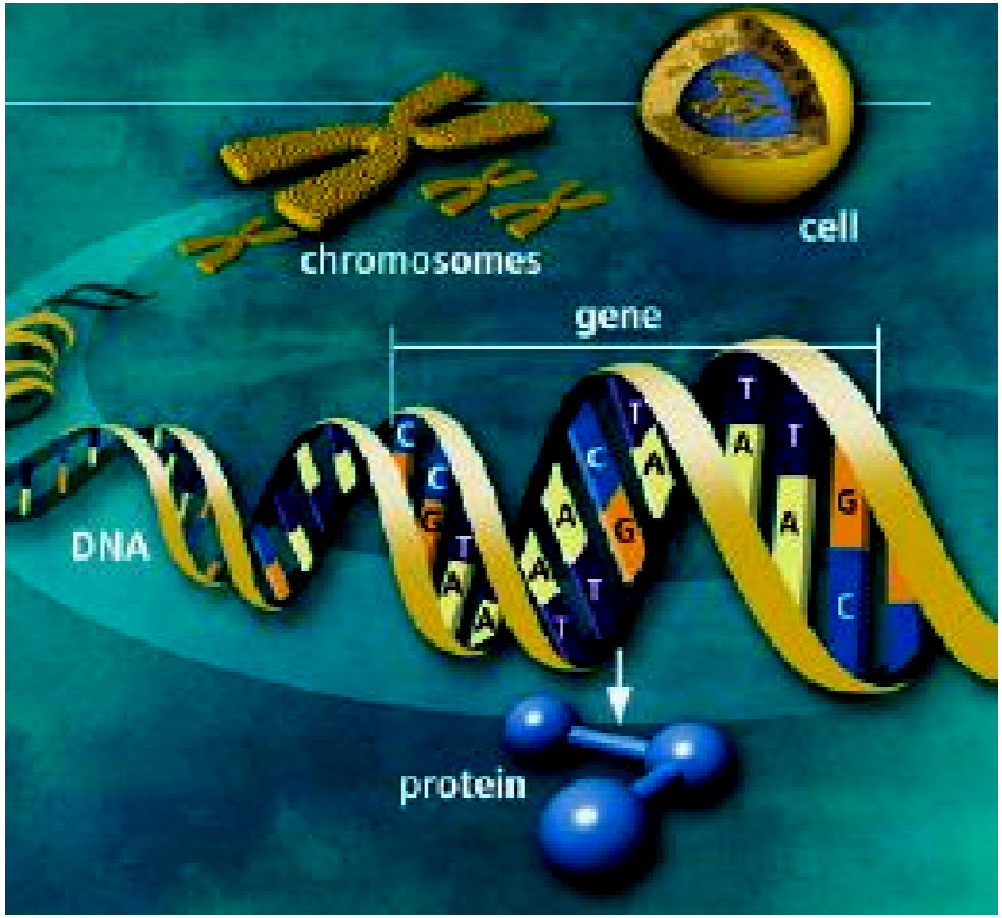
Lecture 12

Genetic Code

DNA replication, transcription and translation

- Molecular mechanism of genetic information transfer
- Genetic Code
- Molecular mechanism of protein synthesis
- Principles of molecular recognition



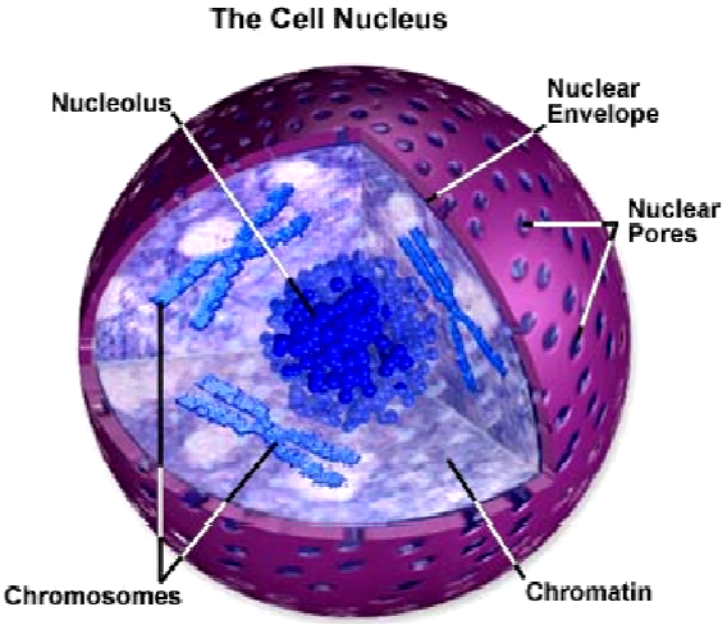


Figure 1

Anatomy of genes

Condensation of DNA into chromosome

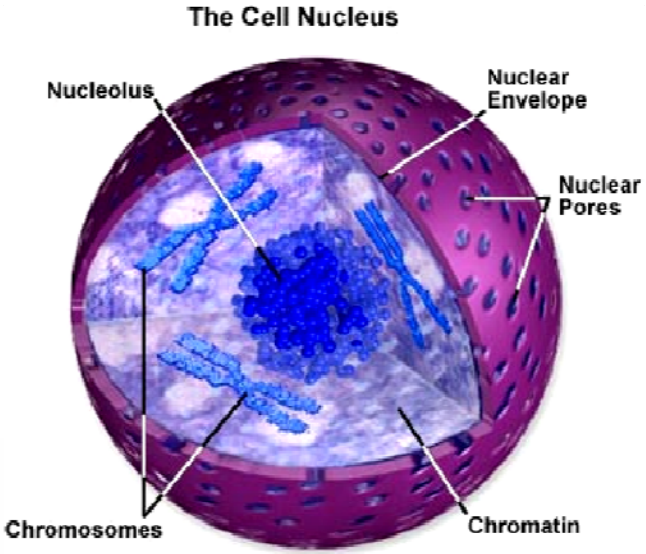
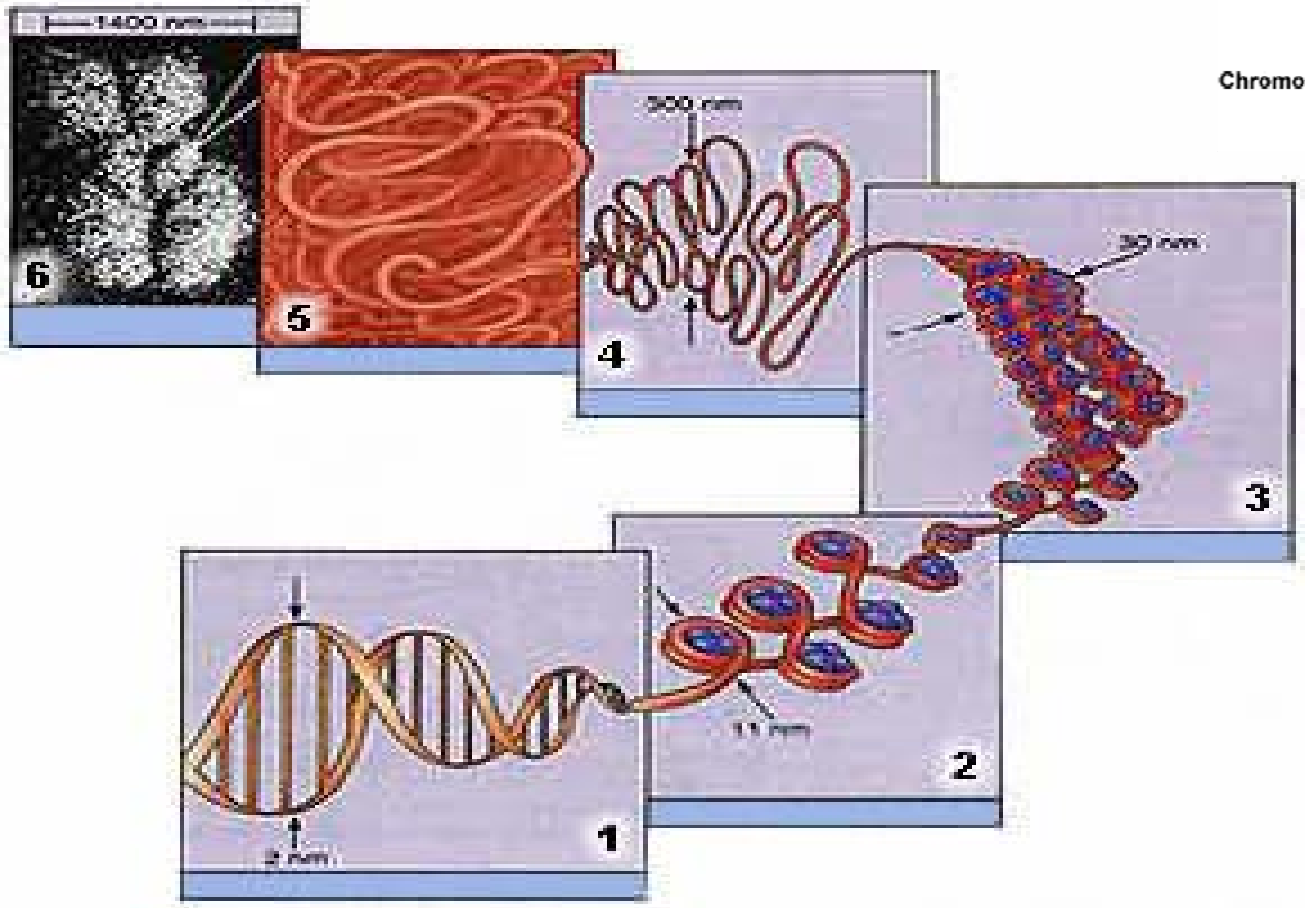
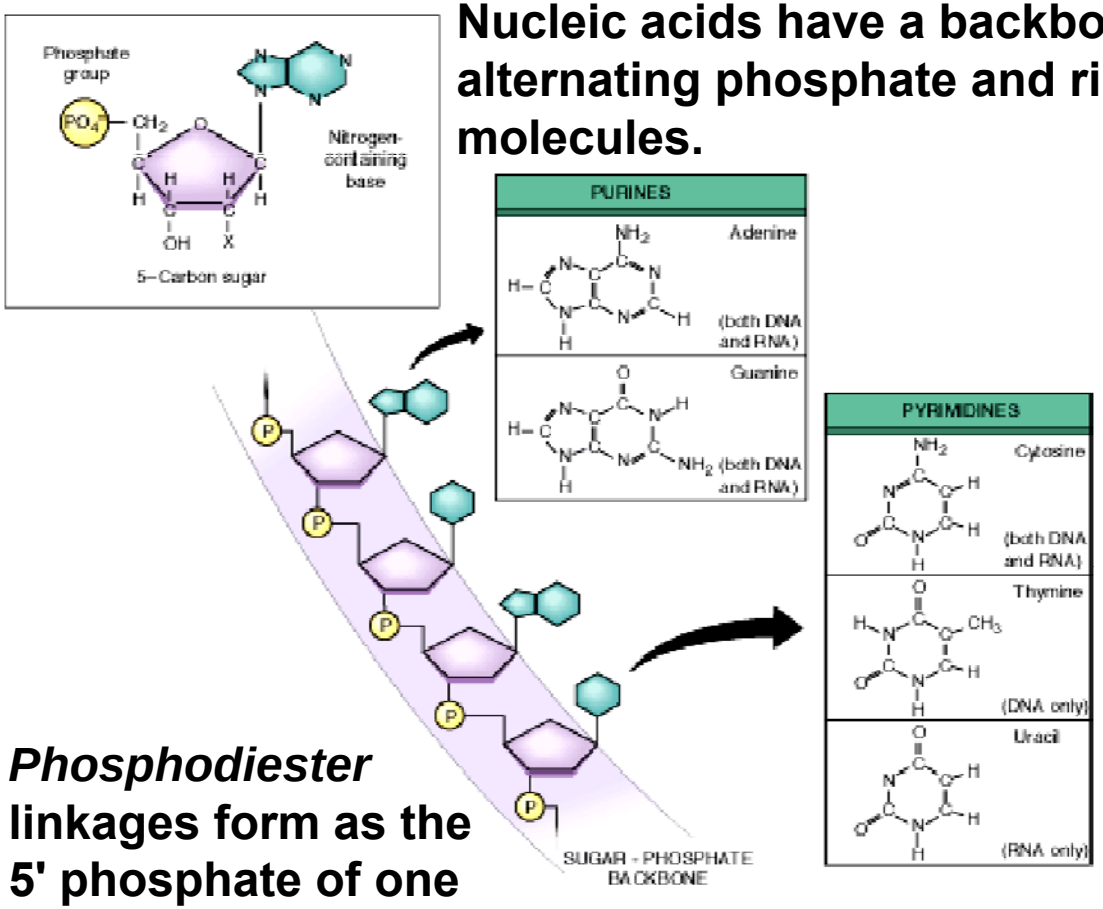


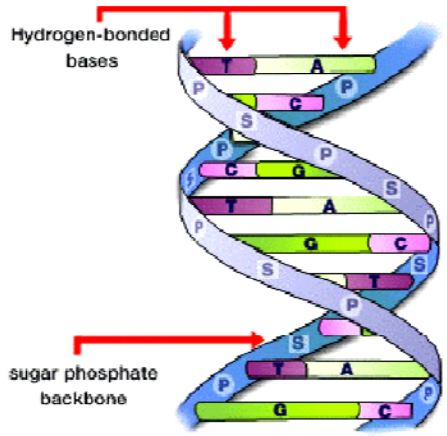
Figure 1



Nucleic acids have a backbone of alternating phosphate and ribose molecules.



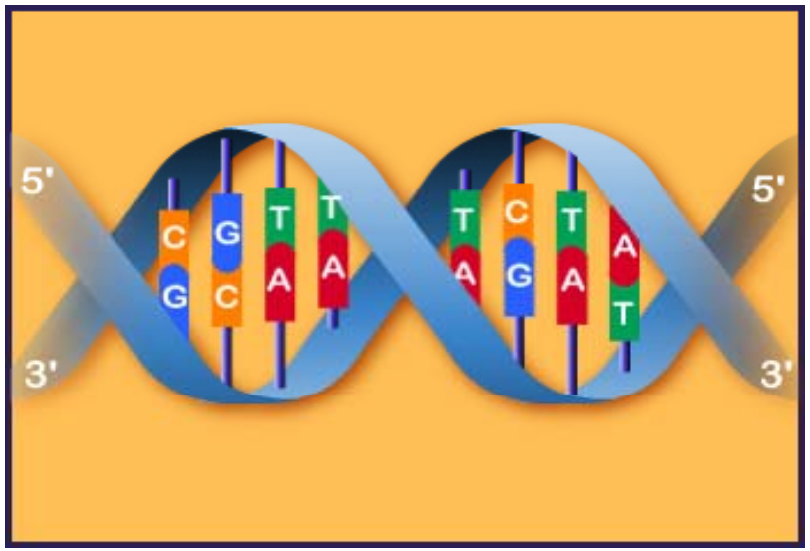
Phosphodiester **linkages form as the 5' phosphate of one nucleotide forms an ester linkage with the 3' hydroxyl of the next nucleotide in the polynucleotide chain.**

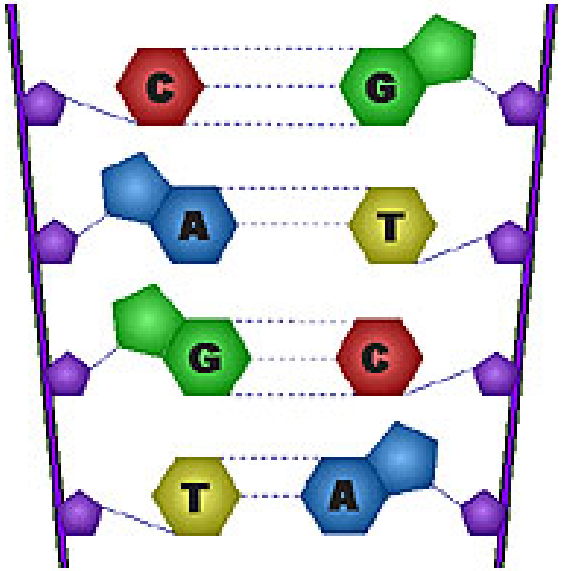


Nucleic acids are polymers of nucleotides. Each nucleotide includes a base, either a *purine* (adenine, guanine) or a *pyrimidine* (cytosine, thymine, uracil) and sugar (deoxyribose or ribose).

There are four nucleotides in DNA. Each nucleotide contains a base: adenine (A), guanin (G), cytosine (C), or thymine (T). In the RNA molecule, the pyrimidine base is uracil (U) instead of thymine.

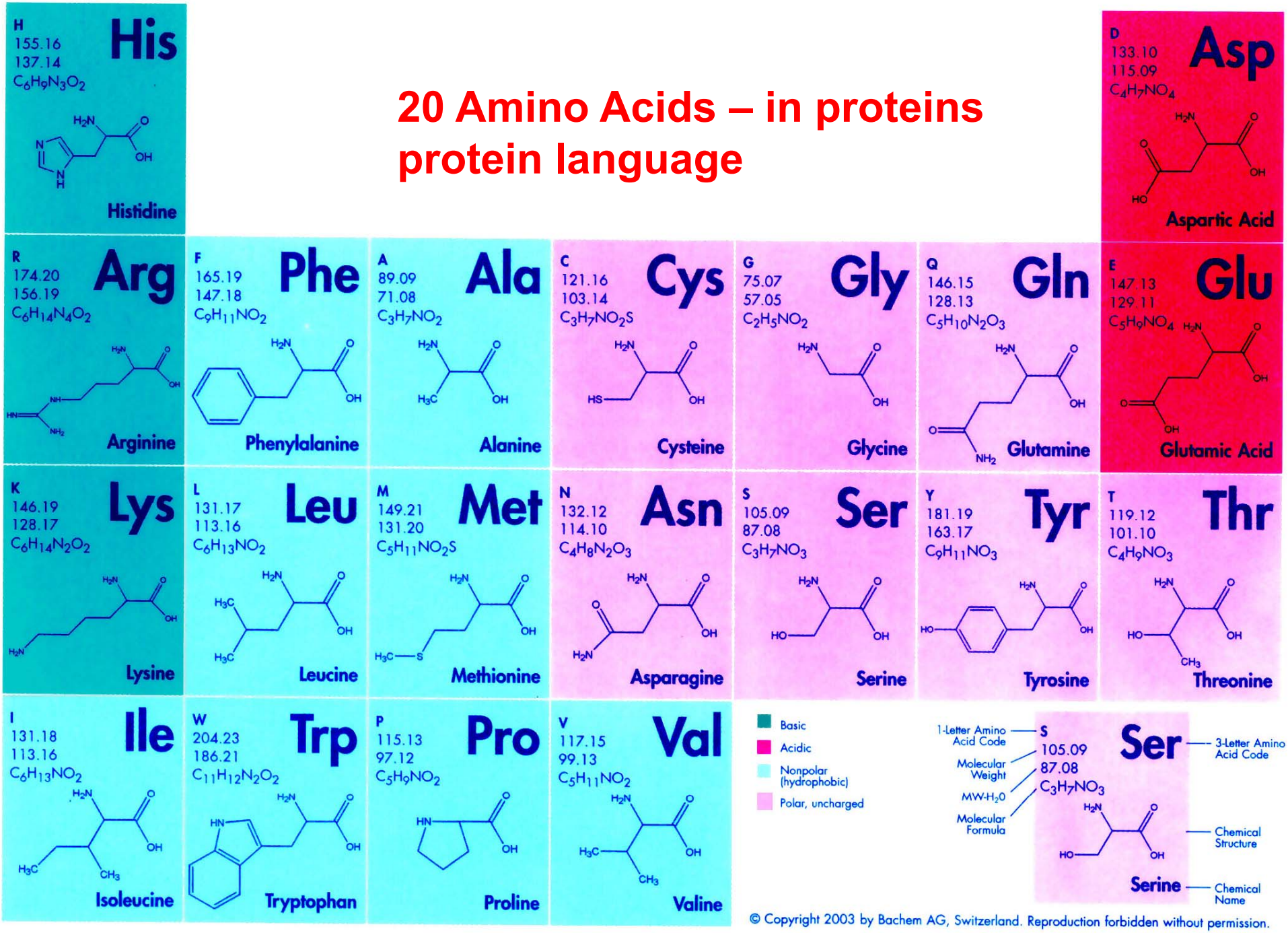
Bases A, C, G, T – DNA language





DNA is a double helix made of two chains of polynucleotides. Base pairs form hydrogen bonds only between A and T and between G and C so the base sequence of each single strand of DNA can be simply deduced from that of its partner strand.

20 Amino Acids – in proteins protein language



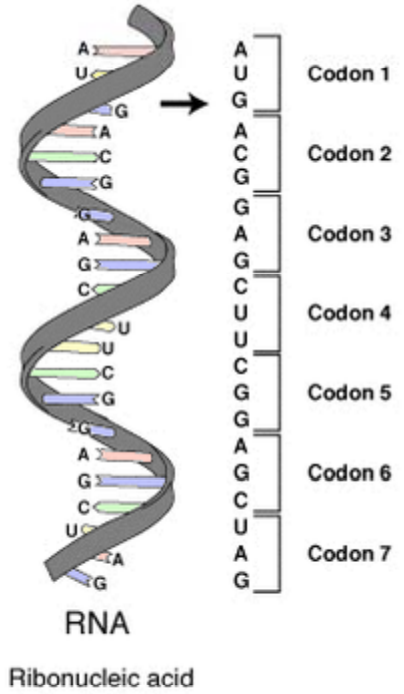
Genetic Code

Summary :

1.It is made up of codons, which are triplets of bases.
Each codon correspond to a specific amino acid.

2.The code includes punctuation in the form of three
“stop” codons that do not code for an amino acid:
UAA, UAG, and UGA.

4.The genetic code is known as a “degenerate” code.
This means that each amino acid can be coded by six codons.
(There are only 20 amino acids and 64 possible codon triplets).

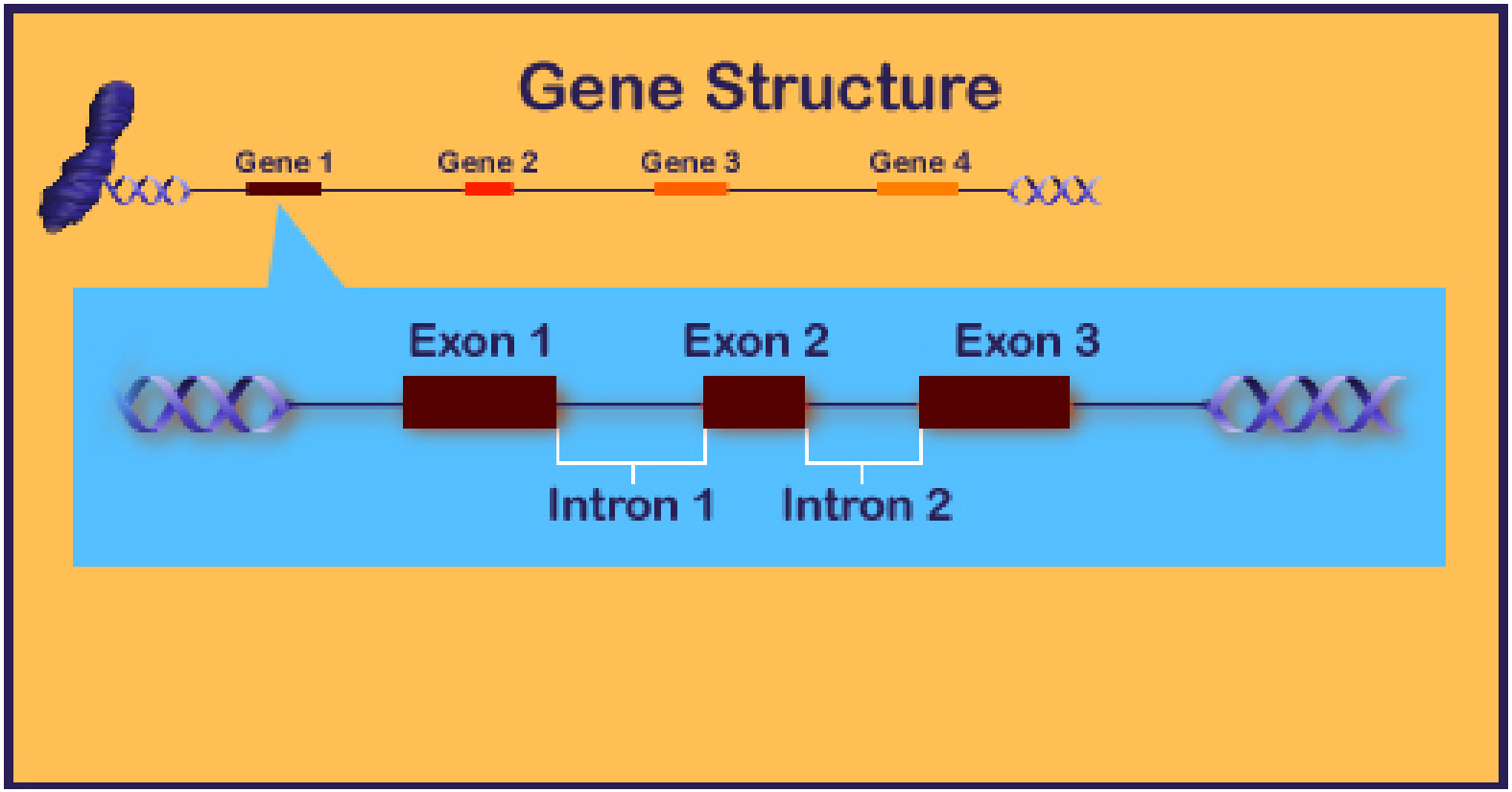


5.To read each gene and glean the necessary information to form proteins,
cells begin at a fixed and particular starting point on the mRNA strand.
The initiation codon is AUG (methionine).

6.The mRNA strand is read from the 5' to the 3' end.

7.If there are mutations or errors in the DNA, the message may be changed and
incorrect protein formation results.

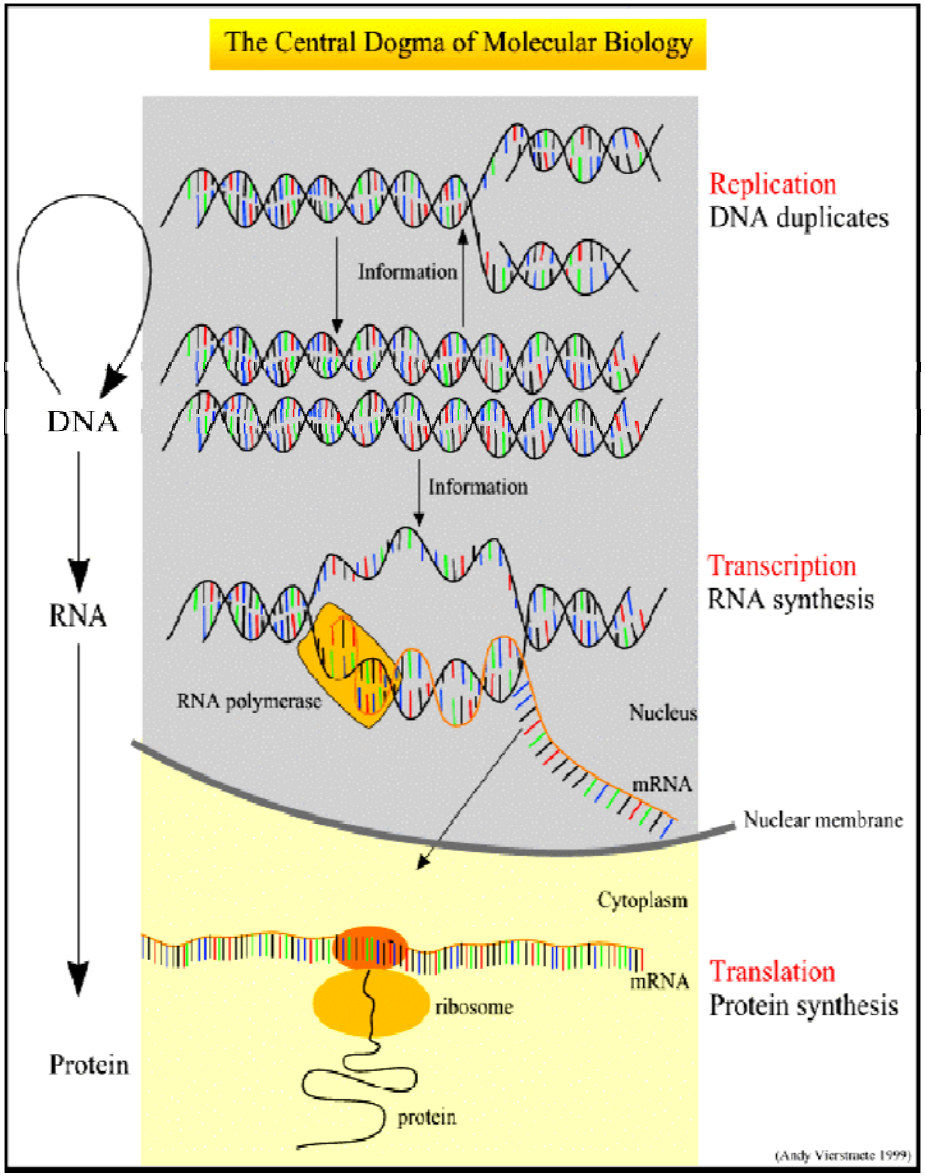
Structure of the genetic information in DNA



Exons – are composed of codons – informative. Codon – 3 bases which code one aminoacid

Introns – intermediate section, non-informative

TYPES OF GENETIC INFORMATION TRANSFER
CENTRAL DOGMA OF MOLECULAR BIOLOGY



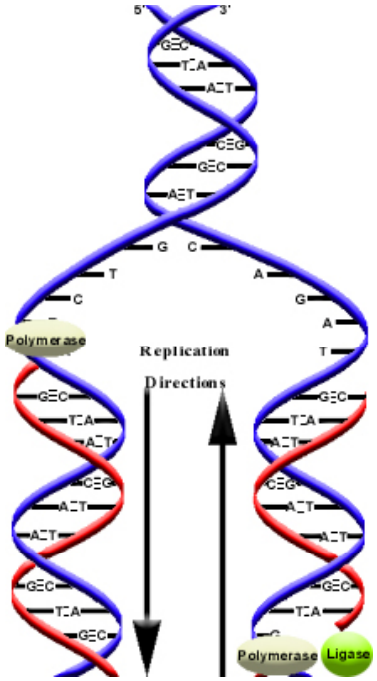
"Central dogma" of biology: DNA → RNA → protein.

The duplication and transmission of genetic material from one generation of cells to the next (from parent to daughter cell) in the process of cell division is the basis for molecular inheritance and is called replication. It is synthesis of complete DNA molecule from a DNA template, and the exact DNA replica is in both cells.

Transcription is the synthesis of RNA from part of DNA molecule. It is a continuous process that goes on during the life of the cell. Part of the DNA is copied into RNA, which can then leave the nucleus. Also, RNA is temporary. If it gets damaged or destroyed, another copy can always be made.

Protein is the final product. After replication i.e. cell division, new cells have to commence their biological functions. Therefore, specific proteins have to be synthesised through the process of translation.

Replication



Replication is a process of duplicating DNA molecule using parent DNA as a template

DNA Replication
http://www.youtube.com/watch?v=z685FFqmrpo&NR=1

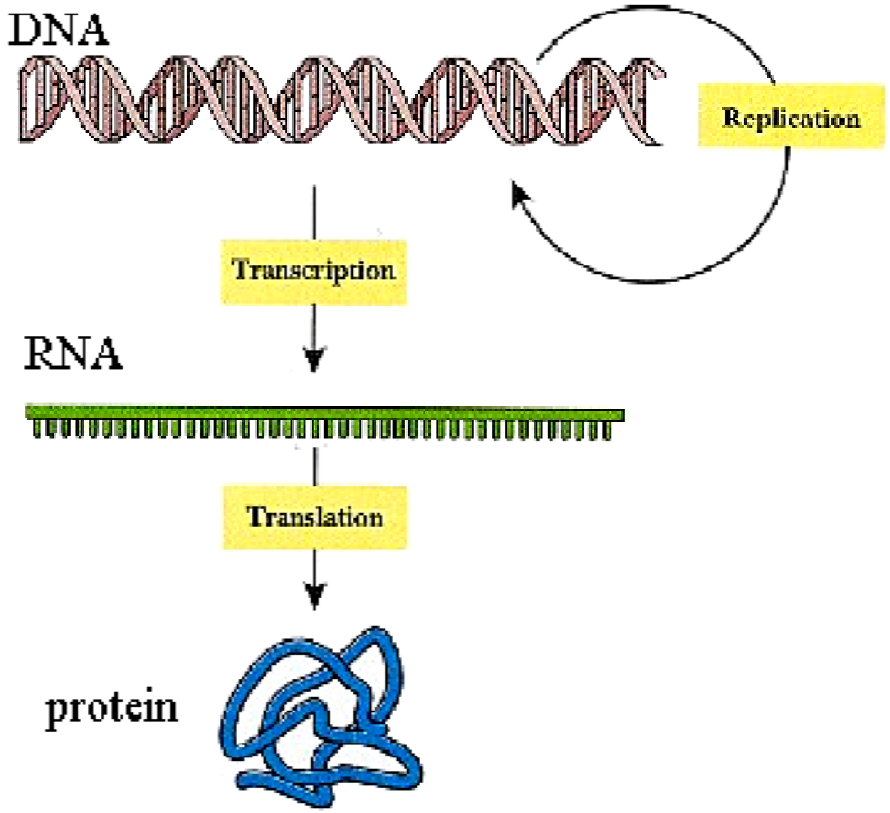
http://www.youtube.com/watch?v=Luw5_z8mIrI&NR=1

Gene expression occurs in two steps:

Transcription of the information encoded in DNA into a molecule of RNA occurs via synthesis of RNA

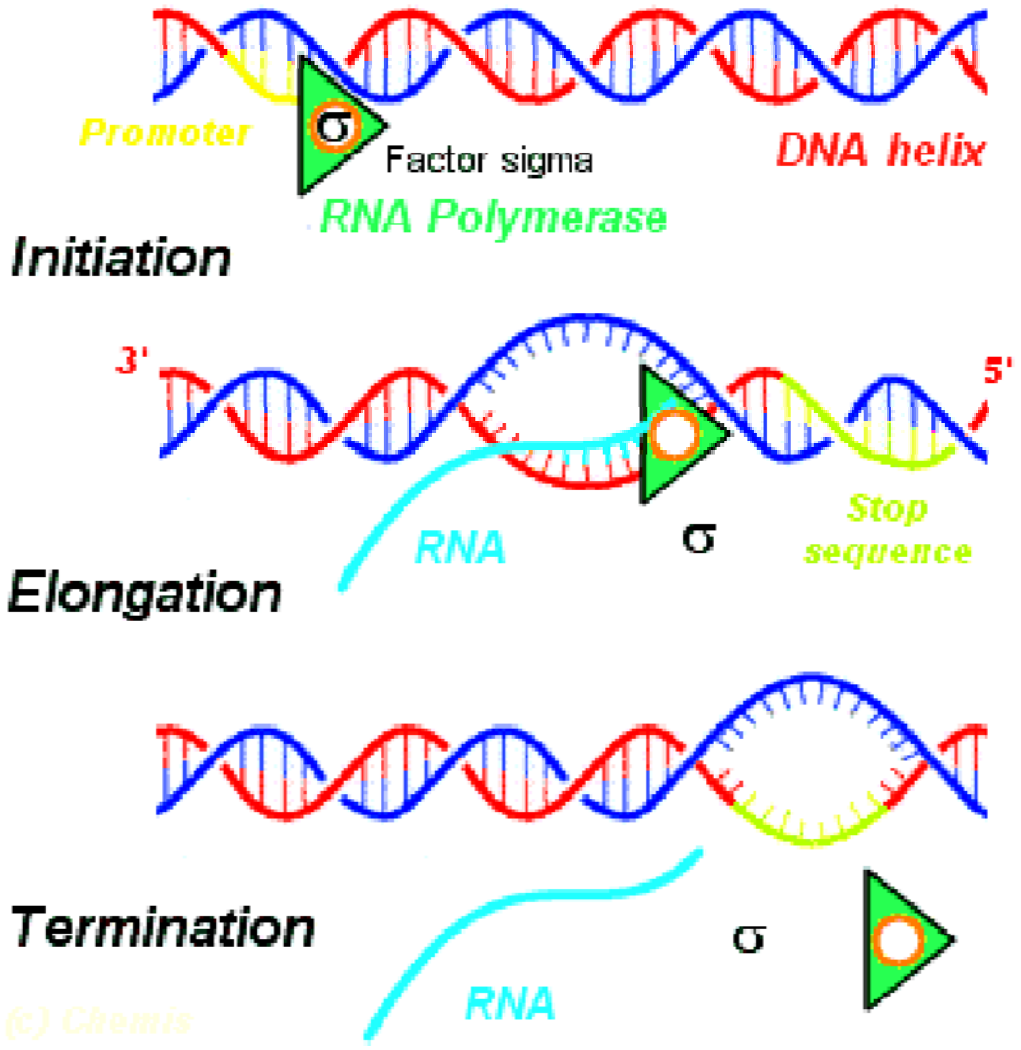
&

Translation of the information encoded in the nucleotides of mRNA into a defined sequence of amino acids in a protein – via protein synthesis using RNA



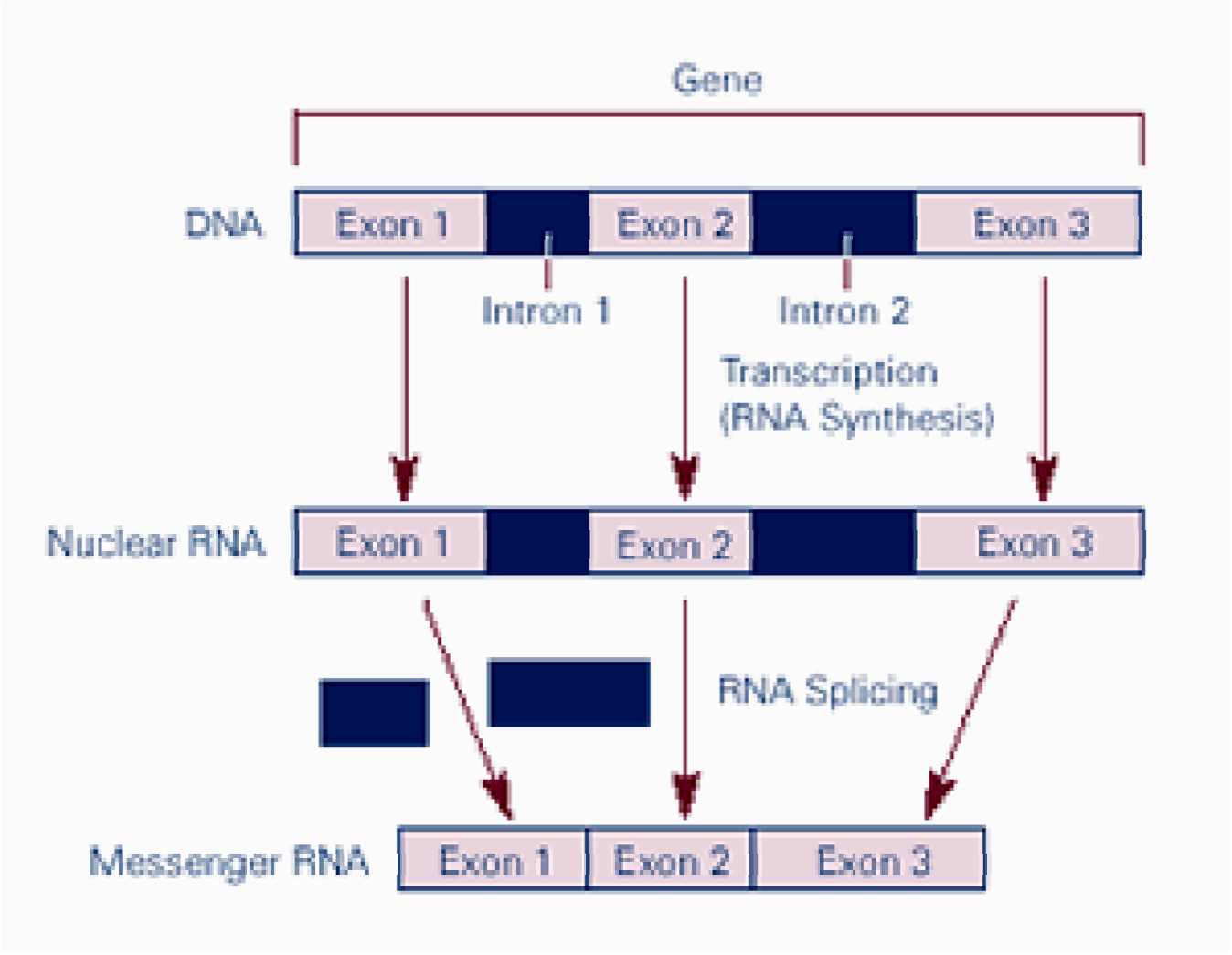
Gene Transcription = DNA → RNA

three steps:



DNA transcription
http://www.youtube.com/watch?v=ztPkv7wc3yU&feature=related

mRNA splicing



Molecular mechanism of protein synthesis
Translation = RNA → protein

This is a process of translation of information from DNA language to protein language

Translation is the process of assembling proteins based on the mRNA code.

Amino acids are assembled step-by-step by a ribosome according the mRNA sequence.

During this process, other specialized RNA molecules, called transfer-RNAs (or tRNA) bring amino acids matching the RNA sequence to the ribosome.

The ribosome stitches the amino acids together one by one to form the protein molecule.

Translation process is based on:

1. Recognition of base-pairs

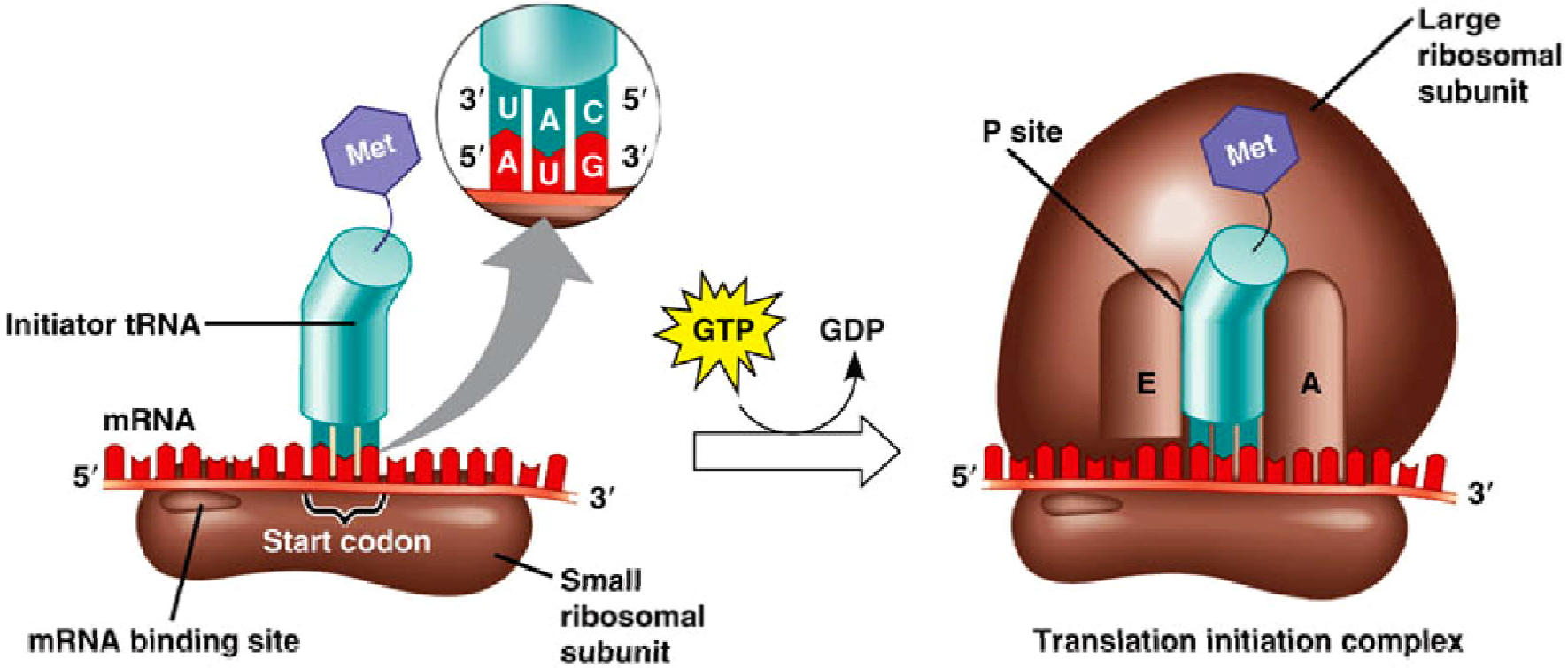
2. Binding of complementary base-pairs with amino acids and synthesis of protein coded by DNA

Is performed in three steps:

Initiation, Elongation, Termination

http://www.youtube.com/watch?v=-zb6r1MMTkc&feature=related

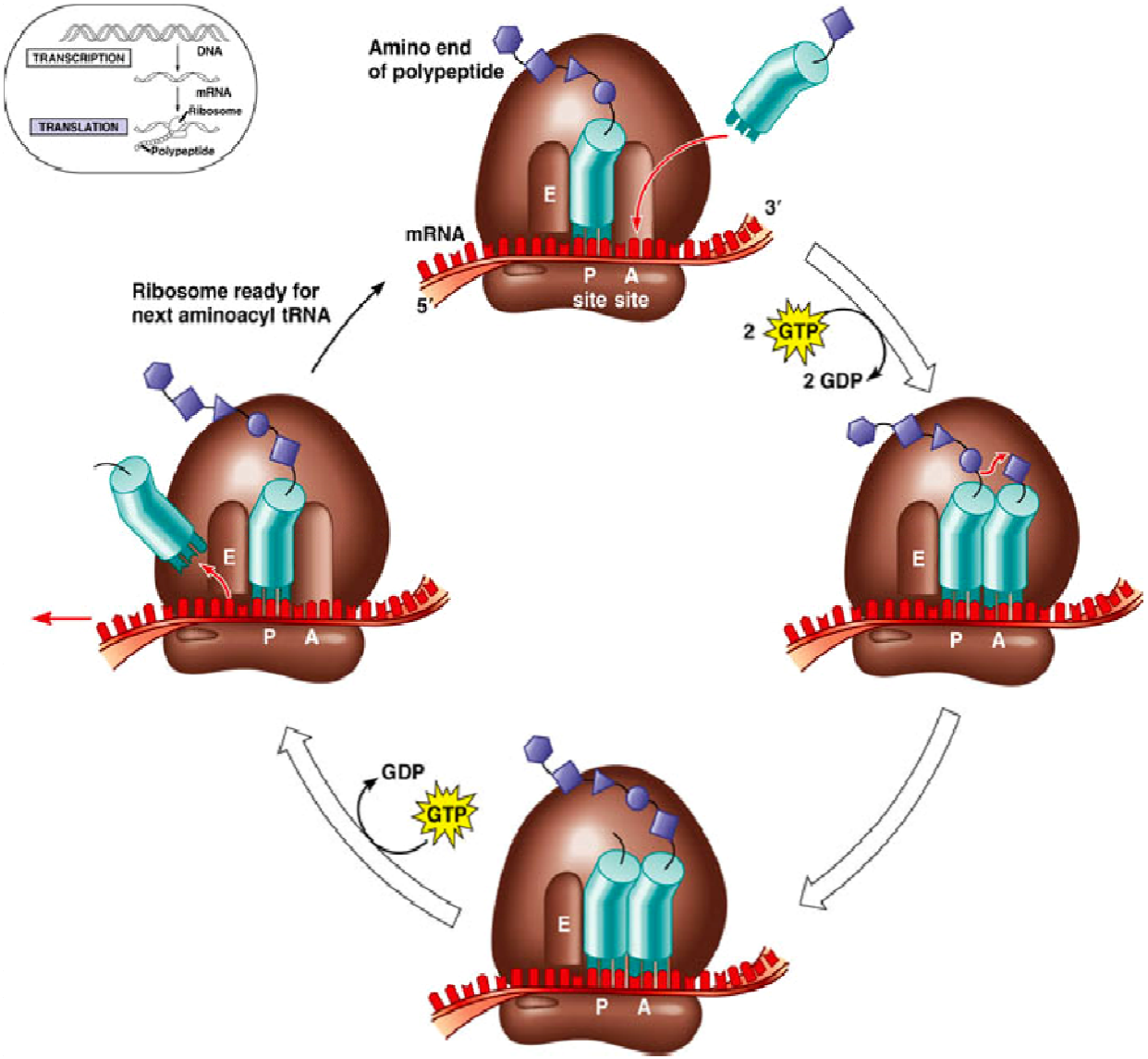
Translation - initiation



The mRNA binds to a special binding site on the small ribosomal unit at the 5' untranslated region.

The large ribosomal subunit has 3 binding sites, E, P, and A.
The large ribosomal subunit attaches to the small subunit in such manner that the first codon is aligned at the P binding site.
A tRNA carrying the amino acid methionine attaches to the start codon (AUG) on the messenger RNA. This initiates elongation.

Translation - elongation



Step 1. Attachment of first amino acid carrying tRNA to A binding site. A tRNA and its amino acid attaches to the A binding site.

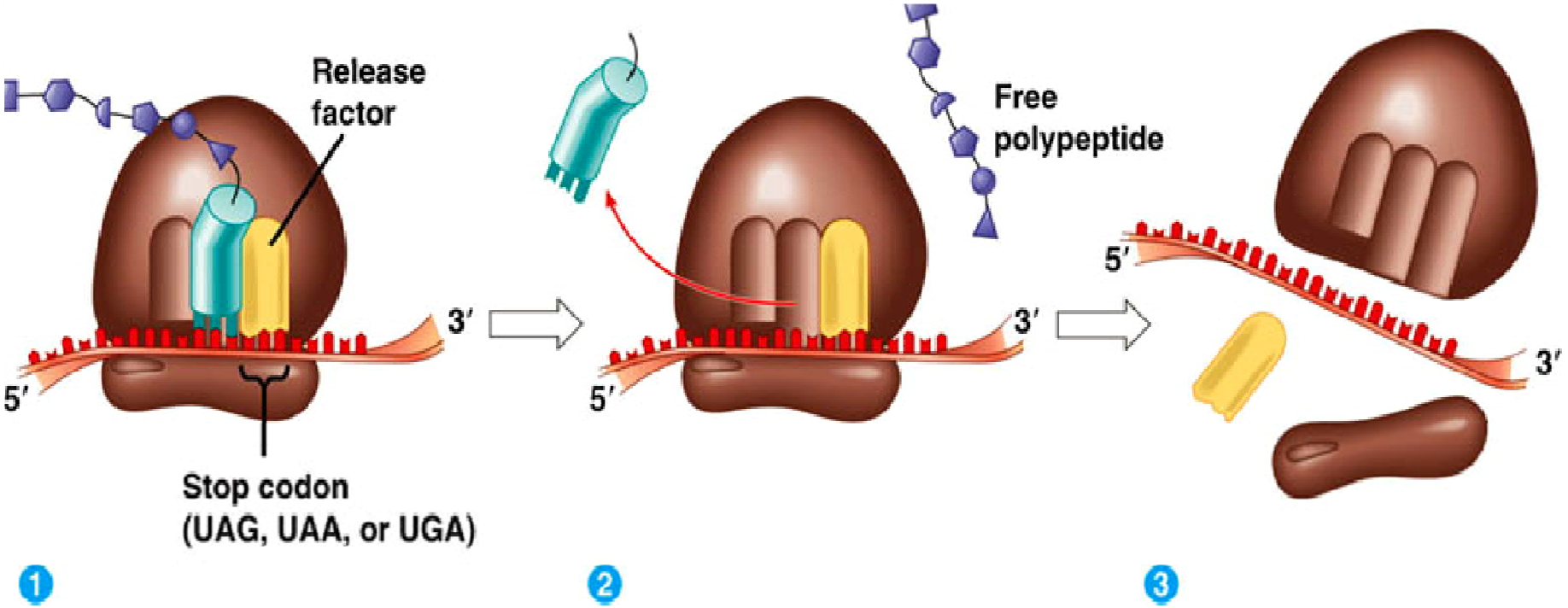
Step 2. Peptide bond formation between the met and the amino acid carried at the A binding site.

Step 3. Ribosome moves in the 3' direction down the messenger RNA by three bases or one codon shifting the tRNA and polypeptide chain to the P Binding site. The A binding site is open and a vacant tRNA is in the E binding site.

Step 4. tRNA ejected from the E binding site.

Repeat Step 1 – 4. until stop codon encountered.

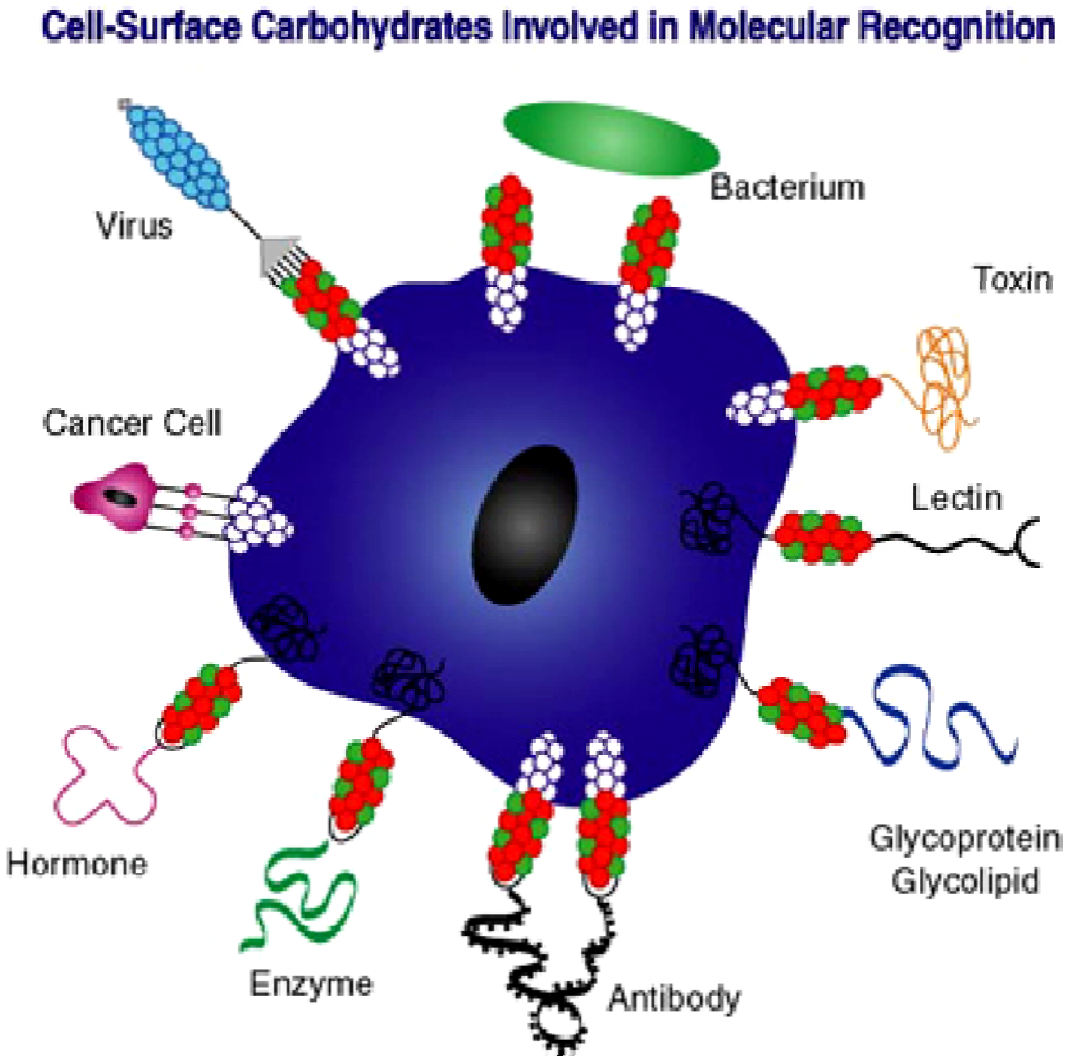
Translation - termination



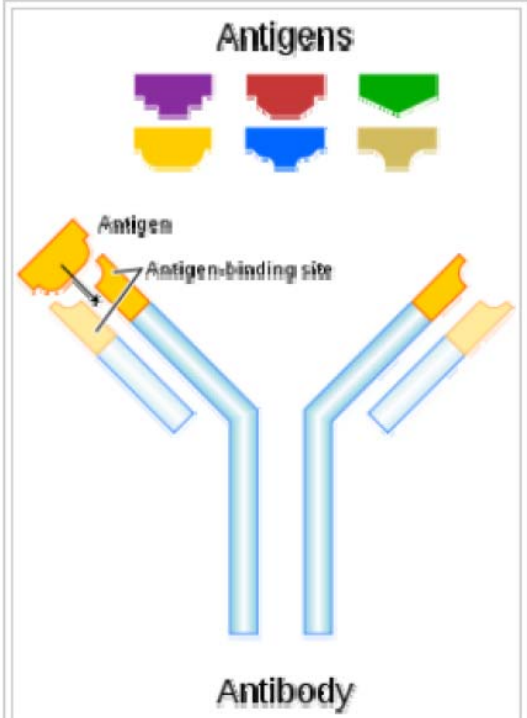
The polypeptide chain is at the P site. The stop codon at the A site.

Step 1. A Release factor protein binds to the stop codon at the A binding site.
Step 2. Release factor protein initiates separation of polypeptide chain:
Step 3. Separation of translation machinery. Polypeptide chain may go to cytoplasm for further processing.

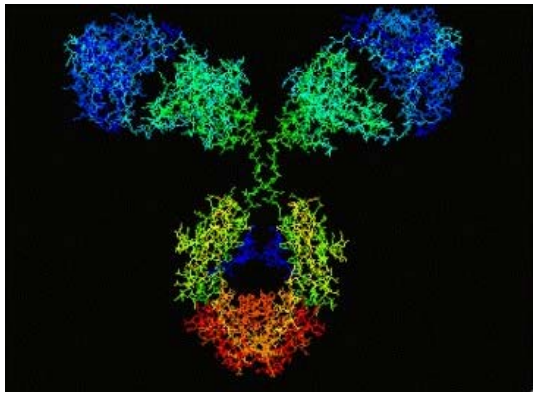
molecular recognition



- Protein biosynthesis
- DNA recognition
- Fertilization i.e. egg-sperm recognition
- Sensory recognition: taste, smell, pheromones
- Immune reaction (AG-AB binding)
- Hormone-receptor interaction
- Enzyme catalysis
- Intercellular interactions



Each antibody binds to a specific antigen; an interaction similar to a lock and key.



Antibody – antigen

Antigen is a foreign substance (virus, microbe) which is harmful to the cell,

Antibody (Immunoglobulines) are glycoproteins that bind antigens with high specificity and affinity

Key and lock mechanism

based on weak interactions, 3 D structure is important

Receptor molecule (the lock) interacts with guest molecule (key) which complements the receptor in size, shape, and functionalities.

http://www.youtube.com/watch?v=lrYlZJiuf18