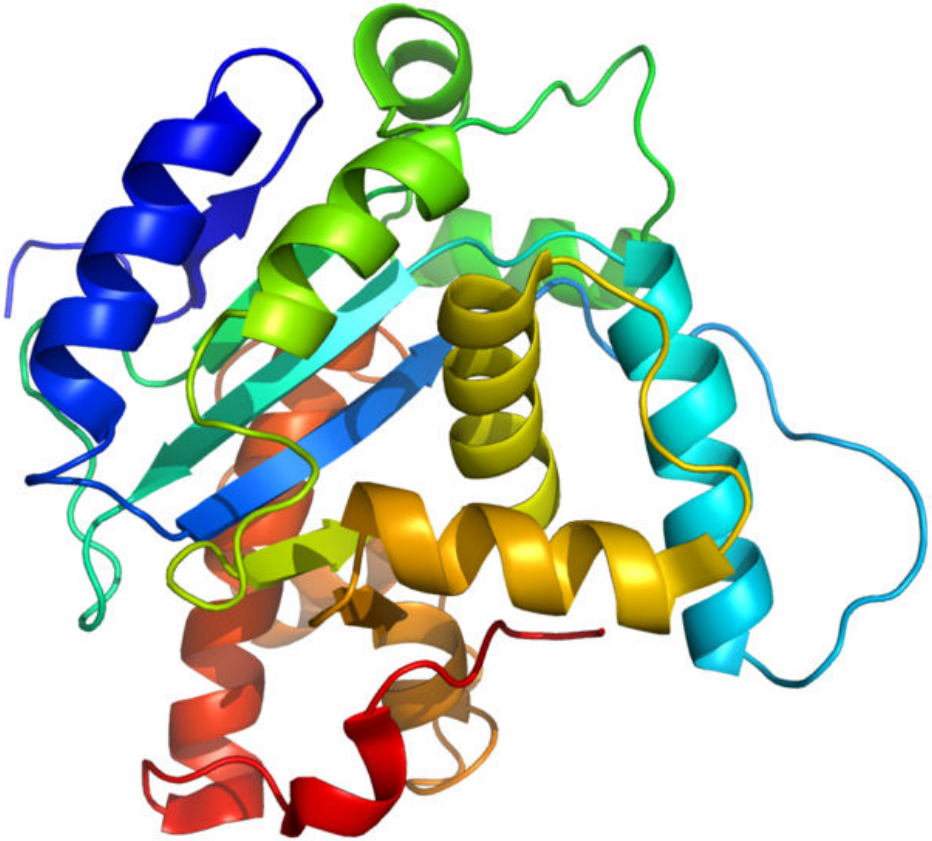
POLAR



Amino Acids – Ionic



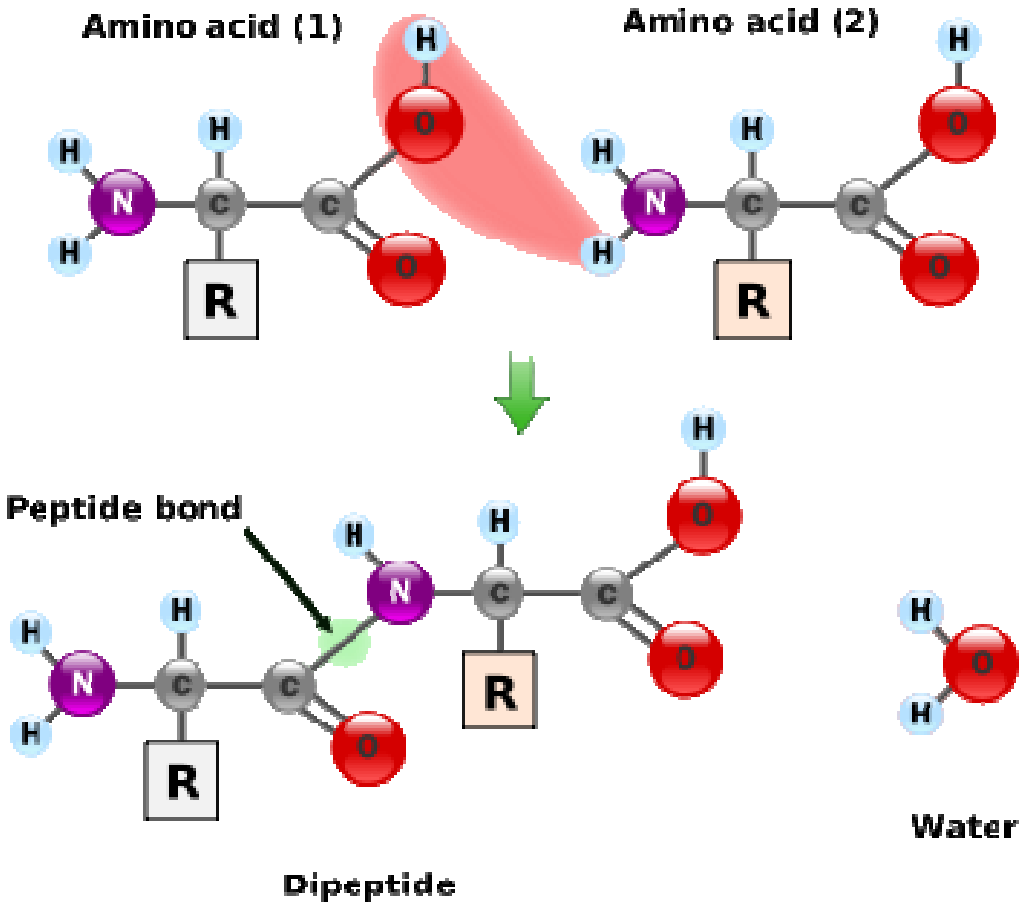
How do amino acids become proteins?



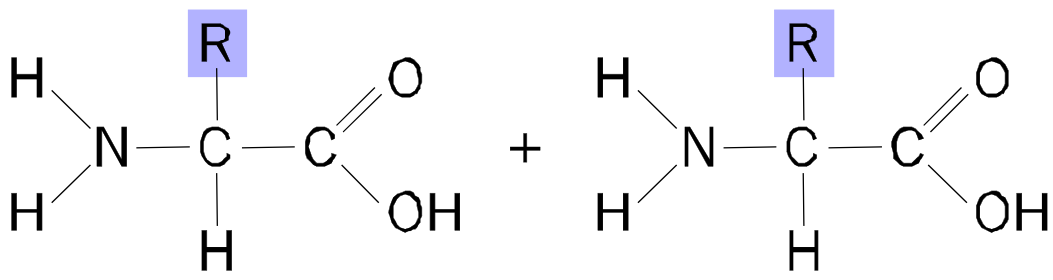
Polypeptides

- A dehydration reaction links the amino acids

- Peptide bond
- Polypeptide

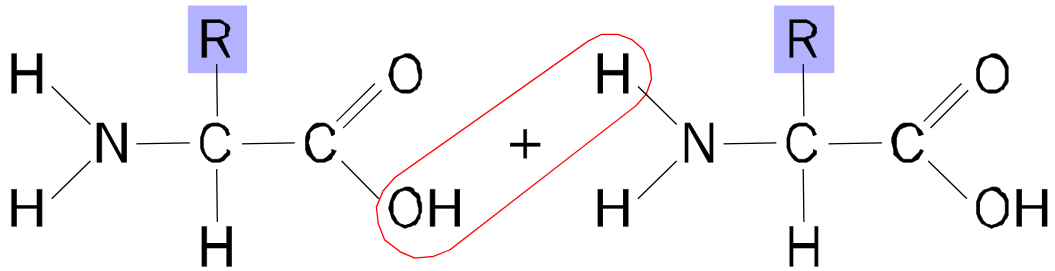


Dehydration

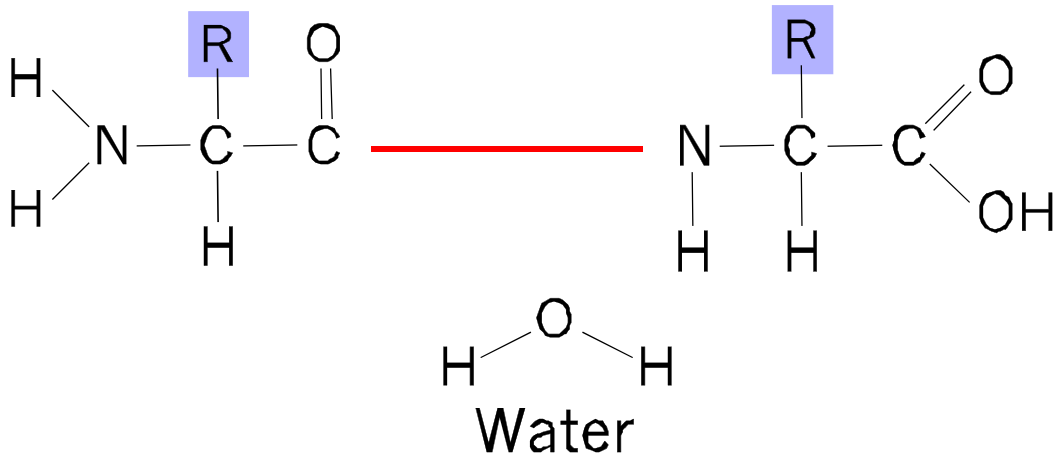


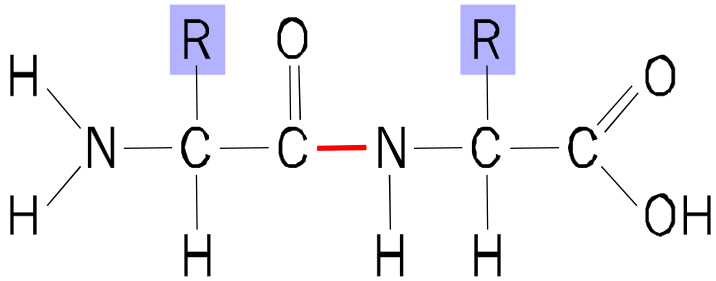
Amino acid Amino acid

Dehydration

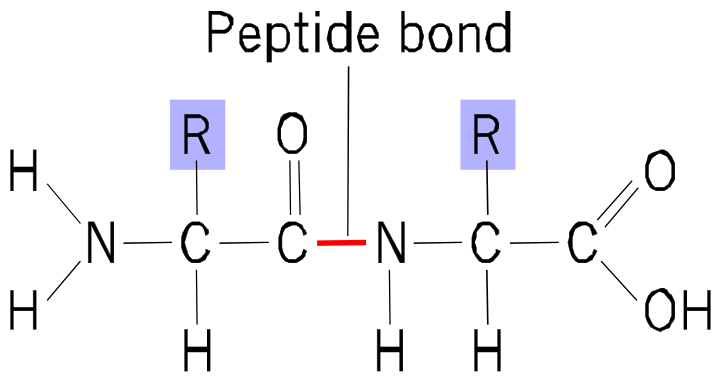


Dehydration



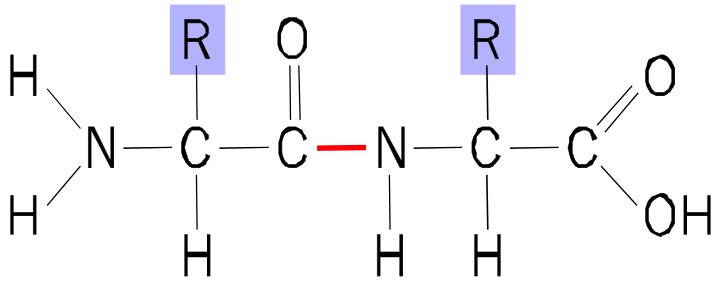


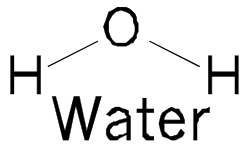
Dipeptide



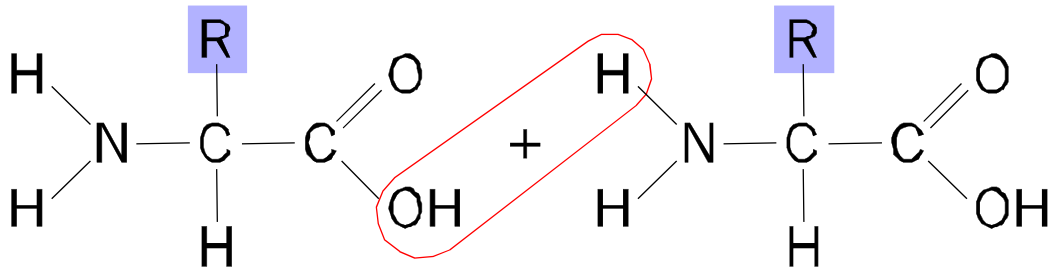
Dipeptide

Hydrolysis

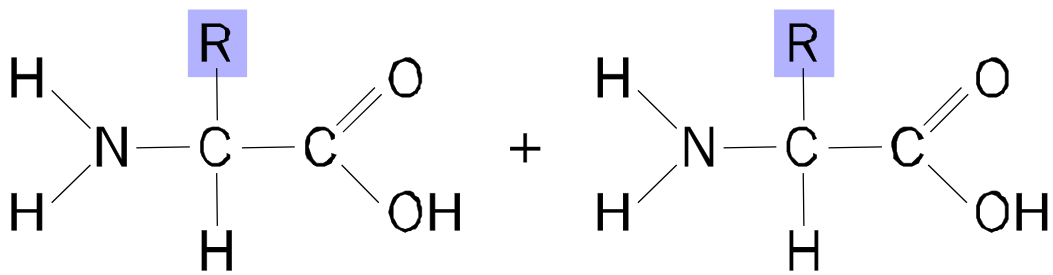




Hydrolysis



Hydrolysis



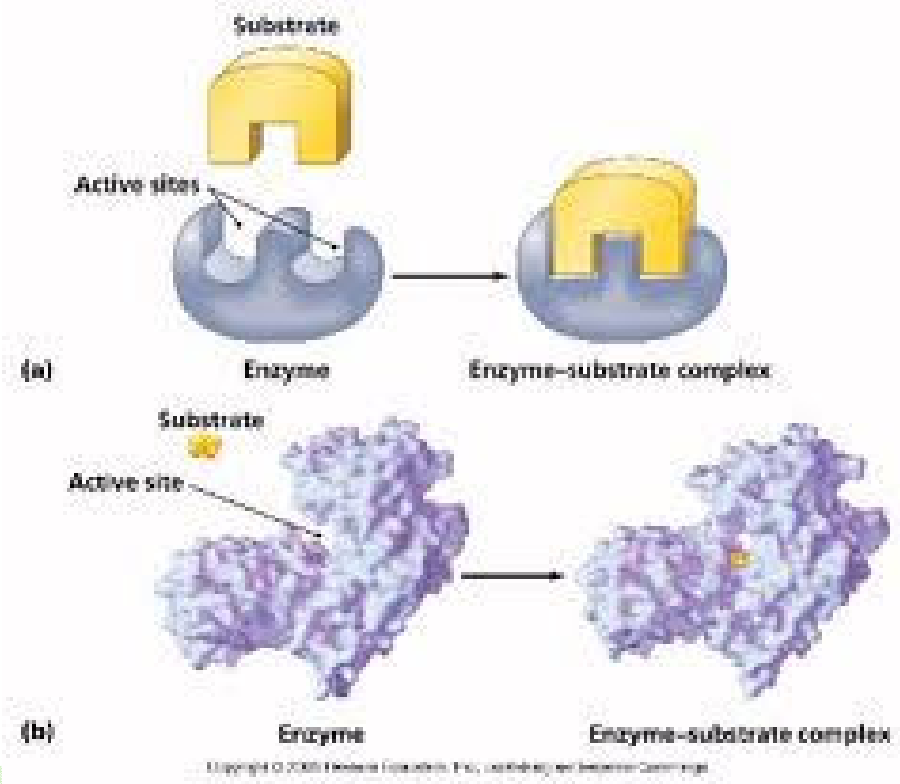
Amino acid Amino acid

Important Fact

- Polypeptide ≠ Protein
- Why not?
- Because proteins have a 3-dimensional shape

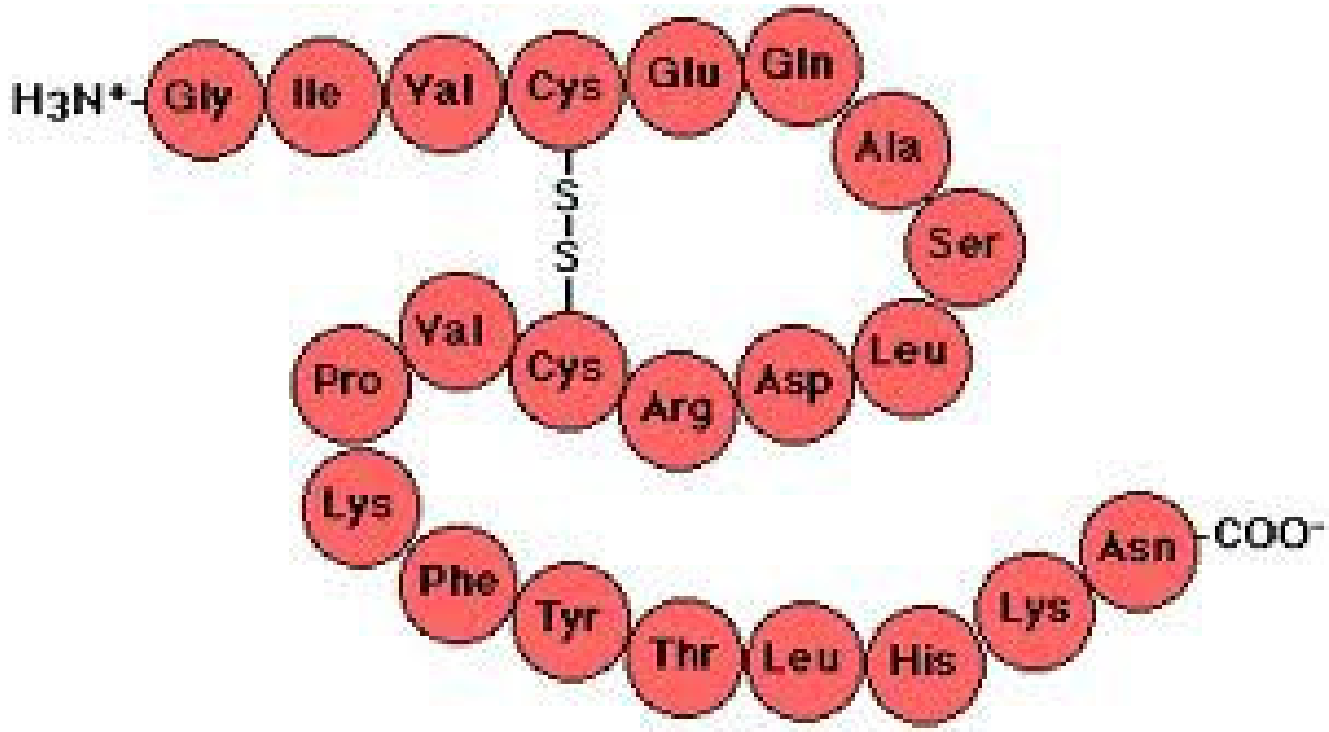
What gives the protein a 3-D shape?

- The sequence of amino acids
- Explain how.
- Unique and specific shapes
  - Binding to other molecules

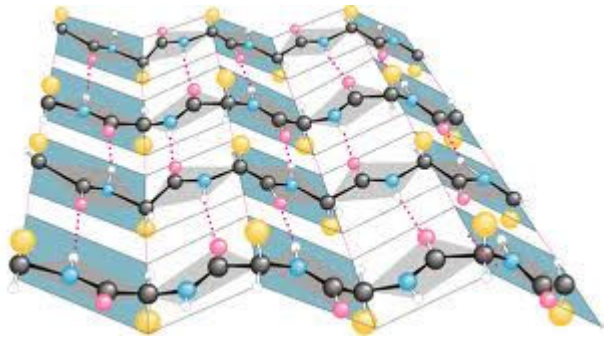


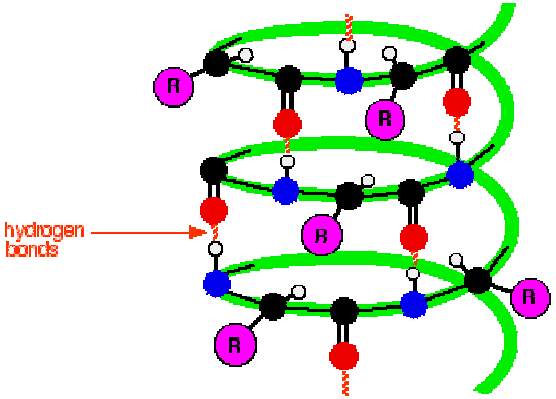
Four Levels of Protein Structure

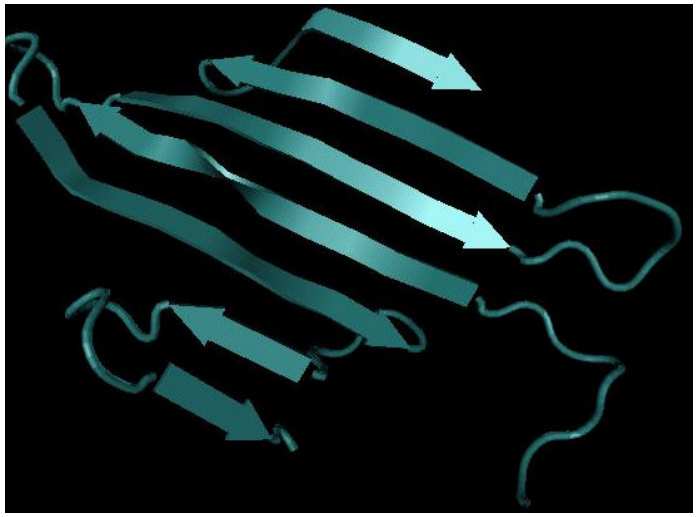
- 1^{O}: unique sequence of amino acids

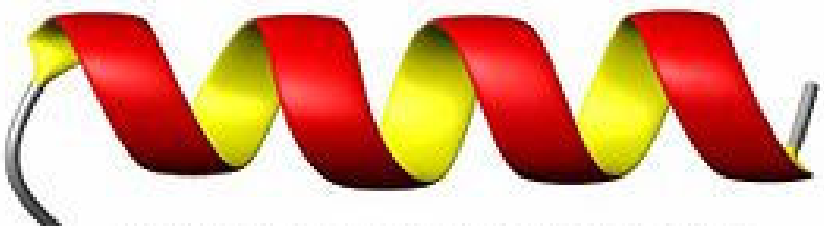


- 2^{O}: H-bonds between nonadjacent carboxyl and amino groups
  - Alpha helix
  - Beta-pleated sheets



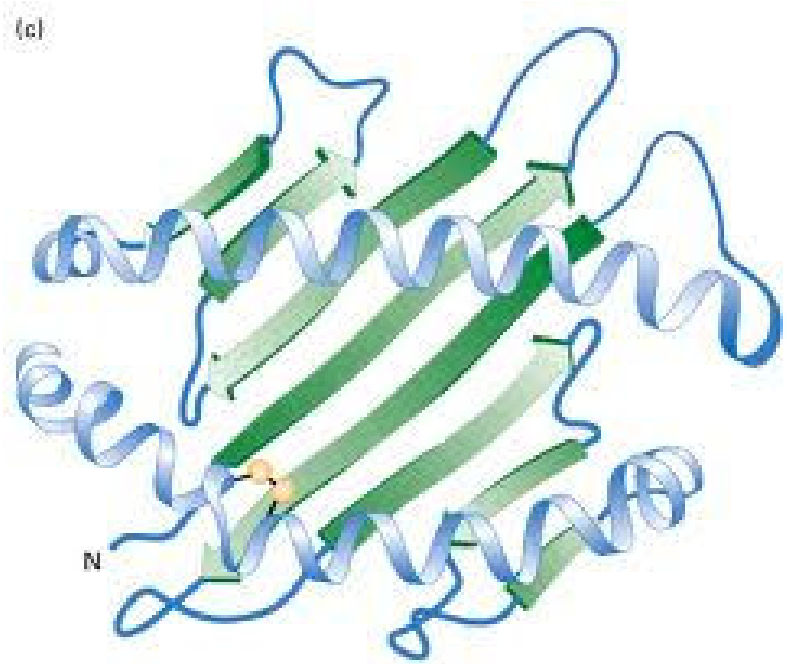


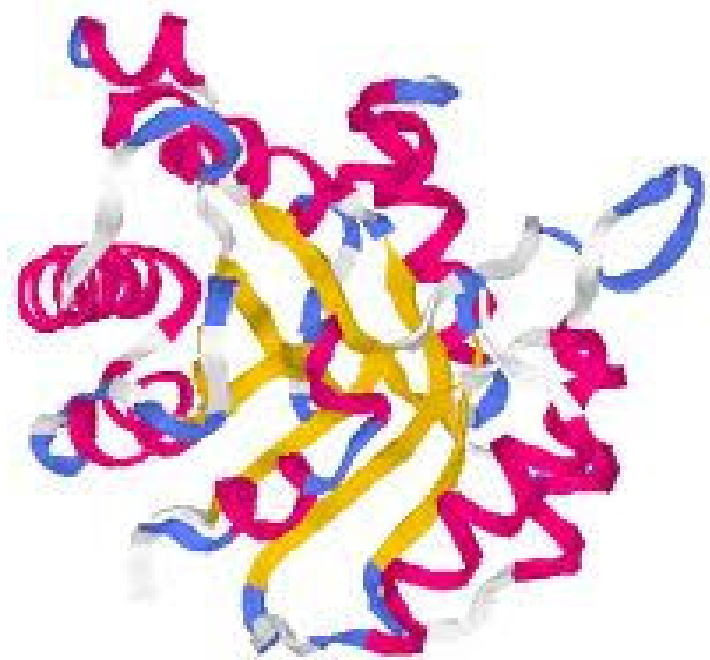




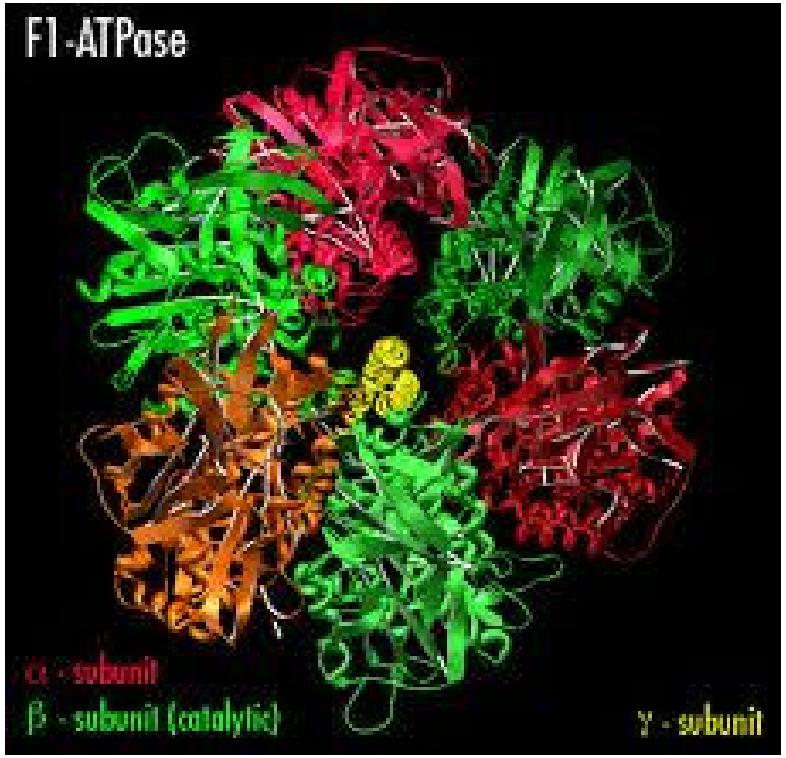
Ribbon Diagram of an alpha-helix

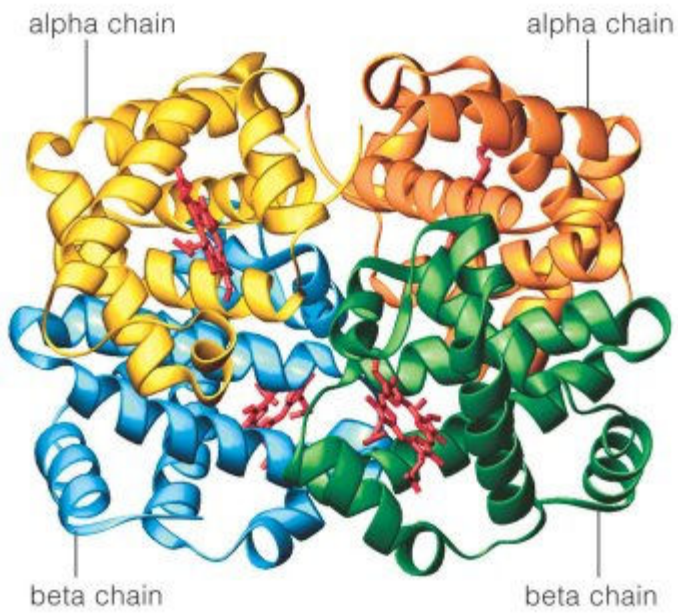
- 3°: disulfide and ionic bonds between R groups

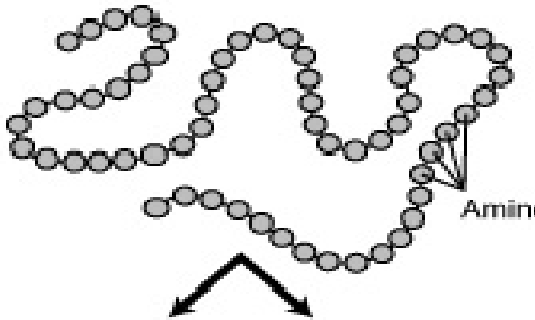




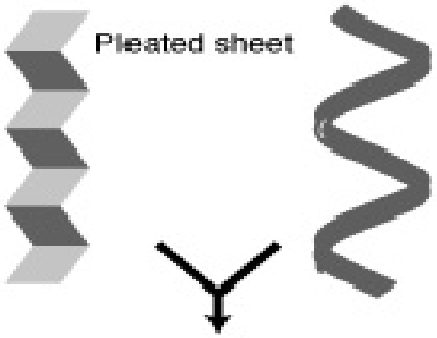
- 4°:H and ionic bonds between separate polypeptides



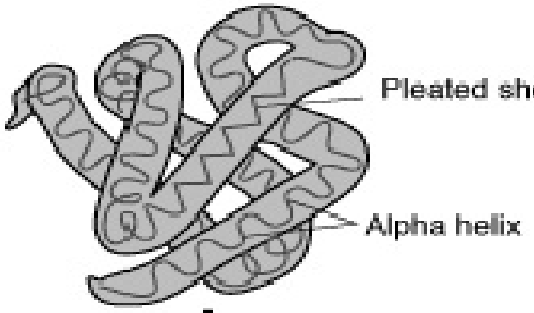




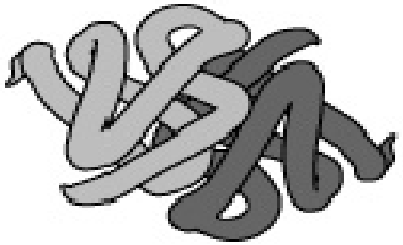
Primary protein structure
is sequence of a chain of amino acids



Secondary protein structure
occurs when the sequence of amino acids are linked by hydrogen bonds



Tertiary protein structure
occurs when certain attractions are present between alpha helices and pleated sheets.



Quaternary protein structure
is a protein consisting of more than one amino acid chain.

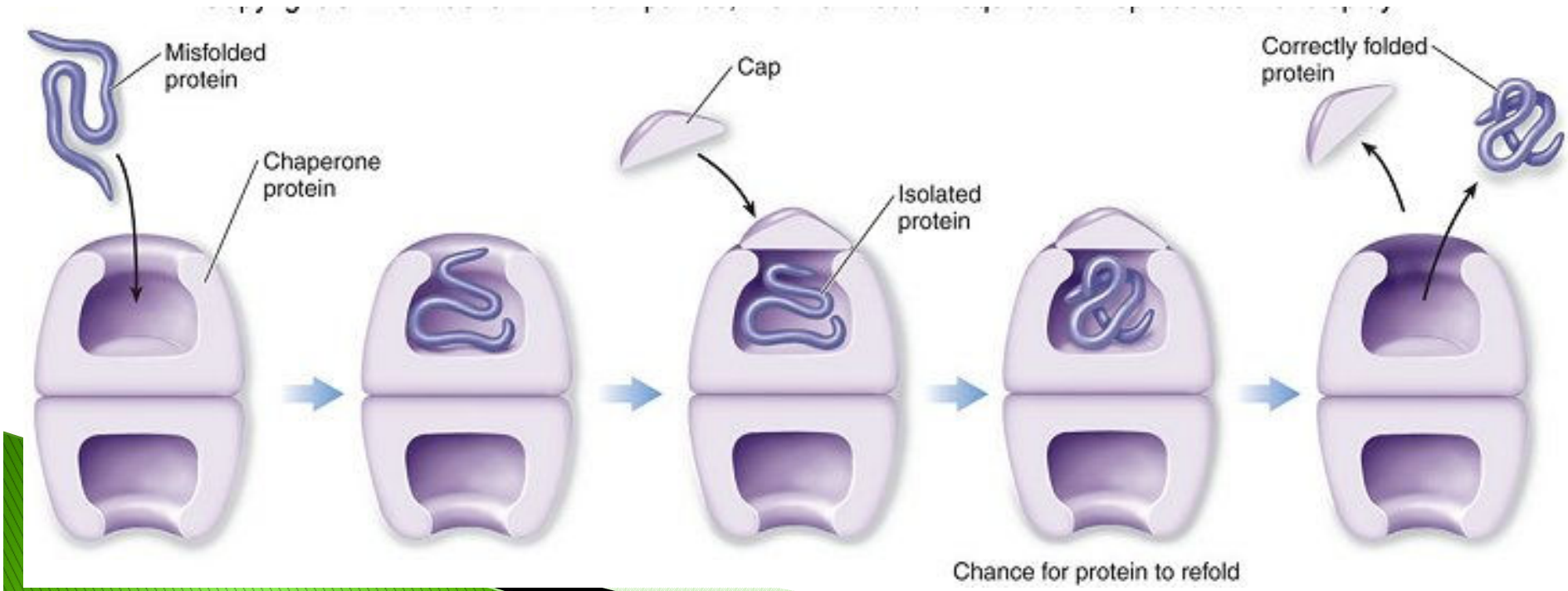
- What happens when the secondary, tertiary or quaternary level of structure changes?
- What happens when primary structure of the polypeptide changes?
- How can these changes happen?

Denature

- Change in pH, temperature, salt concentration etc.
- Chemicals can disrupt bonds and bridges

The environment helps determine protein shape

- Folds occur spontaneously
  - We don't completely understand all this
- Chaperonins help protect the proteins from "bad influences"



Nucleic acids

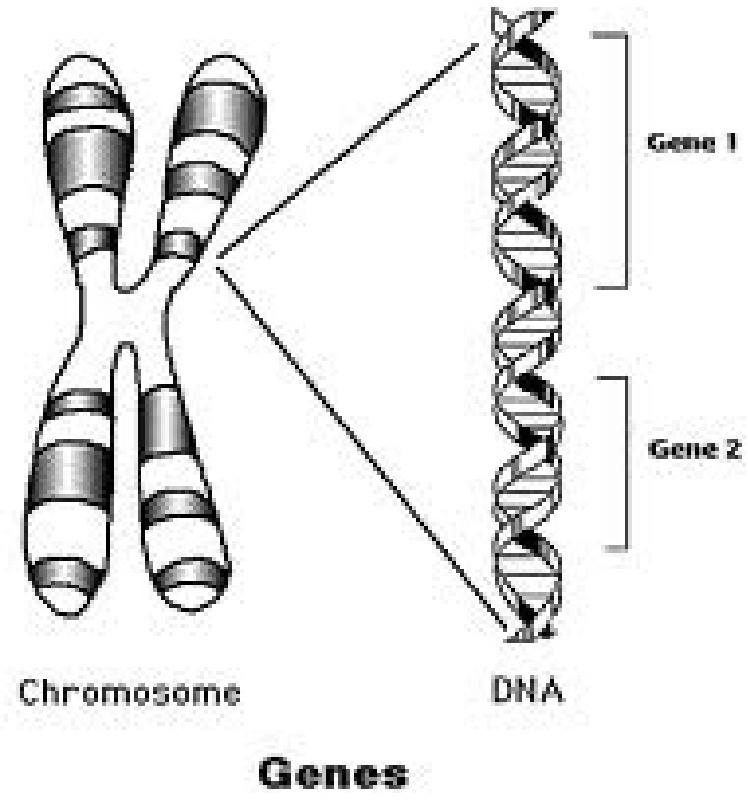
- What do they do?

Role of Nucleic Acids

- Store and transmit hereditary information
  - In the form of a code
- Allows organisms to reproduce their complex components from one generation to the next.

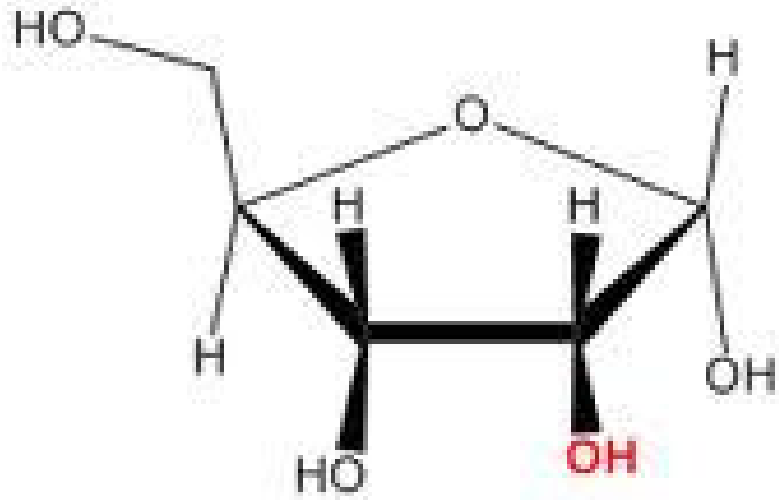
Proteins and nucleic acids

- Associated because genes dictate the primary sequence of proteins
- Genes are segments of DNA and DNA is a nucleic acid polymer

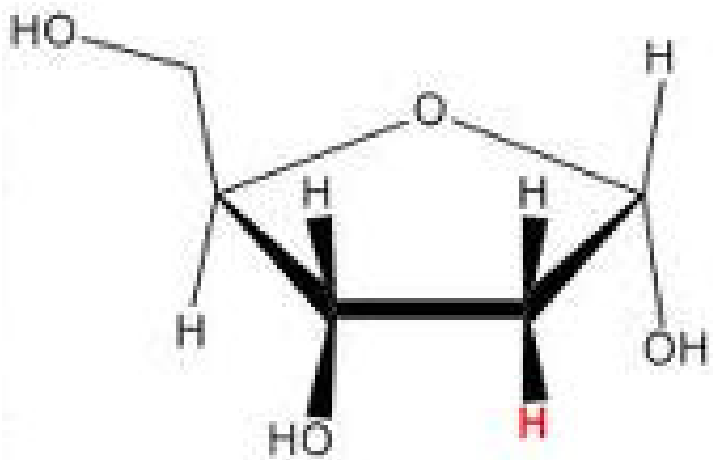


Two types of Nucleic Acids

- RNA (Ribonucleic Acid)
  - Directs protein synthesis
- DNA (Deoxyribonucleic Acid)
  - Hereditary molecule; codes information for all cellular activity
  - Controls the synthesis of RNA



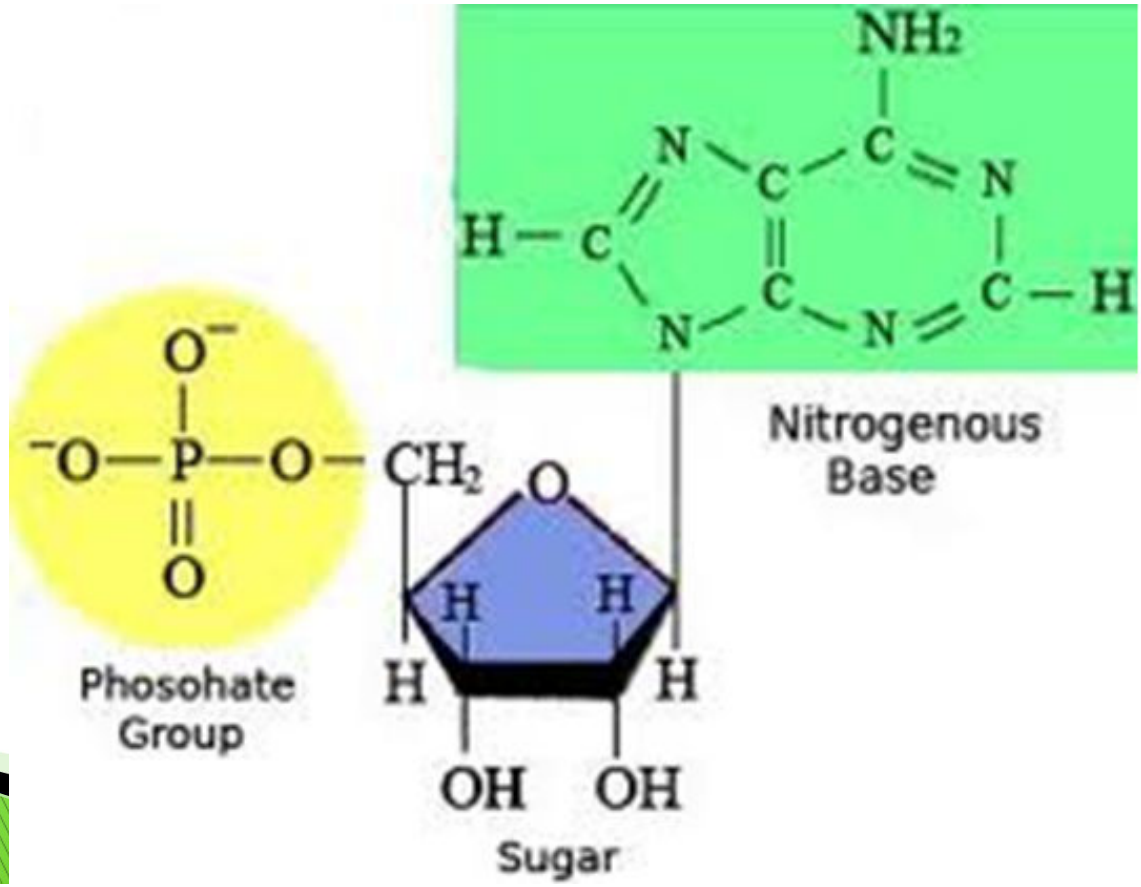
Ribose

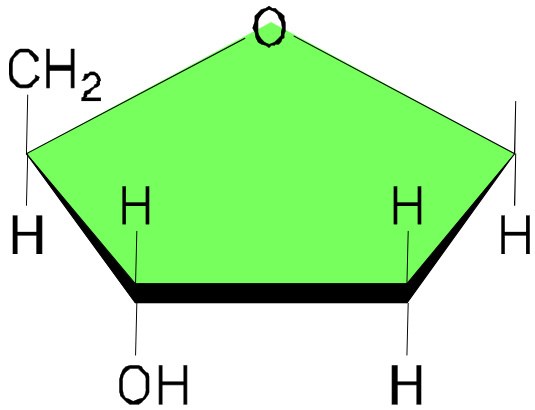


Deoxyribose

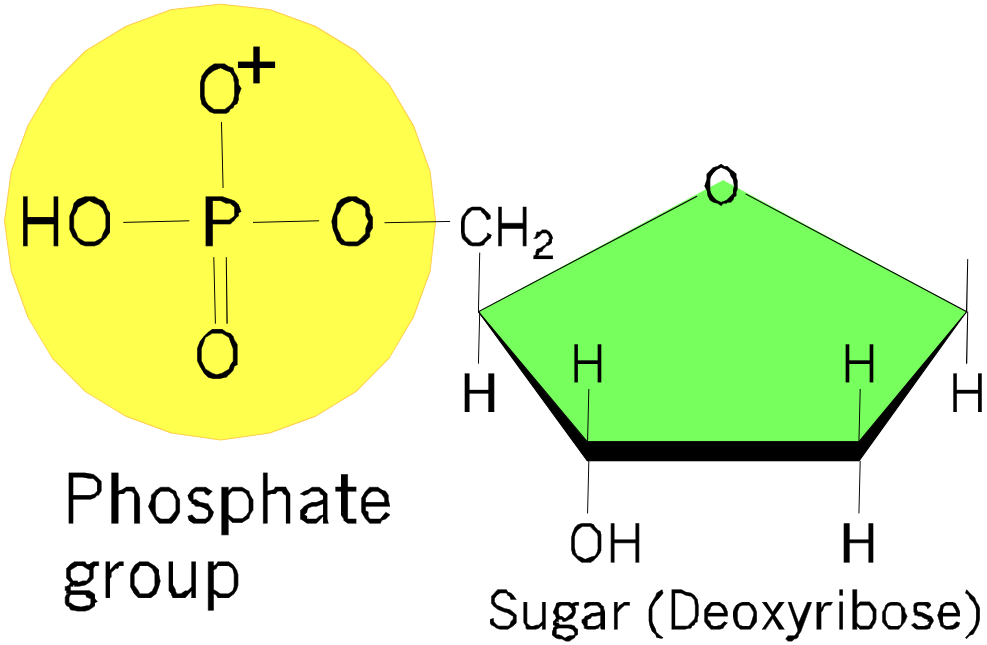
Nucleic Acid Monomers

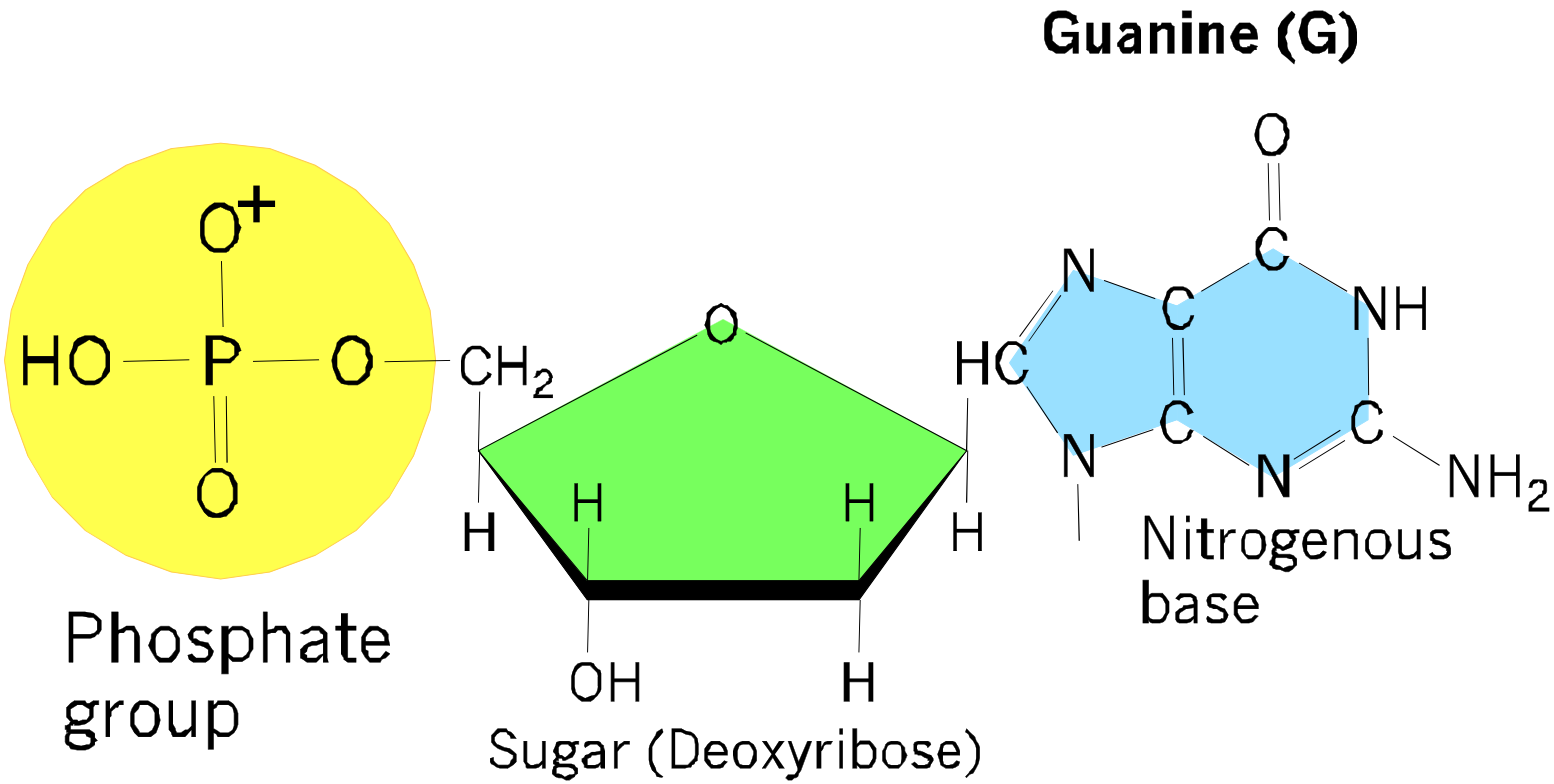
- Monomer: Nucleotide
  - Each is made of 3 parts: sugar, phosphate and base





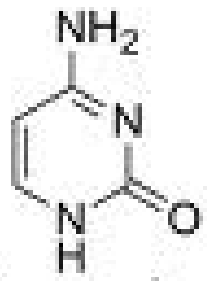
Sugar (Deoxyribose)


O+
HO
P
O
CH2
O
O
H
H
H
H
OH
H
Phosphate group
Sugar (Deoxyribose)

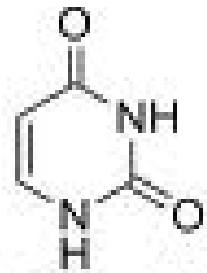

Guanine (G)
O+
HO
P
O
O
CH2
O
H
H
H
H
OH
H
HC
N
C
C
NH
N
C
C
N
NH2
O
Phosphate group
Sugar (Deoxyribose)
Nitrogenous base

Two classifications of monomers

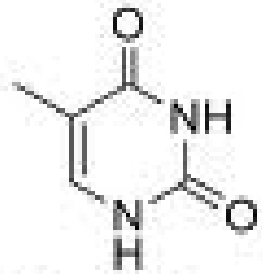
- Pyrimidines: Cytosine, Thymine, Uracil



Cytosine



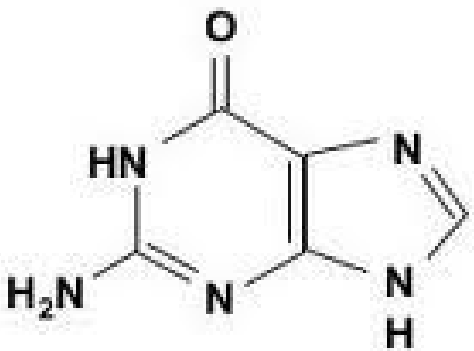
Uracil



Thymine

- Purines: Adenine, Guanine

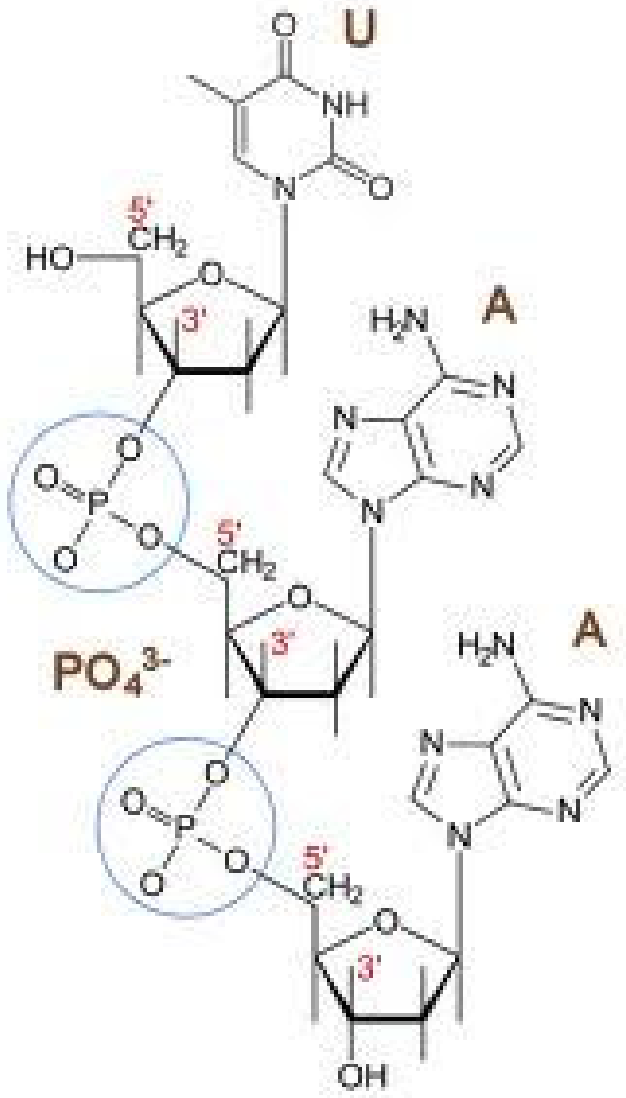
Adenine

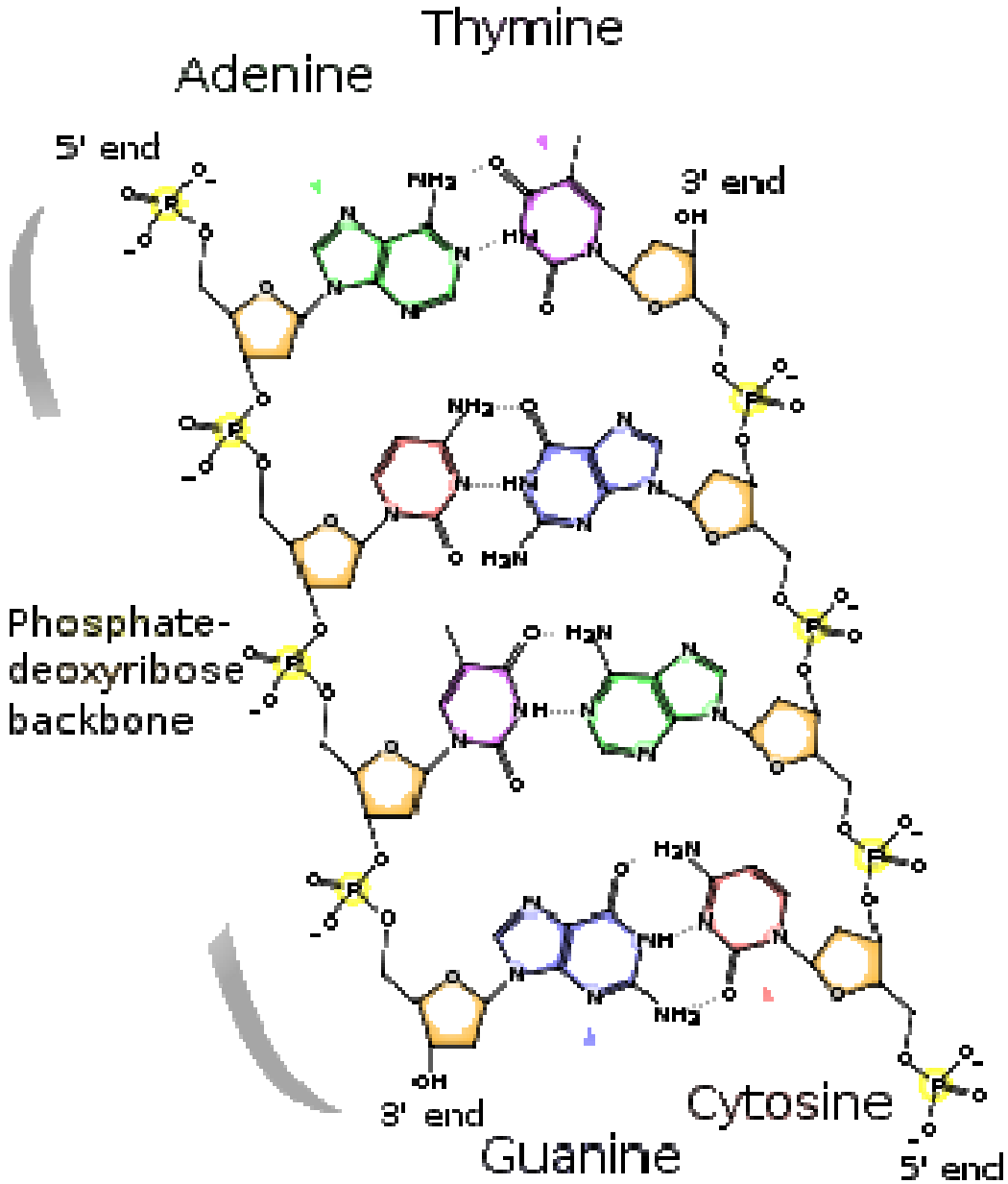


Guanine

Polynucleotides

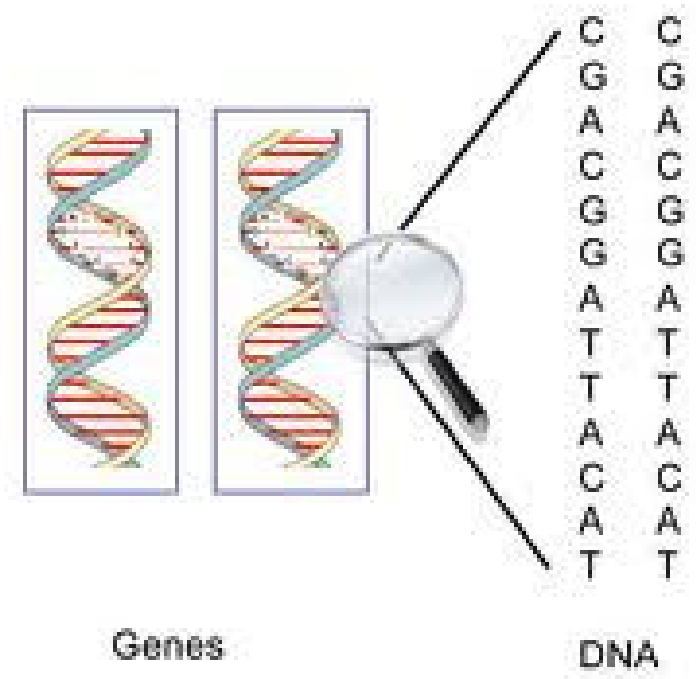
- Nucleotides are joined by a phosphodiester linkage to make a polymer
  - From –OH on the 3’ carbon to the phosphate on the 5’ carbon
  - Gives the molecule directionality 5’ to 3’




Thymine
Adenine
5' end
3' end
Phosphate-
deoxyribose
backbone
3' end
Cytosine
Guanine
5' end

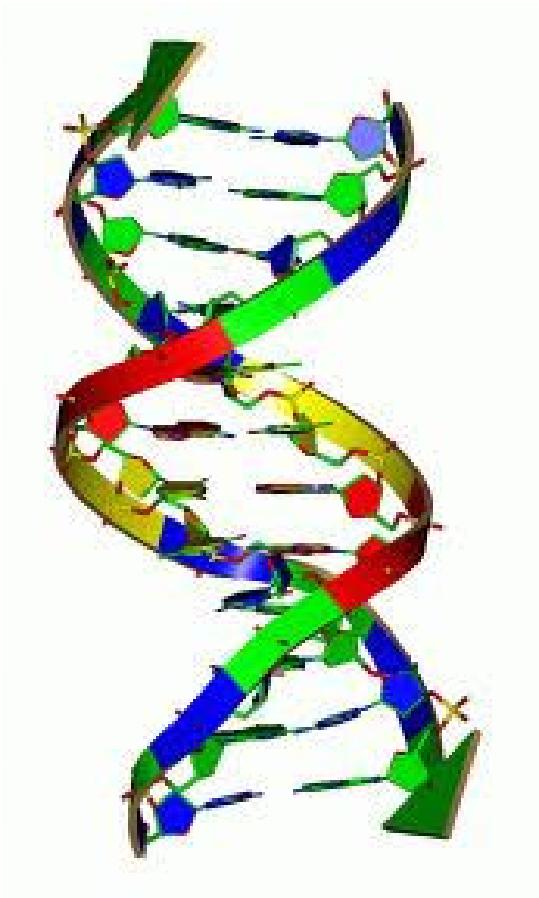
Genes

- Segments of a strand of DNA
  - hundreds to thousands of nucleotides long
- Sequence of bases determines the sequence of amino acids
- How is the sequence of aa important?



Helicies

- RNA forms a single helix
- DNA forms an antiparallel double helix
  - Strands held together by hydrogen bonds
  - Van der Waals forces stabilize structure



Base Pairing

- Complementary rules:

- A–T C– G

- This allows DNA to serve as a template for RNA and DNA

DNA and proteins can be used to track evolution

- How is this possible?