MARUDHAR KESARIJAIN COLLEGE FOR WOMEN, VANIYAMBADI

PG DEPARMENT OF CHEMISTRY

CLASS – II M.Sc CHEMISTRY
SUBJECT CODE- GCH41
SUBJECT- ORGANIC CHEMISTRY- IV

UNIT-III

PROTEINS AND NUCLEIC ACIDS

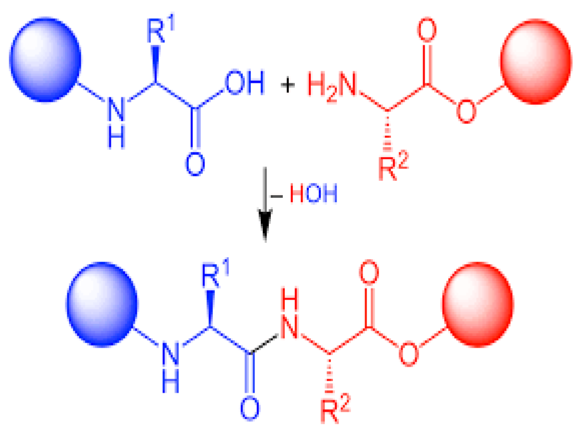
Proteins - peptides and their synthesis - synthesis of tripeptide - Merrifield synthesis - determination of tertiary structure of protein - biosynthesis of proteins - nucleic acids - types - DNA & RNA polynucleotide chain - components - biological functions - structure and role of (genetic code) DNA and RNA (nucleotides only) - Biosynthesis of Cholesterol

Proteins

Proteins are large, complex molecules that play many critical roles in the body. They do most of the work in cells and are required for the structure, function, and regulation of the body's tissues and organs.

The complete structure of a protein can be described at four different levels of complexity: primary, secondary, tertiary, and quaternary structure.

peptides and their synthesis



In organic chemistry, peptide synthesis is the production of peptides, compounds where multiple amino acids are linked via amide bonds, also known as peptide bonds.

Peptides are chemically synthesized by the condensation reaction of the carboxyl group of one amino acid to the amino group of another.

Protecting group strategies are usually necessary to prevent undesirable side reactions with the various amino acid side chains.

Chemical peptide synthesis most commonly starts at the carboxyl end of the peptide (C-terminus), and proceeds toward the amino-terminus (N-terminus).

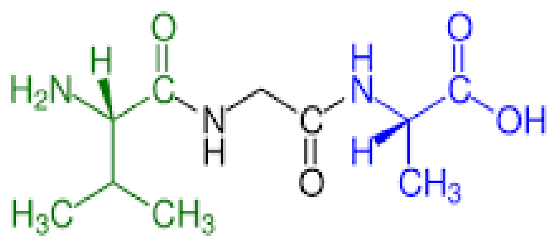
Protein biosynthesis (long peptides) in living organisms occurs in the opposite direction.

The chemical synthesis of peptides can be carried out using classical solution-phase techniques, although these have been replaced in most research and development settings by solid-phase methods (see below).

Solution-phase synthesis retains its usefulness in large-scale production of peptides for industrial purposes however.

Chemical synthesis facilitates the production of peptides which are difficult to express in bacteria, the incorporation of unnatural amino acids, peptide/protein backbone modification, and the synthesis of D-proteins, which consist of D-amino acids.

synthesis of tripeptide



A tripeptide is a peptide derived from three amino acids joined by two or sometimes three peptide bonds. As for proteins, the function of peptides is determined by the constituent amino acids and their sequence. The simplest tripeptide is glycylglycylglycine

Peptide synthesis most often occurs by coupling the carboxyl group of the incoming amino acid to the N-terminus of the growing peptide chain.

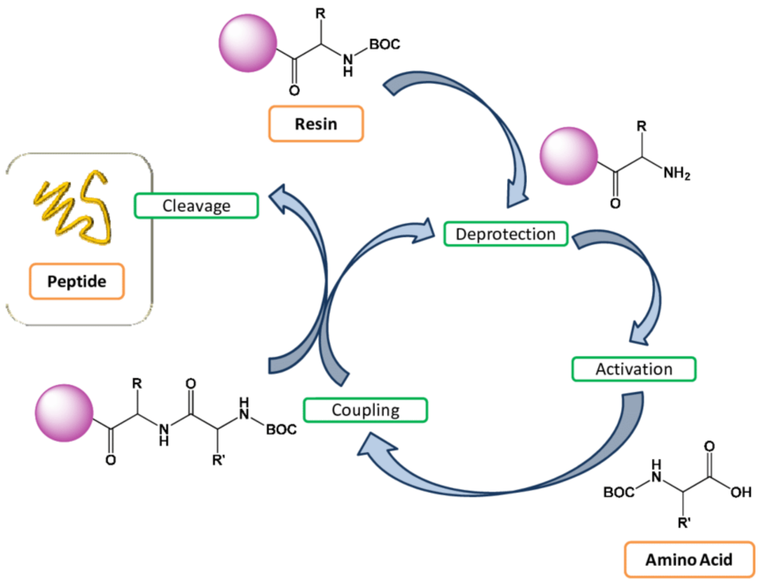
This C-to-N synthesis is opposite from protein biosynthesis, during which the N-terminus of the incoming amino acid is linked to the C-terminus of the protein chain (N-to-C).

Merrifield synthesis

The synthesis of peptides and small proteins in which the resinous polymer supported amino acid and succeeding peptide repeatedly reacts with N-protected amino acids followed by deprotection until the desired peptide or protein is assembled is generally referred to as the Merrifield solid phase peptide synthesis.

Bruce Merrifield, involves attaching the C-terminus of the peptide chain to a polymeric solid, usually having the form of very small beads.

Separation and purification is simply accomplished by filtering and washing the beads with appropriate solvents.

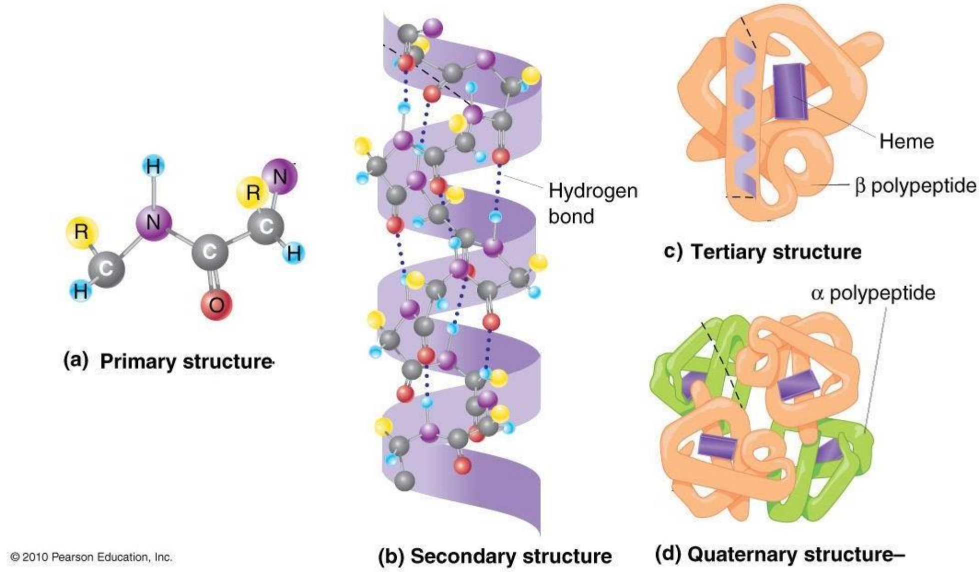


solid-phase synthesis is a method in which molecules are covalently bound on a solid support material and synthesised step-by-step in a single reaction vessel utilising selective protecting group chemistry.

Determination of tertiary structure of protein

The interactions and bonds of side chains within a particular protein determine its tertiary structure. The protein tertiary structure is defined by its atomic coordinates.

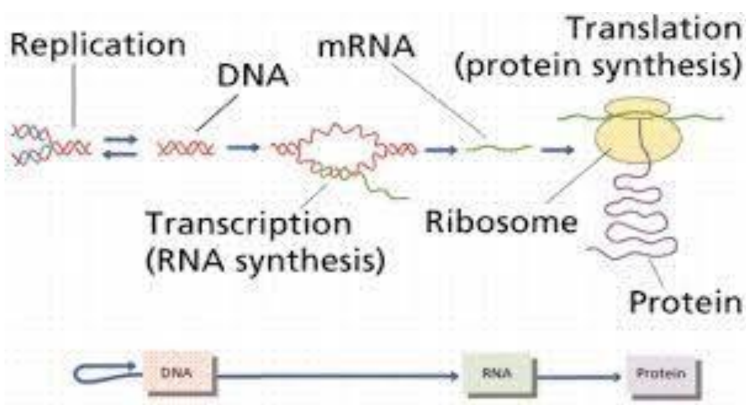
These coordinates may refer either to a protein domain or to the entire tertiary structure.



Hydrophobic Forces-The most important determinant of tertiary structure

Biosynthesis of proteins

Protein biosynthesis (or protein synthesis) is a core biological process, occurring inside cells, balancing the loss of cellular proteins (via degradation or export) through the production of new proteins. Proteins perform a number of critical functions as enzymes, structural proteins or hormones.



5 Major Stages of Protein Synthesis (explained with diagram)

(a) Activation of amino acids

(b) Transfer of amino acid to tRNA

(c) Initiation of polypeptide chain

(d) Chain Termination

(e) Protein translocation

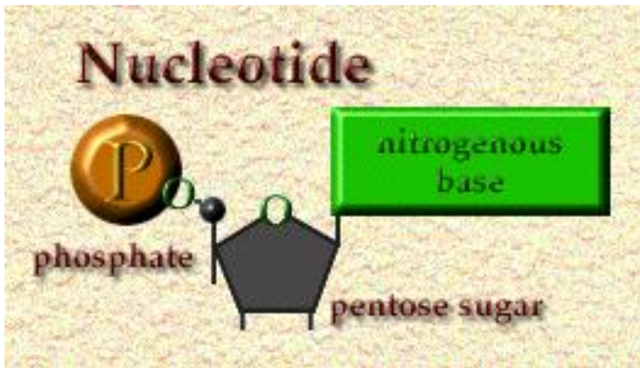
Nucleic acids - types - DNA & RNA polynucleotide chain

The nitrogenous bases found in DNA are, adenine, guanine, cytosine and thymine. DNA molecules have two polynucleotide chains, held together in a ladderlike structure.

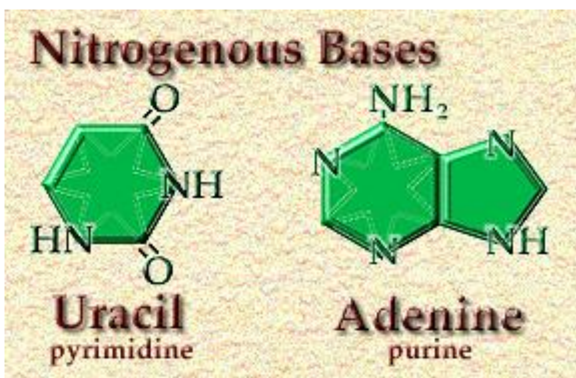
The sugar phosphate backbones of the two chains run parallel to each other in opposite directions.

Nucleotides are the building blocks of polymers called polynucleotides.

Each nucleotide monomer consists of a pentose (five-carbon) sugar, to which is attached two other groups; a phosphate group and a nitrogenous base.



The nitrogenous base is either a double ringed structure known as a purine or single ringed structure known as a pyrimidine. There are five common nitrogenous bases; adenine, guanine, thymine, cytosine and uracil.



Nucleotides are joined together by covalent bonds between the phosphate group of one nucleotide and the third carbon atom of the pentose sugar in the next nucleotide. This produces an alternating backbone of sugar - phosphate - sugar - phosphate all along the polynucleotide chain.

The simplest of the polynucleotides is a single chain in which the pentose sugar is always ribose. The name of this polynucleotide comes from the sugar ribonucleic acid, abbreviated to the three letters RNA. Adenine, guanine, cytosine and uracil are the four nitrogenous bases always found in RNA.

There are several different forms of RNA, each playing a slightly different role in the cell.

mRNA: messenger RNA - these molecules are complementary copies of genetic messages taken from the DNA genes. They deliver their "messages" to the protein synthesizing machinery in the cytoplasm of the cell.

rRNA: ribosomalRNA - these molecules are critical structural components in cellular ribosomes (tiny structures important in protein synthesis). There are several kinds of rRNA, some are found in the large ribosomal subunit and some in the small subunit.

tRNA: transferRNA - the smallest type of RNA. There are more than 20 types of tRNA. They act as the link between the genetic code and the process of joining amino acids together to form polypeptides.

Deoxyribose is the pentose sugar found in this type of polynucleotide, hence its name Deoxyribonucleic Acid, or DNA.

The nitrogenous bases found in DNA are, adenine, guanine, cytosine and thymine. DNA molecules have two polynucleotide chains, held together in a ladderlike structure.

The sugar phosphate backbones of the two chains run parallel to each other in opposite directions. Each "rung" of the ladder is a pair of nitrogenous bases, one purine and one pyrimidine extending into the center of the molecule.
The pairing of these bases is always adenine with thymine
(A - T)
and guanine with cytosine
(G - C).

The sugar-phosphate backbones of the two polynucleotide chains coil around one another (making the "ladder" into a spiral "staircase"). This superstructure is known as a "double helix".

Structure and role of (genetic code) DNA and RNA (nucleotides only

Genetic code, the sequence of nucleotides in deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) that determines the amino acid sequence of proteins.

Though the linear sequence of nucleotides in DNA contains the information for protein sequences, proteins are not made directly from DNA. Instead, a messenger RNA (mRNA) molecule is synthesized from the DNA and directs the formation of the protein. RNA is composed of four nucleotides:

adenine (A), guanine (G), cytosine (C), and uracil (U). Three adjacent nucleotides constitute a unit known as the codon, which codes for an amino acid. For example, the sequence AUG is a codon that specifies the amino acid methionine.

There are 64 possible codons, three of which do not code for amino acids but indicate the end of a protein. The remaining 61 codons specify the 20 amino acids that make up proteins. The AUG codon, in addition to coding for methionine, is found at the beginning of every mRNA and indicates the start of a protein.

Methionine and tryptophan are the only two amino acids that are coded for by just a single codon (AUG and UGG, respectively).

The other 18 amino acids are coded for by two to six codons. Because most of the 20 amino acids are coded for by more than one codon, the code is called degenerate.

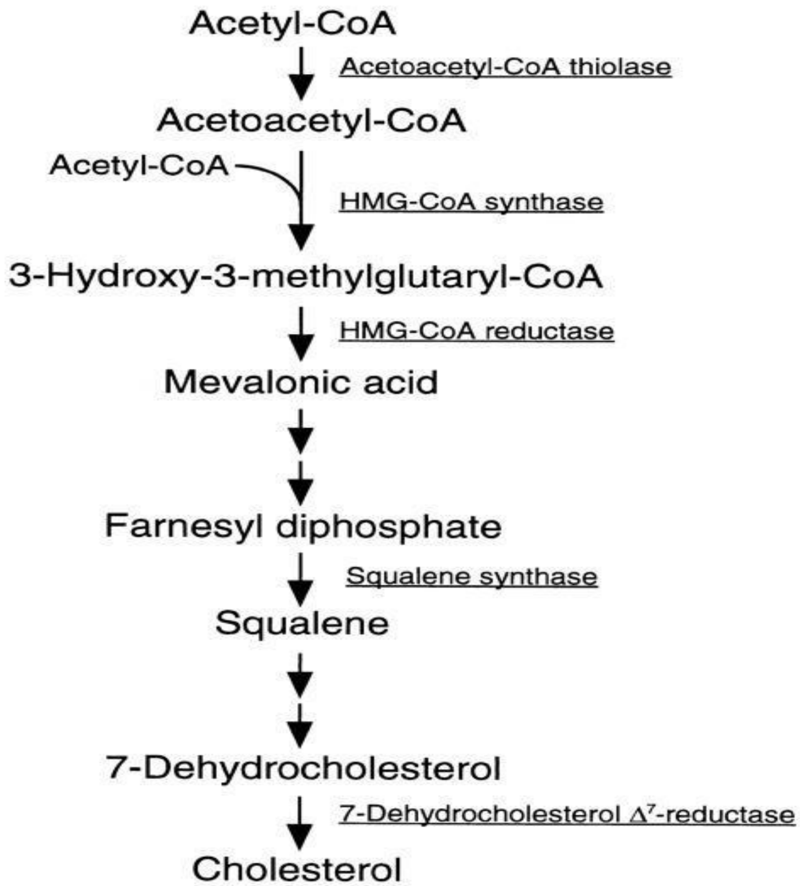
Biosynthesis of Cholesterol

Biosynthesis of cholesterol generally takes place in the endoplasmic reticulum of hepatic cells and begins with acetyl- CoA, which is mainly derived from an oxidation reaction in the mitochondria.
However, acetyl-CoA can also be derived from the cytoplasmic oxidation of ethanol by acetyl-CoA synthetase.

Cholesterol synthesis is regulated at the step involving HMG-CoA reductase.

The enzyme activity is regulated at the transcriptional level, that is, by changing the rate of synthesis of the mRNA encoding the enzyme.

HMG-CoA reductase is regulated by phosphorylation and dephosphorylation



Cholesterol biosynthesis occurs in every nucleated cell in the body. Although it is often thought that the majority of cholesterol synthesis occurs in the liver, studies have shown that the bulk tissues of the body account for the overwhelming majority of endogenous cholesterol production.