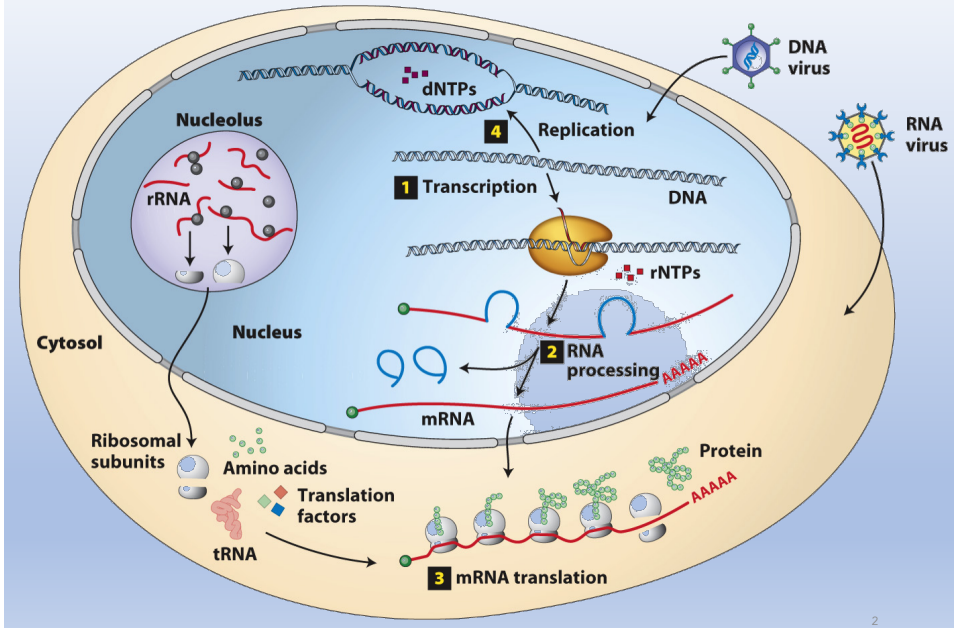
MBioS 503: Section 1 Chromosome, Gene, Translation, & Transcription

Gene Organization

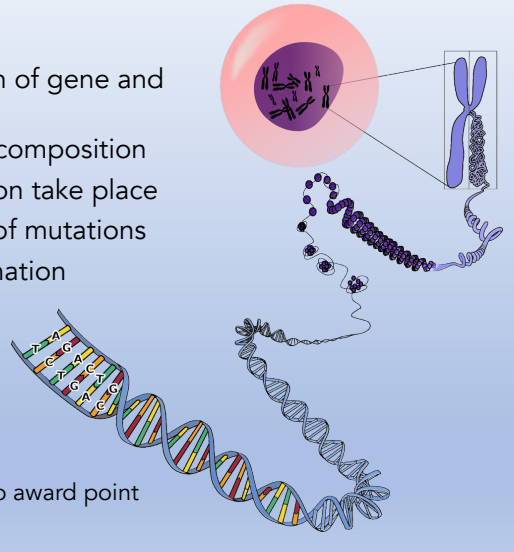
Joy Winuthayanon, PhD
School of Molecular Biosciences
Biotech/Life Sciences BLS239
w.winuthayanon@wsu.edu
https://labs.wsu.edu/winuthayanon

Overview & Recap of Molecular Biology before the last two sections



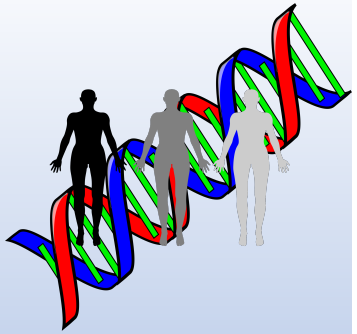
Objectives: Gene Organization

- Describe the composition of gene and its organization
- Describe DNA and RNA composition
- Know how DNA replication take place
- Describe different types of mutations
- Understand the recombination mechanism



Kahoot! 1, no award point

Genome



- The hereditary basis of every living organism is its genome.
- a long sequence of deoxyribonucleic acid (DNA) that provides the complete set of hereditary information carried by the organism as well as its individual cells.
  - Chromosomal DNA
  - Organellar DNA
    - (i.e. mitochondrial DNA & Chloroplast DNA)

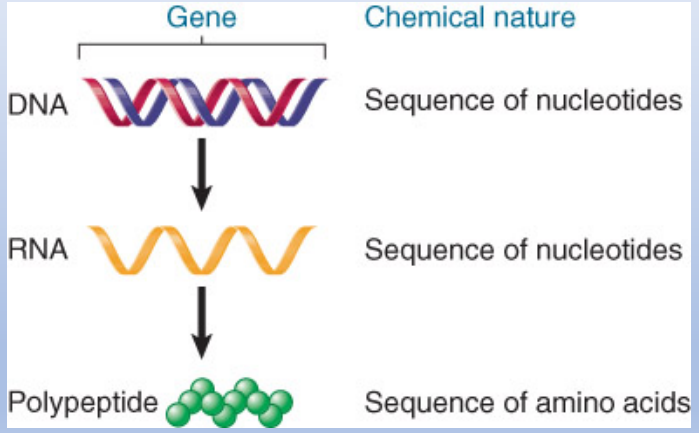
Figure 4-18 Molecular Biology of the Cell 6e (© Garland Science 2015)

- Genome can be divided into a number of different DNA molecules, or chromosomes.

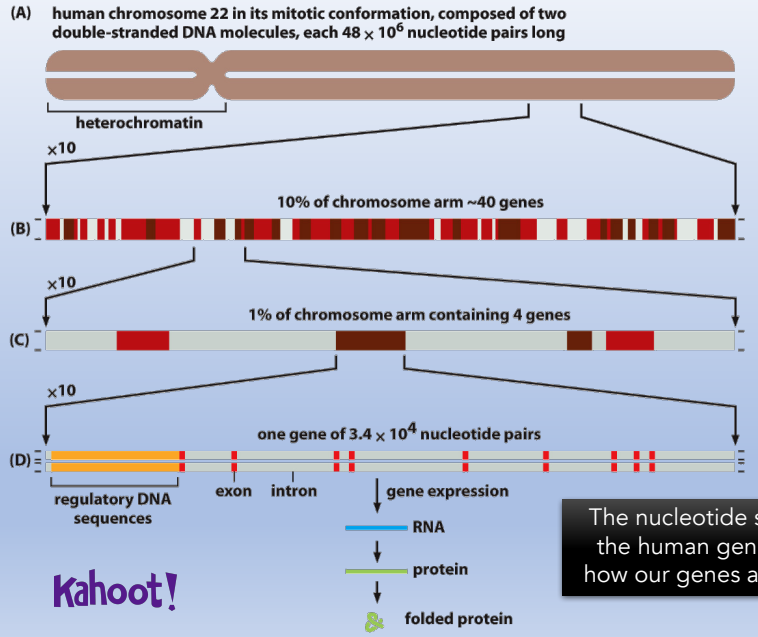
A unit of the genome carrying many genes.

Kahoot! 2 & 3

A gene encodes an RNA, which can encode a polypeptide



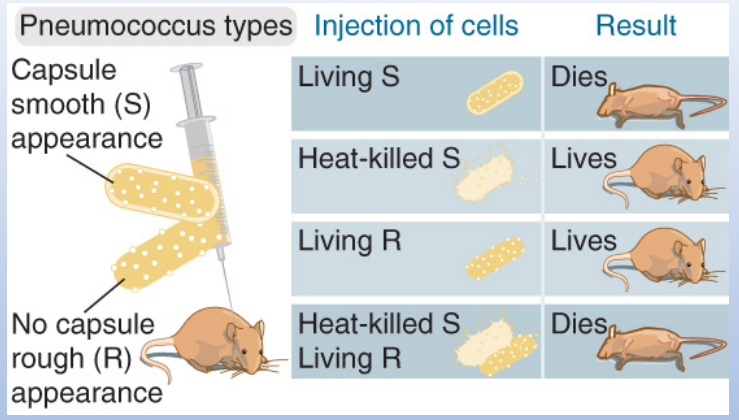
The organization of genes on a human chromosome



Kahoot!

The nucleotide sequence of the human genome shows how our genes are arranged.

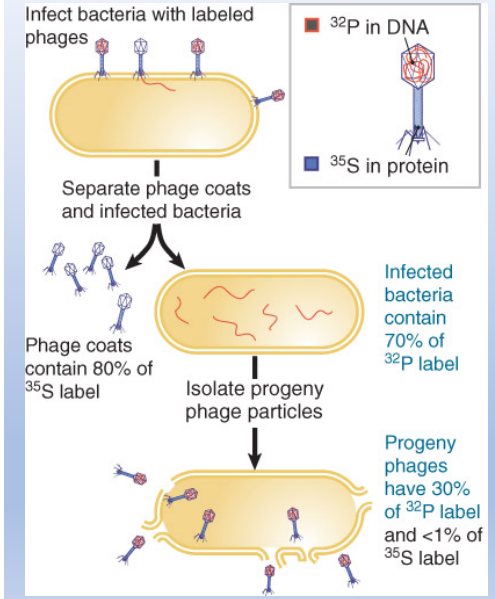
DNA is the genetic material of bacteria

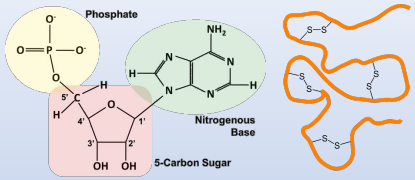


- The idea that the genetic material of organisms is DNA has its roots in the discovery of transformation by Frederick Griffith in 1928.
- Some property of the dead IIIS bacteria can transform the live IIR bacteria so that they make the capsular polysaccharide and become virulent.

This was called the "transforming principle".

The genetic material of phage T2 is DNA





Only the **DNA of the parent phages**

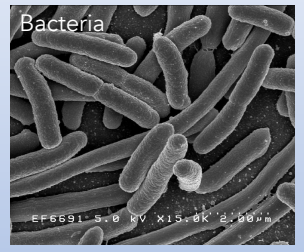
- enters the bacteria
- becomes part of the progeny phages.

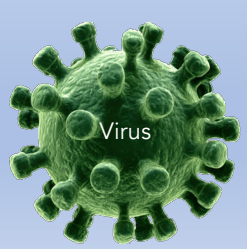
DNA is the genetic material of the genome of living cells or virus.

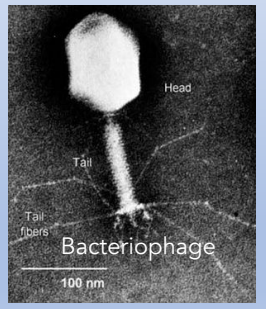
General nature of the genetic material is that

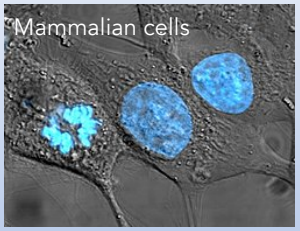
it is always nucleic acid;

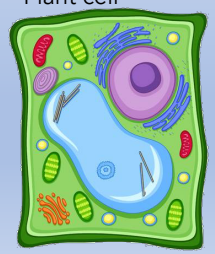
specifically, it is DNA, except in the RNA viruses.





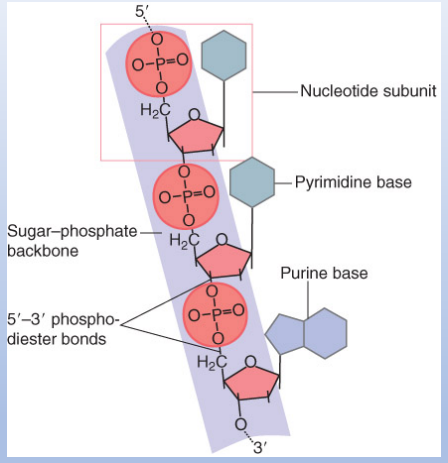






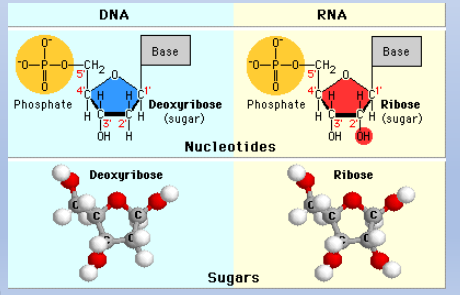
What is the constitution of DNA?

Polynucleotide chains have nitrogenous bases linked to a sugar–phosphate backbone



A nucleotide consists of

1. a **nucleoside** linked to
2. a **phosphate** group on either the 5′ or 3′ carbon of
3. the **(deoxy)ribose**.



The **difference between DNA and RNA** is in the group at the 2′ position of the sugar.

- DNA has a deoxyribose sugar (2′–H)
- RNA has a ribose sugar (2′–OH).

DNA contains the four bases:

1. A: adenine,
2. G: guanine,
3. C: cytosine, and
4. T: thymine.

RNA has U (uracil) instead of thymine.

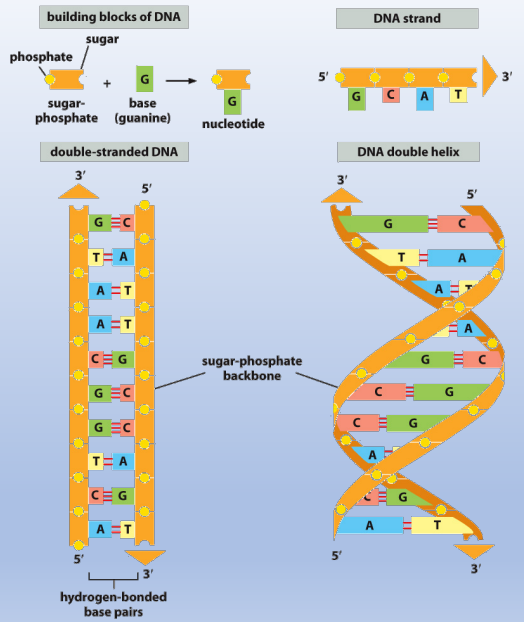
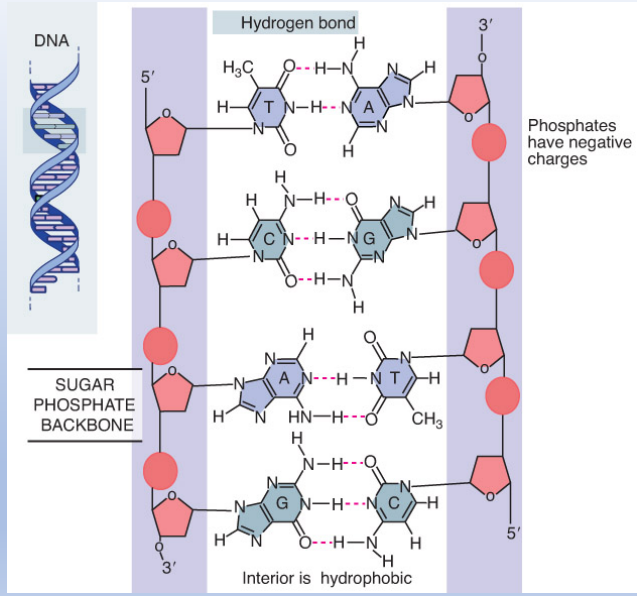


Figure 4-3 Molecular Biology of the Cell 6e (© Garland Science 2015)

DNA Is a Double Helix

A spiral consisting of two strands in the surface of a cylinder that coil around its axis.

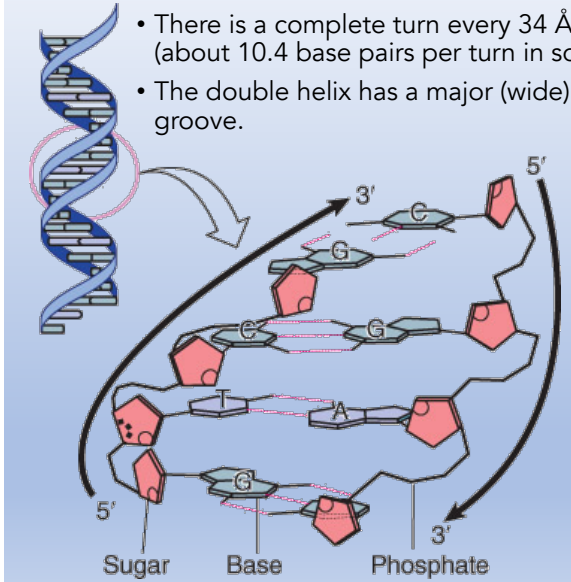
The double helix maintains a constant width because purines always face pyrimidines in the complementary A-T and G-C base pairs.

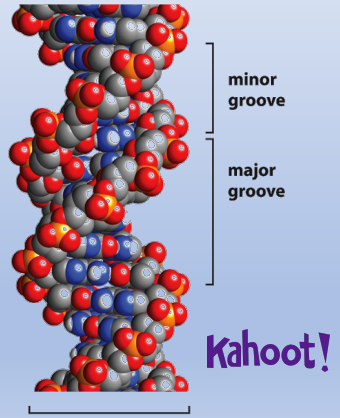


Kahoot! 4

Flat base pairs lie perpendicular to the sugar-phosphate backbone

- The diameter of the double helix is 20 Å.
- There is a complete turn every 34 Å, with 10 base pairs per turn (about 10.4 base pairs per turn in solution).
- The double helix has a major (wide) groove and a minor (narrow) groove.





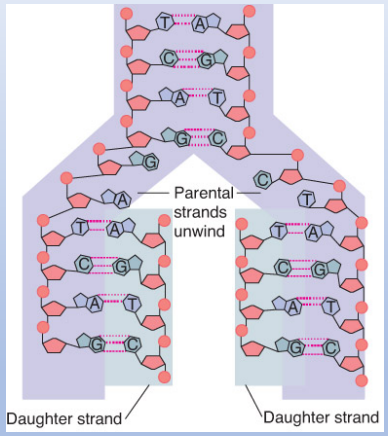
Kahoot!

Figure 4-5a Molecular Biology of the Cell 6e (© Garland Science 2015)

DNA replication is semiconservative

DNA replication accomplished by

1. separation of the strands of a parental duplex
2. each strand then acting as a template for synthesis of a complementary strand.



Base pairing provides the mechanism for replicating DNA.

The sequences of the daughter strands are determined by complementary base pairing with separated parental strands.

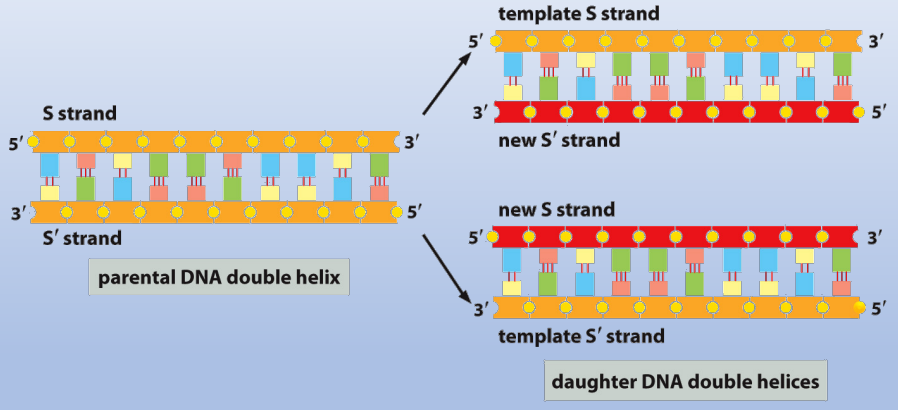
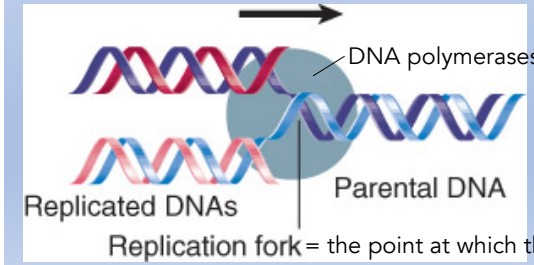


Figure 4-6 Molecular Biology of the Cell 6e (© Garland Science 2015)

Polymerases act on separated DNA strands at the replication fork

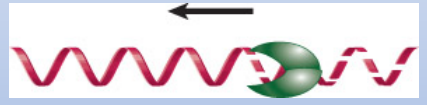
- Replication of DNA is undertaken by a complex of enzymes that separate the parental strands and synthesize the daughter strands.
- denaturation – separation of the two strands due to breaking of hydrogen bonds between bases.
- renaturation – reassociation of denatured complementary single strands of a DNA double helix.



Nucleases

- Enzymes that degrade nucleic acids;
- Include DNases and RNases and can be categorized as endonucleases or exonucleases.

An endonuclease cleaves a bond within a nucleic acid. This example shows an enzyme that attacks one strand of a DNA duplex.

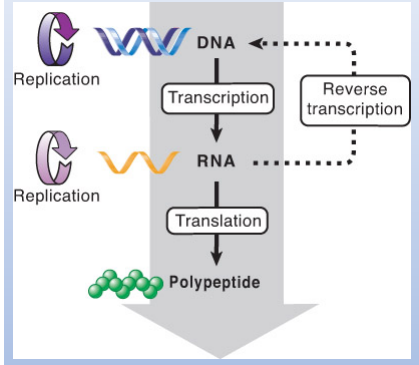


An exonuclease removes bases one at a time by cleaving the last bond in a polynucleotide chain.

Genetic information can be provided by DNA or RNA

- DNA can converted into RNA by transcription.
- RNA may be converted into DNA by reverse transcription.
- RNA polymerase – enzyme that synthesizes RNA using a DNA template.

Central Dogma:

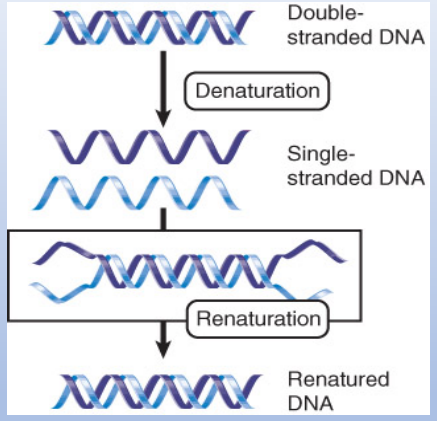


Information in nucleic acid can be perpetuated or transferred, but the transfer of information into a polypeptide is irreversible.

- Information cannot be transferred from protein → protein or protein → nucleic acid,
- But can be transferred between nucleic acids and from nucleic acid to protein.
- The translation of RNA into protein is unidirectional.

Kahoot! 5 & 6

Nucleic Acids Hybridize by Base Pairing



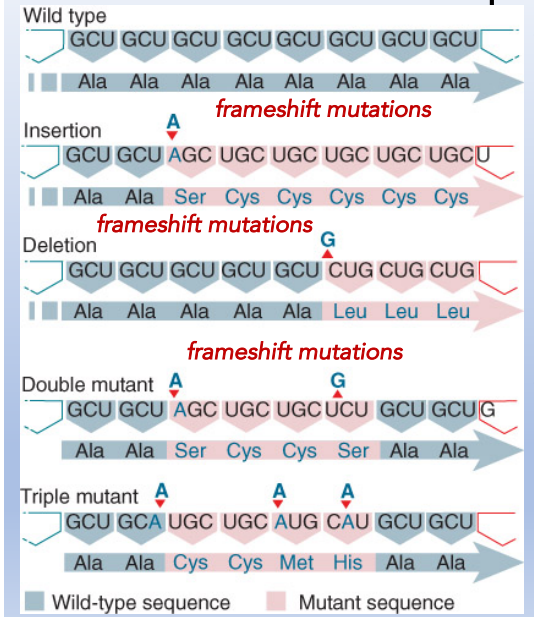
Denatured single strands of DNA can renature to give the duplex form.

- Heating causes the two strands of a DNA duplex to separate.
- The melting temperature (T_m) is the midpoint of the temperature range for denaturation.
- Complementary single strands can renature or anneal when the temperature is reduced.

The Genetic Code Is Triplet

- The genetic code is read in triplet nucleotides called codons.
- The triplets are non-overlapping and are read from a fixed starting point.

The Genetic Code Is Triplet



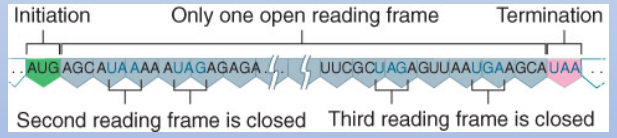
- Mutations that insert or delete individual bases cause a shift in the triplet sets after the site of mutation; these are frameshift mutations.

Kahoot! 7 & 8

- Combinations of mutations that together insert or delete three bases (or multiples of three) insert or delete amino acids, but do not change the reading of the triplets beyond the last site of mutation.

Every coding sequence has 3 possible reading frames

- Usually only one of the 3 possible reading frames is translated and the other 2 are closed by frequent termination signals.
- Open reading frame (ORF) – A sequence of DNA consisting of triplets that can be translated into amino acids starting with an initiation codon and ending with a termination codon.

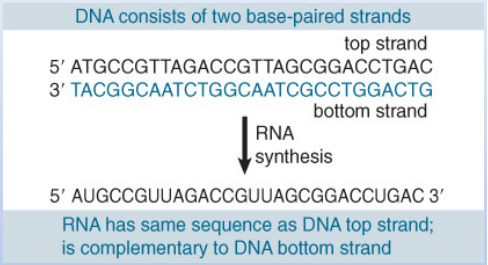


An open reading frame starts with AUG and continues in triplets to a termination codon.

- closed (blocked) reading frame – A reading frame that cannot be translated into polypeptide because of the occurrence of termination codons.
- unidentified reading frame (URF) – An open reading frame with an as yet undetermined function.

Several processes are required to express the product of a gene

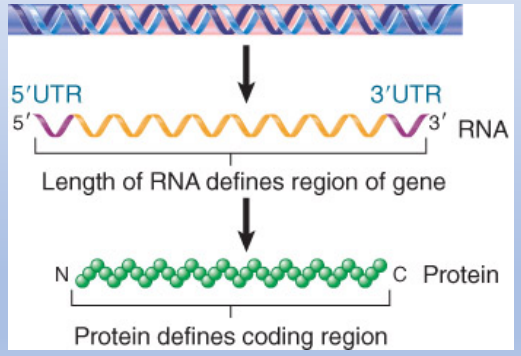
- A typical bacterial gene is expressed by transcription into mRNA and then by translation of the mRNA into polypeptide.
- Gene expression – The process by which the information in a sequence of DNA in a gene is used to produce an RNA or polypeptide, involving transcription and (for polypeptides) translation.



RNA is synthesized by using one strand of DNA as a template for complementary base pairing.

Several processes are required to express the product of a gene

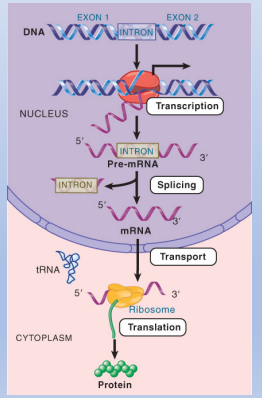
Each mRNA consists of a untranslated 5′ region (5′ UTR or leader), a coding region, and an untranslated 3′ UTR or trailer.



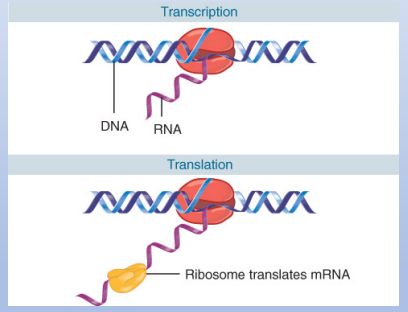
The gene is usually longer than the sequence encoding the polypeptide.

Several processes are required to express the product of a gene

- In eukaryotes, a gene may contain introns that are not represented in the polypeptide product.
- Introns are removed from the pre-mRNA transcript by splicing to give an mRNA that is colinear with the polypeptide product.



In eukaryotes, transcription occurs in the nucleus and translation occurs in the cytoplasm.



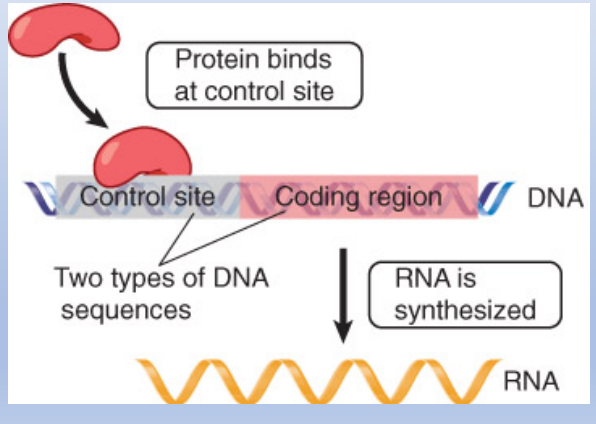
Transcription and translation take place in the same compartment in bacteria.

Terms often used in the process of gene expression

- **RNA processing** – Modifications to RNA transcripts of genes. This may include alterations to the 3′ and 5′ ends and the removal of introns.
- **pre-mRNA** – The nuclear transcript that is processed by modification and splicing to give an mRNA.
- **exon** – Any segment of an interrupted gene that is represented in the mature RNA product.
- **ribosome** – A large assembly of RNA and proteins that synthesizes polypeptidesunder direction from an mRNA template.
- **ribosomal RNAs (rRNAs)** – A major component of the ribosome.
- **transfer RNA (tRNA)** – The intermediate in polypeptide synthesis that interprets the genetic code.
  - Each tRNA molecule can be linked to an amino acid.
  - A tRNA has an anticodon sequence that is complementary to a triplet codon representing the amino acid.

Proteins are trans-acting but sites on DNA are cis-acting

- All gene products (RNA or polypeptides) are trans-acting. They can act on any copy of a gene in the cell.



Control sites in DNA provide binding sites for proteins; coding regions are expressed via the synthesis of RNA.

List 2 new things you have learnt today

Kahoot!

9, no award point