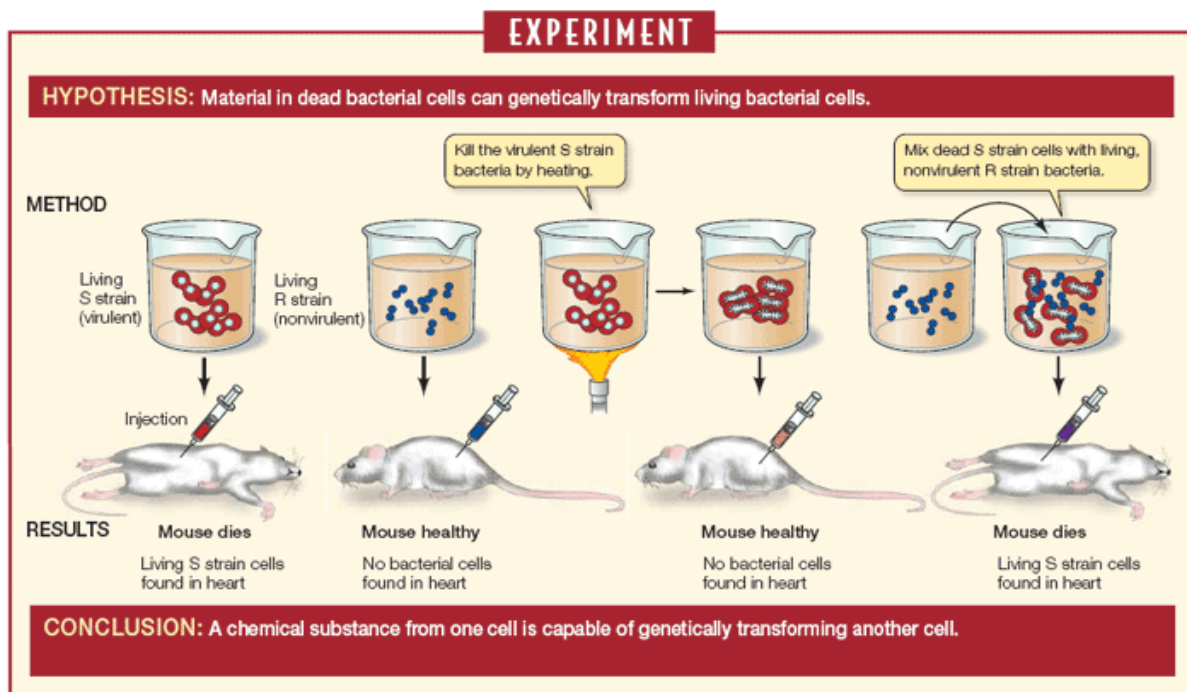


Biology Unit 5 DNA, RNA, and Protein Synthesis

5:1 History of DNA Discovery

Fredrick Griffith-conducted one of the first experiment's in 1928 to suggest that bacteria are capable of transferring genetic information through a process known as transformation

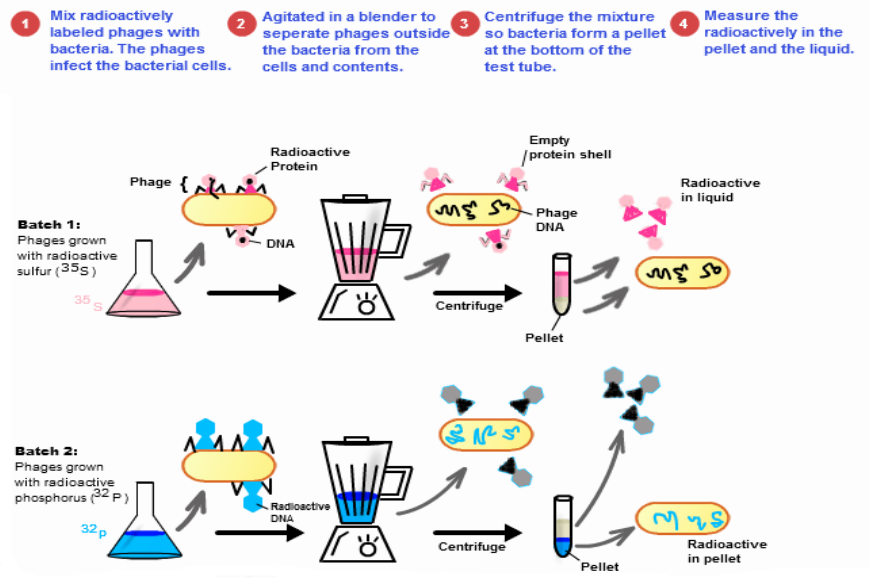


Oswald Avery-In the 1940s, tested whether the transforming agent in Griffith's experiment was protein, RNA, or DNA. Also, concluded that DNA is responsible for transformation in bacteria

Martha Chase and Alfred Hershey-In 1952, tested whether DNA or protein was the hereditary material viruses transfer when viruses enter a bacterium→

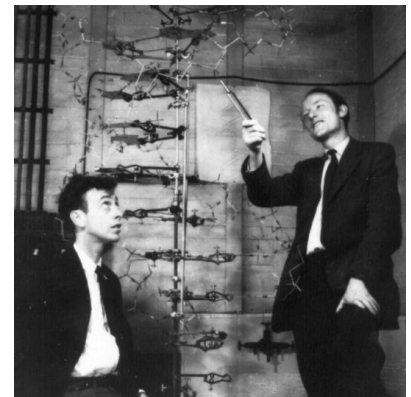
Discovered that DNA is the hereditary molecule in viruses

- Known as Blender Experiment

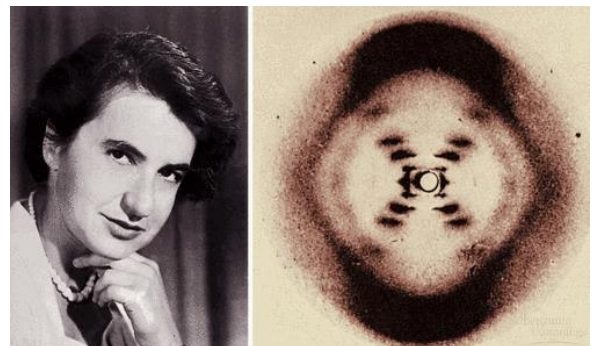


DNA Structure

James Watson and Francis Crick-In 1953, first to put together a model of DNA→relied heavily on the work of other scientists to develop their model



Rosalind Franklin-In 1952, used X-ray diffraction photographs of DNA crystals to show the structure of DNA



Erwin Chargaff showed the amounts of the four bases in DNA (A,T,C,G). In a body (somatic) cell:

- A=30.3%
- T=30.3%
- C=19.5%
- G=19.5%

Chargaff's Rule: Adenine must pair with Thymine and Guanine must pair with Cytosine.

5:2 Introduction to DNA

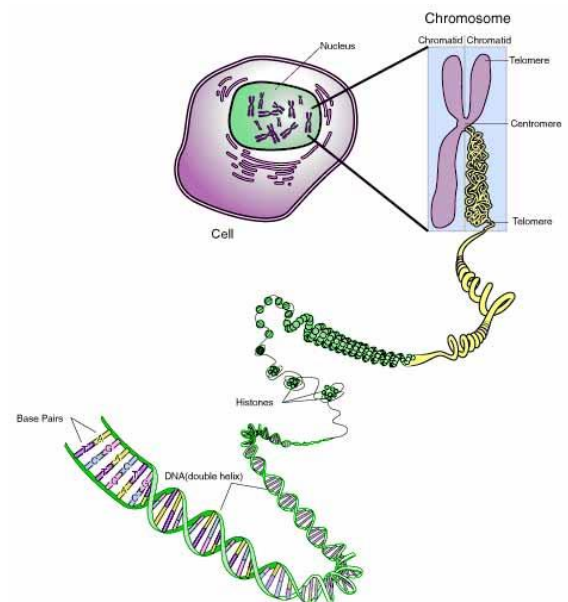
CHROMOSOMES: rod shaped form of genetic material in the cell nucleus that controls all cell activities through protein synthesis

Chromosomes and chromatin are the SAME material in different forms.

Chromosomes are a condensed, rod-shaped form found during cell division.

Chromatin is a long, thin thread-like form found when cells are not dividing.

Chromosomes & chromatin are made of DNA, a nucleic acid.

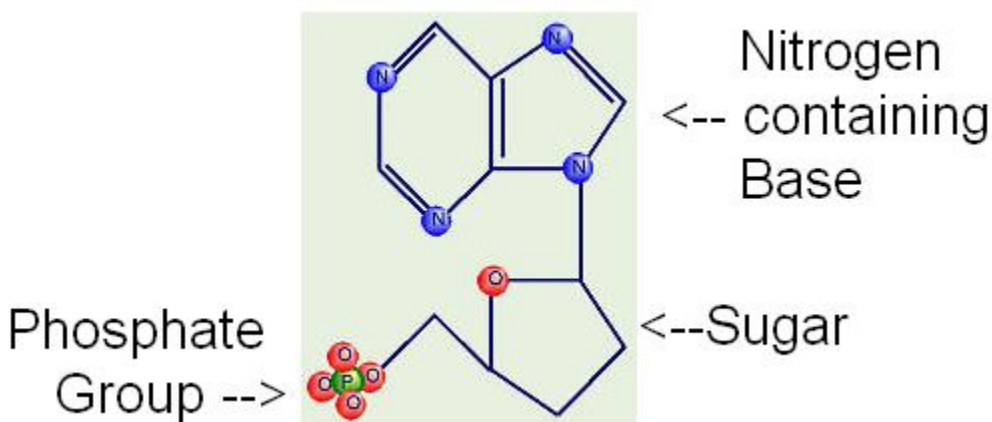


Chromosome Structure in Prokaryotes

- DNA molecule in bacteria is single circular
- Found in cytoplasm in the nucleoid region (no nucleus)

NUCLEIC ACIDS: complex biological compounds made of chains of nucleotides, serve as instructions for protein synthesis.

NUCLEOTIDE: 3 part units that make up nucleic acids, contain 1 sugar group, 1 phosphate group, and 1 nitrogen containing base



Nucleic acids are named for the sugar they contain.

DEOXYRIBONUCLEIC ACID: (DNA) nucleic acid that makes up chromosomes, controls protein synthesis and all other cell activities in all organisms

DEOXYRIBOSE: 5-carbon sugar in DNA

GENE: unit of heredity, enough DNA to instruct for the synthesis of one protein

DNA → genes → chromatin/chromosomes

5:3 DNA Shape and Structure

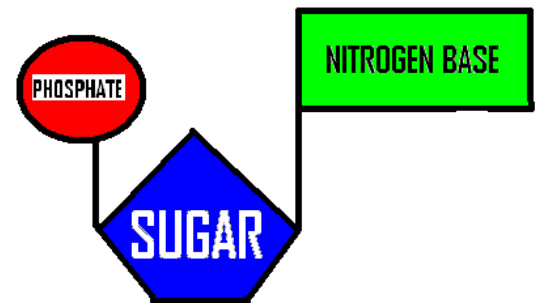
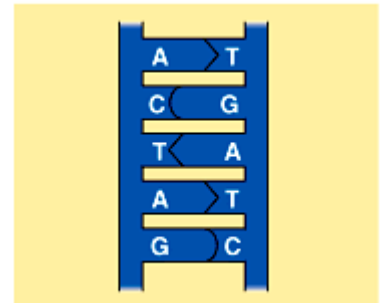
Shape of DNA

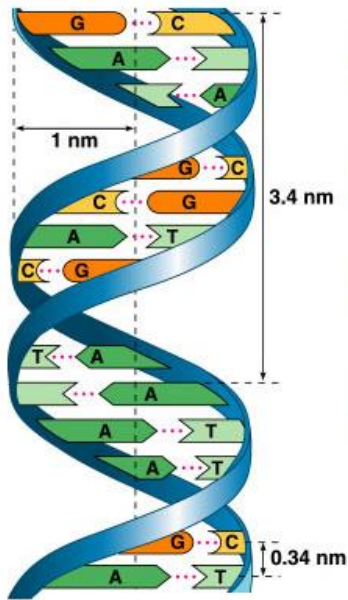
DNA is a DOUBLE HELIX: twisted ladder

The weakest part of the DNA ladder is the middle of the rungs, where DNA will split.

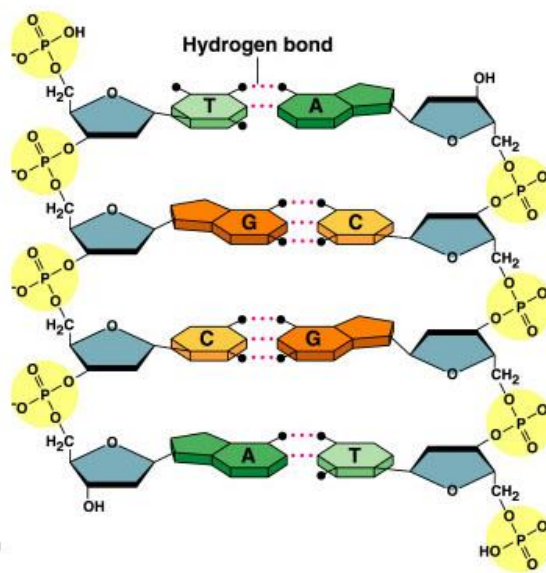
Structure of DNA

1. The sides of the DNA ladder are made of alternating phosphate groups and sugar (pentose) groups
2. Each deoxyribose has a nitrogen-containing base attached. There are 4 bases possible adenine, thymine, cytosine, and guanine.
3. Each nucleotide is a single 3-part unit consisting of 1 deoxyribose, 1 phosphate group, and 1 nitrogen-containing base.
4. Two strands of nucleotides bond together by their bases to form a DNA molecule. A will only bond to T, G will only bond to C. There are only two possible bonds A-T and G-C, called complementary base pairs. Nitrogen bases are bonded together by weak hydrogen bonds.

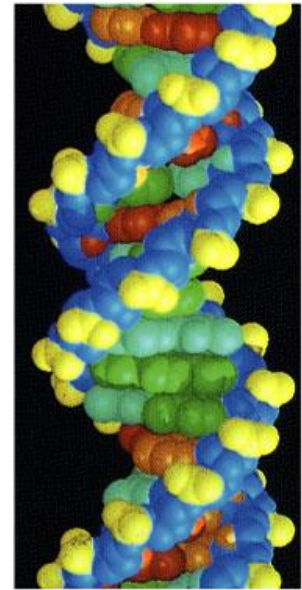




(a) Key features of DNA structure



(b) Partial chemical structure



(c) Space-filling model

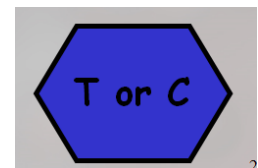
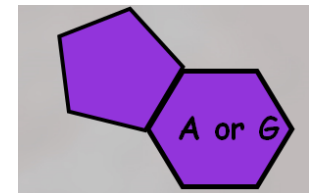
Nitrogenous Bases

PURINES: double ring of carbon and nitrogen atoms

- Adenine and Guanine

PYRIMIDINES: single ring of carbon and nitrogen atoms

- Thymine and Cytosine



Purines only pair with pyrimidines.

5:4 DNA Replication

DNA has to be copied before a cell can divide.

New cells will need identical DNA strands.

REPLICATION: when DNA makes an exact copy of itself to be used when cells divide or to pass the code for making proteins to offspring

Steps of DNA Replication

1. DNA unwinds from double helix and “unzips” (splits) down the center when bonds between the bases break by the enzyme Helicase.



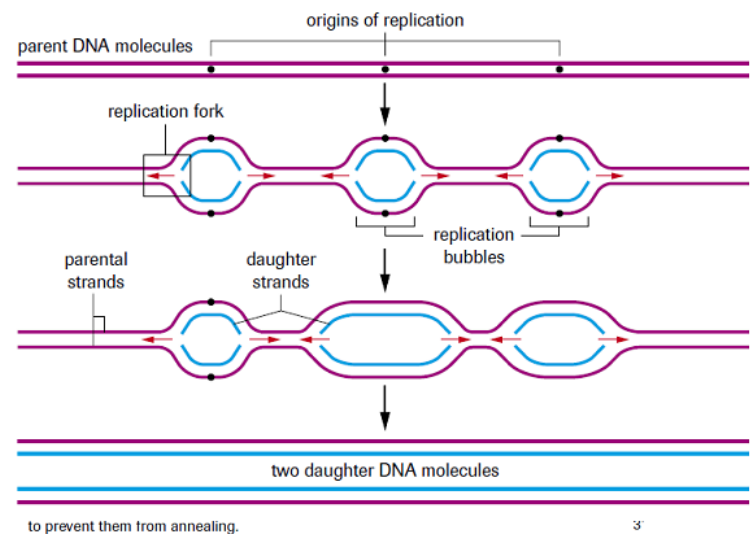
2. A Single-Strand Binding protein attaches and keeps the 2 DNA strands separated and untwisted.

3. As the 2 DNA strands open at the origin,

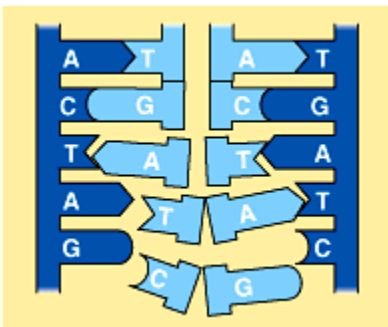
Replication bubbles form

a. Prokaryotes have a SINGLE bubble

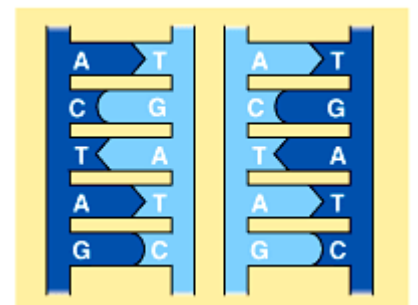
b. Eukaryotes have MANY bubbles



4. Replication begins at the Origin of Replication, two strands open forming 2 Replication Forks



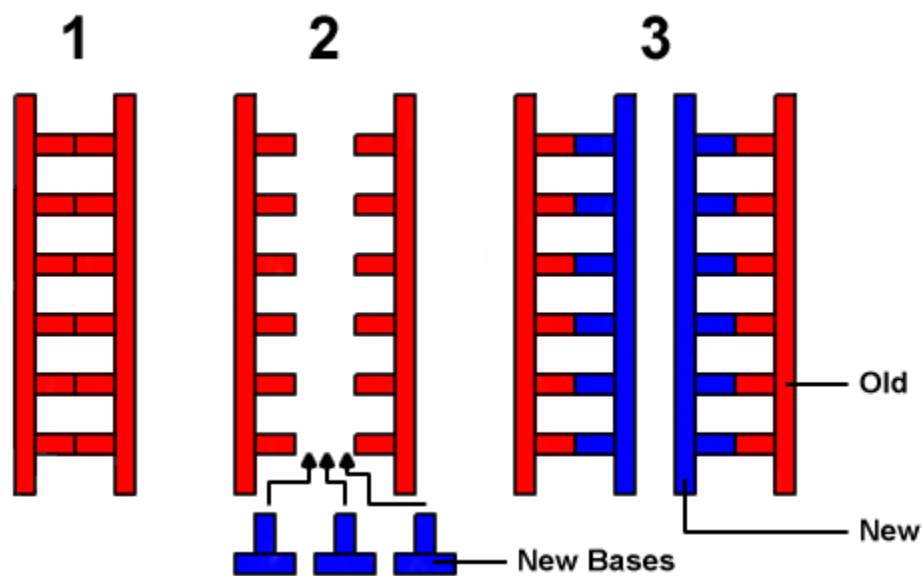
5. Spare nucleotides move in and attach to their proper “old” bases using the enzyme DNA polymerase.



6. Two identical DNA molecules are formed. In the new DNA strand, half is “old” and half is “new” in each.

Proofreading New DNA

- DNA polymerase initially makes about 1 in 10,000 base pairing errors
- The DNA Polymerase enzyme proofreads and corrects these mistakes
- The new error rate for DNA that has been proofread is 1 in 1 billion base pairing errors



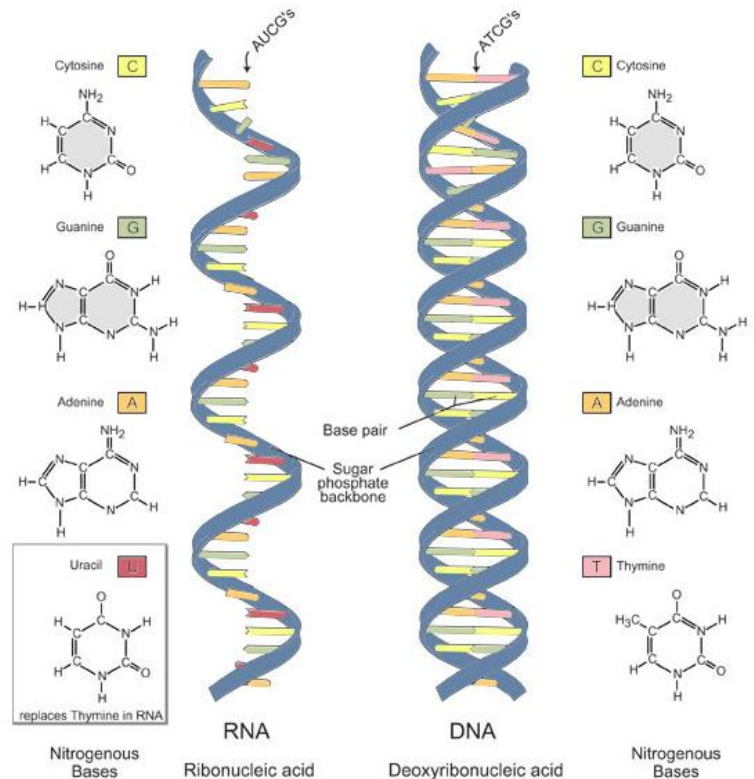
5:5 RNA

DNA always stays in the nucleus, but it must send the code for making proteins to the ribosomes in the cytoplasm.

RIBONUCLEIC ACID: near copy of DNA that carries the code (or instructions) for protein synthesis from the nucleus to the cytoplasm

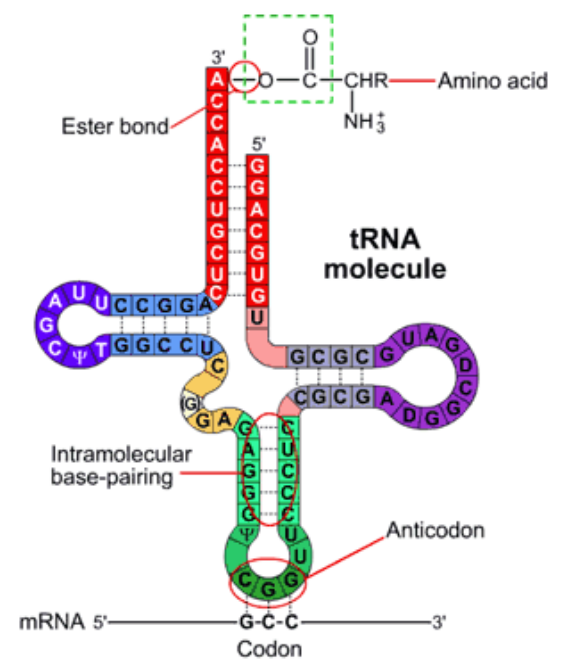
RNA differs from DNA

1. Ribose is the sugar in RNA, deoxyribose is the sugar in DNA.
2. RNA contains uracil where DNA contains thymine. In RNA uracil bonds to adenine.
3. RNA is a single strand of nucleotides, DNA is a double strand of nucleotides.



Three Types of RNA

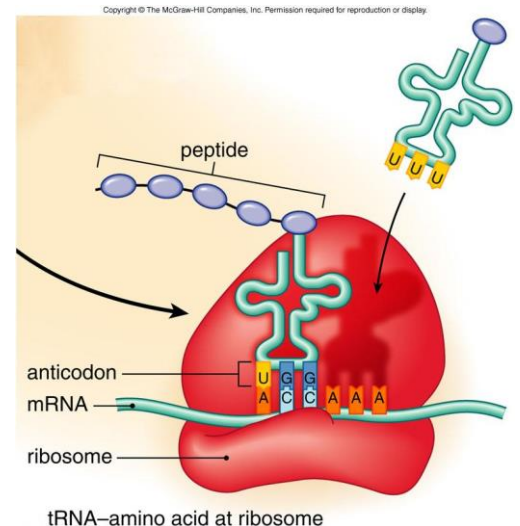
1. **MESSENGER RNA:** (mRNA) copies DNA's code and carries the genetic information to the ribosomes to perform protein synthesis
 - a. Long straight chain of 500-1000 nucleotides
 - b. Made in the nucleus
 - c. Copies DNA and leaves through nuclear pores
 - d. Contains A, G, C, U (no T)
2. **TRANSFER RNA:** (tRNA) transfers amino acids to the ribosomes where proteins are synthesized



- a. Clover-leaf shape
- b. Single stranded molecule with attachment site at one end for an amino acid
- c. Opposite end has three nucleotide bases called **ANTICODON**: three nucleotides on the RNA that are complementary to the sequence of a codon in mRNA

3. **RIBOSOMAL RNA: (rRNA)** globular form of RNA that makes up ribosomes, along with protein

- a. Single strand 100-300 nucleotides long
- b. Made inside the nucleus
- c. Site of protein synthesis



5:6 Transcription

Pathway to Making a Protein:
 DNA → mRNA → tRNA
 (ribosomes) → Protein

Protein Synthesis

Protein: organic molecules of which organisms are made

Synthesis: to make or build

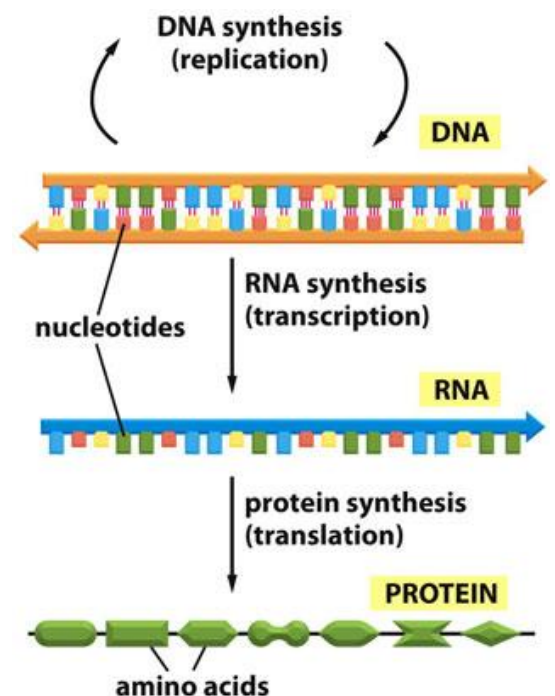


Figure 1-2 Essential Cell Biology 3/e (© Garland Science 2010)

PROTEIN SYNTHESIS: the process through which cells build the proteins they need and of which they are made

All cells carry out protein synthesis, each making their own proteins.

Each organism makes its own specific proteins; those proteins make an organism different from other organisms.

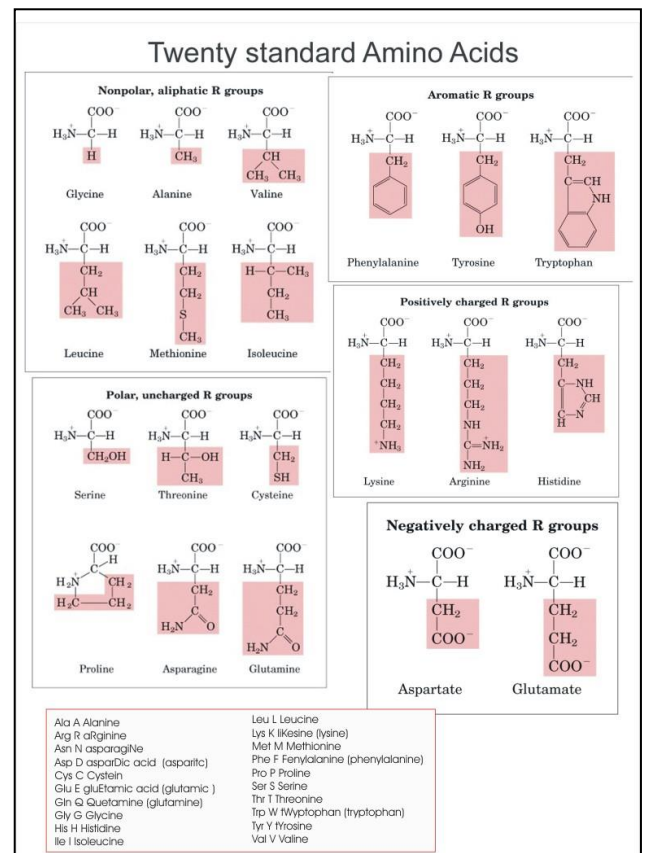
AMINO ACIDS: building blocks of proteins

Different combinations of amino acids → different proteins

RIBOSOMES: site of protein synthesis in the cytoplasm of the cell

Ribosomes need instructions (BLUEPRINTS) to build the correct proteins. This chemical information (DNA) is passed from parent to offspring in chromosomes.

TRANSCRIPTION: the process through which a single strand of mRNA is produced from a DNA strand

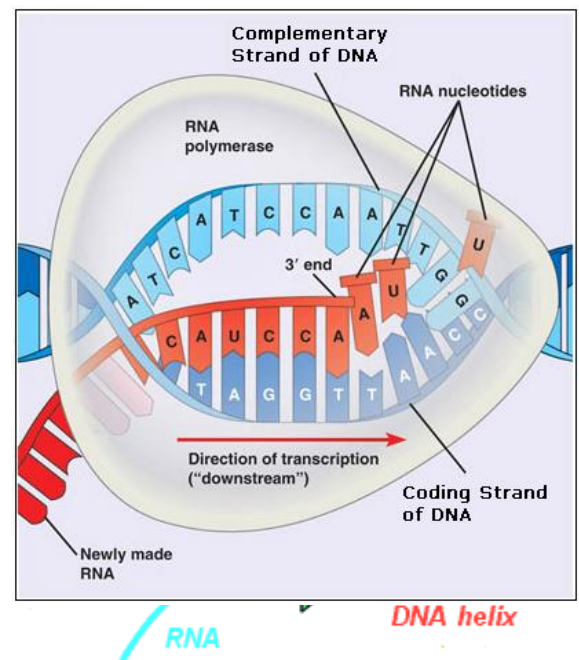


Steps of Transcription

1. **RNA polymerase binds to the gene's PROMOTER: a specific nucleotide sequence of DNA where transcription is initiated**
The DNA strands unwind and separate.
2. **Complementary RNA nucleotides are added and then joined.**

<u>RNA</u>		<u>DNA</u>
U	bonds to	A
A	bonds to	T
C	bonds to	G
G	bonds to	C

3. **When RNA polymerase reaches a termination signal in the DNA, the DNA and new RNA are released by the polymerase.**



5:7 Translation

TRANSLATION: process of decoding the mRNA into a polypeptide chain (protein)

Ribosomes

- Made of a large and small subunit
- Composed of rRNA and proteins

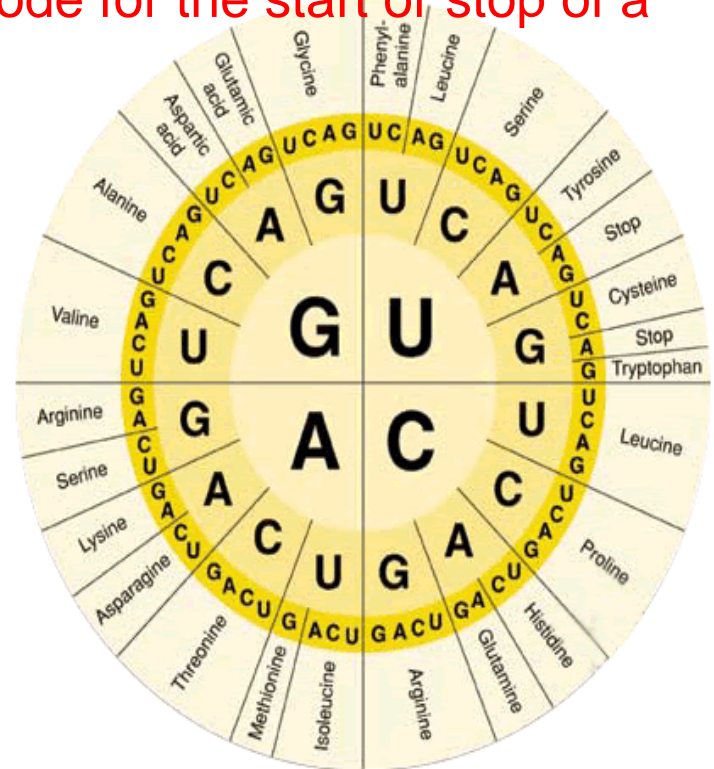
TRIplet CODONS : group of 3 bases on a mRNA strand that act as a code word for a specific amino acid

The 4 RNA bases combine in 64 different triplet codons. Since there are only 20 amino acids, several codons code for the same amino acid, some code for the start or stop of a protein.

	U	C	A	G
U	UUU Phe UUC UUA Leu UUG	UCU Ser UCC UCA UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp
C	CUU Leu CUC CUA CUG	CCU Pro CCC CCA CCG	CAU His CAC CAA Gln CAG	CGU Arg CGC CGA CGG
A	AUU Ile AUC AUA AUG	ACU Thr ACC ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG
G	GUU Val GUC GUA GUG	GCU Ala GCC GCA GCG	GAU Asp GAC GAA Glu GAG	GGU Gly GGC GGA GGG

Amino acid names:

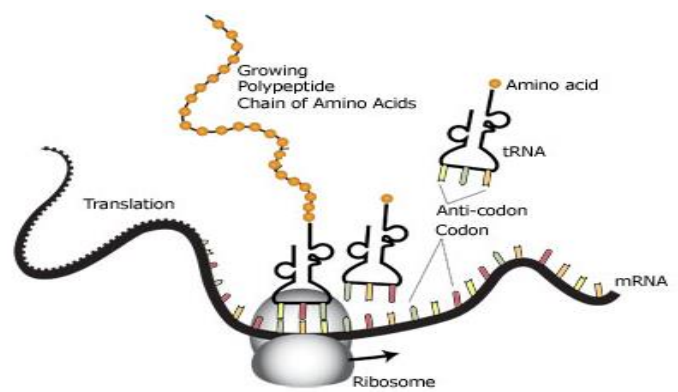
Ala = alanine	Gln = glutamine	Leu = leucine	Ser = serine
Arg = arginine	Glu = glutamate	Lys = lysine	Thr = threonine
Asn = asparagine	Gly = glycine	Met = methionine	Trp = tryptophan
Asp = aspartate	His = histidine	Phe = phenylalanine	Tyr = Tyrosine
Cys = cysteine	Ile = Isoleucine	Pro = proline	Val = valine



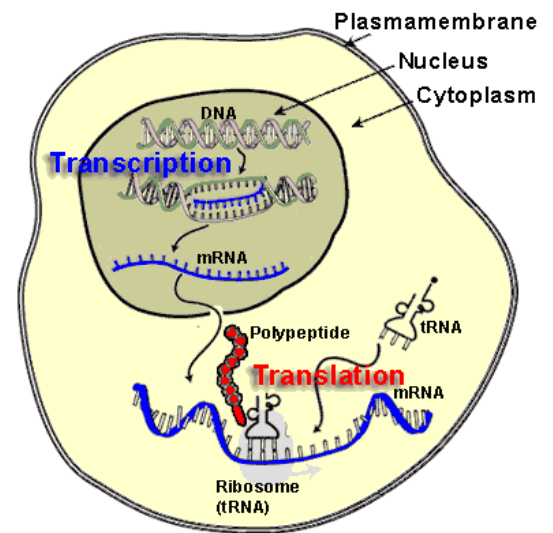
THE ORDER OF THE TRIplet CODONS ON A STRAND OF mRNA CODES FOR THE ORDER OF AMINO ACIDS ON A PROTEIN CHAIN.

Steps of Translation

1. mRNA transcript start codon AUG (Methionine) attaches to the small ribosomal subunit; small



- subunit attaches to large ribosomal subunit
2. The tRNA carrying the amino acid specified by the next codon binds to the codon. A peptide bond forms between adjacent amino acids. The ribosome moves the tRNA and mRNA.
 3. The first tRNA detaches and leaves its amino acid behind. The polypeptide chain continues to grow.
 4. The process ends when a stop codon is reached. A stop codon is one for which there is no tRNA that has a complementary anticodon.
 5. The ribosome complex falls apart. The newly made protein is released.



Ribosome can build only one protein at a time several ribosomes may work on one mRNA template. mRNA template may be used several times, then broken down and nucleotides reused.

