Biology – Chapters 12 & 13

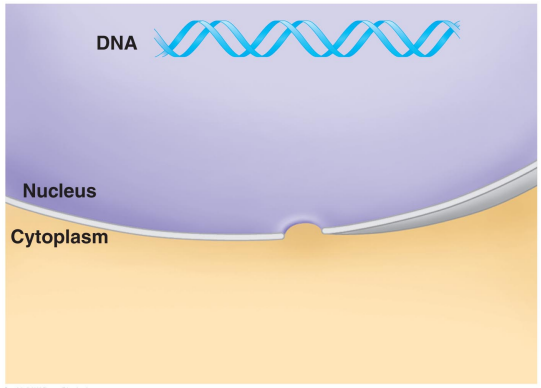
DNA

RNA and Protein Synthesis

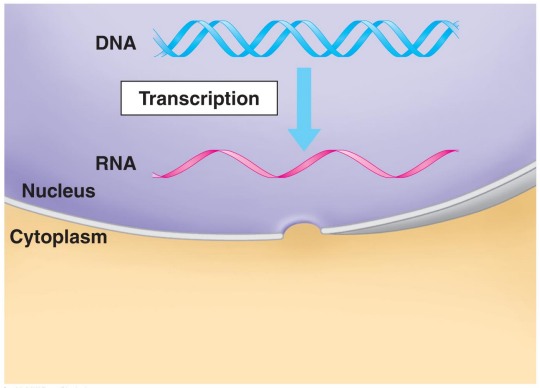
Honors Biology – Chapter 10

Molecular Biology of the Gene

Ridgefield Memorial High School



DNA → mRNA → PROTEIN → TRAIT
Another name for the trait is PHENOTYPE.



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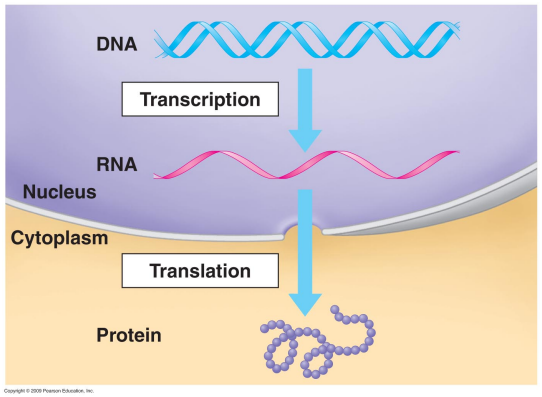

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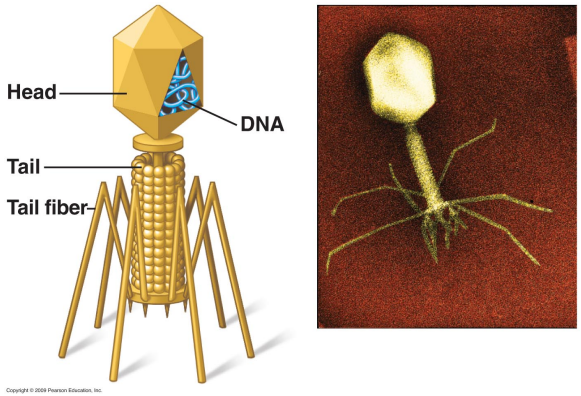
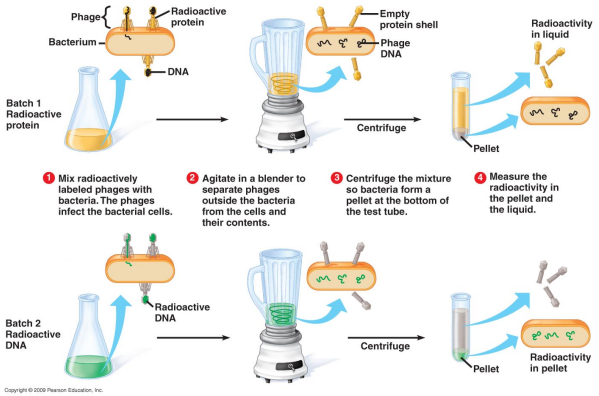


A lytic virus, called a bacteriophage, was used by Hershey and Chase in a very famous experiment that proved that DNA, not protein, is the genetic material.



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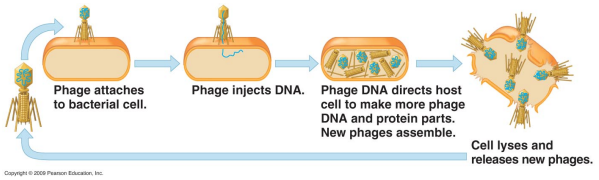
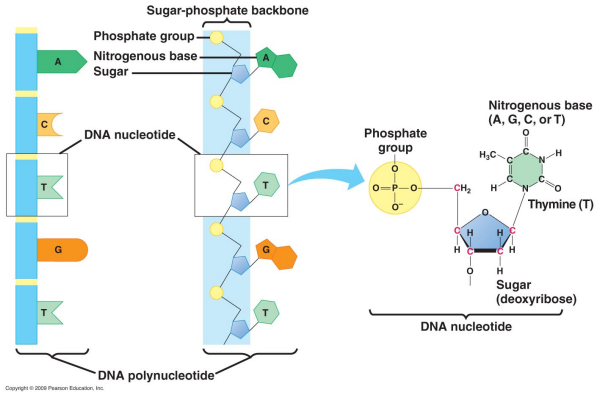
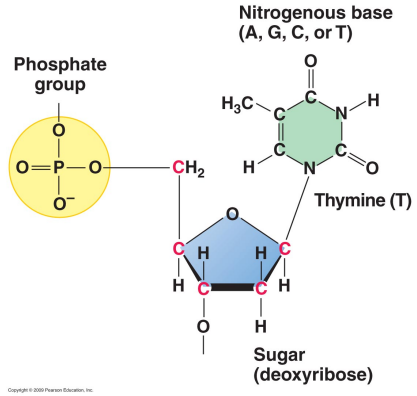


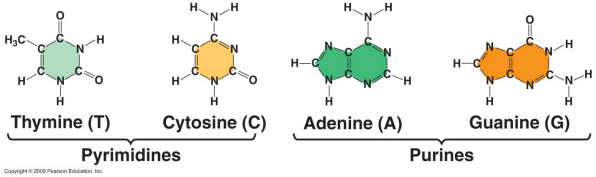
The Hershey-Chase experiment was successful because they used a lytic virus, which injects its DNA into the host cell. It was proven that the virus does not inject protein into the host cell.



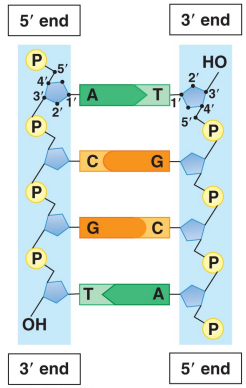
DNA is polynucleotide, a repeating chain of different nucleotides.



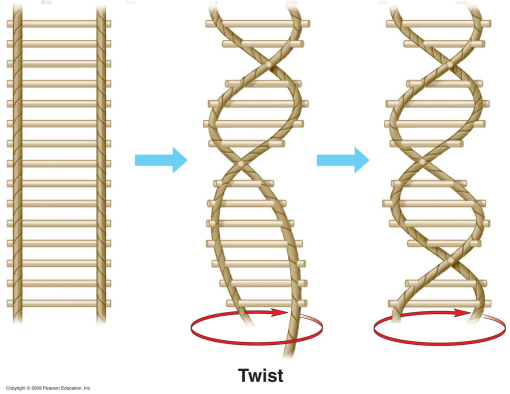
A DNA nucleotide is made of a sugar (deoxyribose), a phosphate, and a nitrogenous base (A, T, C, G). DNA is usually double-stranded.



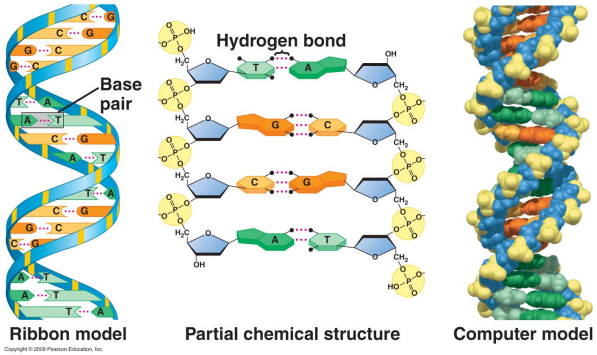
In DNA, the four nucleic acids are adenine, thymine, guanine, and cytosine.



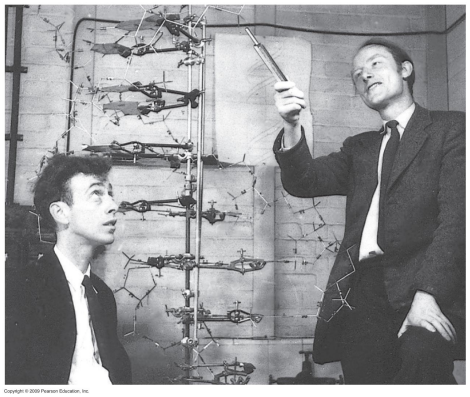
Complementary bases make a lock and key fit and are held together by hydrogen bonds. Chargaff's rules state that A bonds with T and C bonds with G.



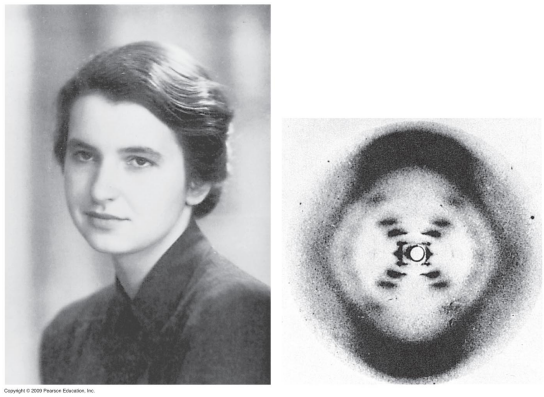
The DNA "ladder" is twisted to form a double helix. The outside of the "ladder" consists of sugars and phosphates. The inner "rungs" consist of A, T, C, and G held together by H-bonds.



This diagram shows 3 different models of a DNA molecule.

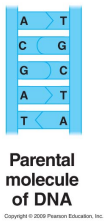


Watson and Crick are credited with the discovery of DNA in 1953...

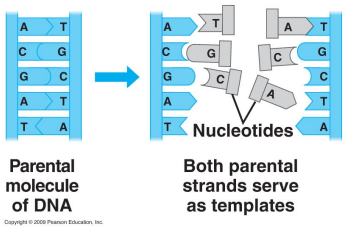


...but they really stole the credit from Rosalind Franklin.

DNA replication is semi-conservative.
Each daughter molecule consists of one "old" strand and one "new" strand.



The original, template strands of DNA separate.
The new nucleotides are added, one-by-one, based on Chargaff's base-pairing rules.
(This picture is slightly inaccurate because it ignores the 5′ and 3′ ends.)



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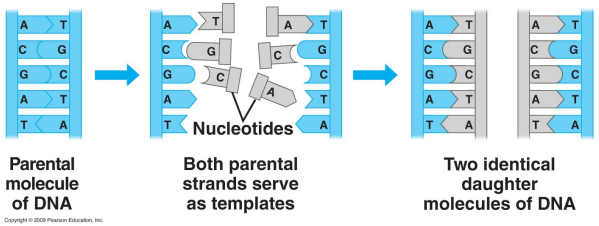

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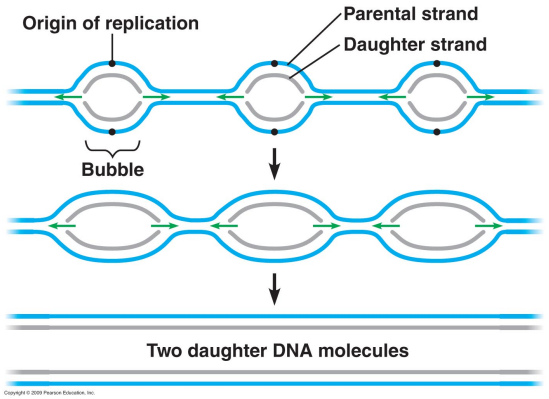
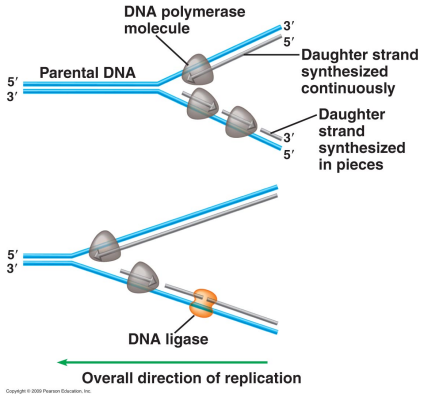
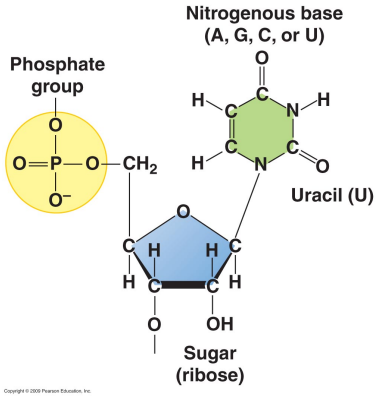


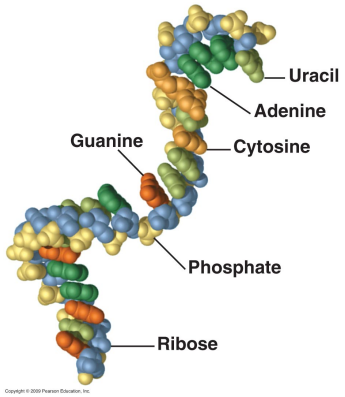
Each replication bubble actually contains two replication forks (one on each side of the bubble). Since DNA strands are so long, replication occurs at many bubbles simultaneously.



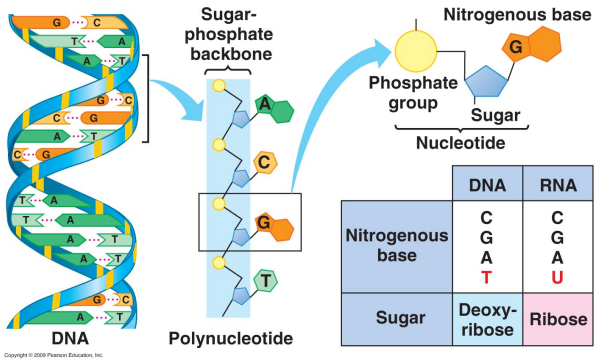
DNA is built only from 5' to 3', which means that the template strands are read from 3' to 5'. The enzymes helicase, polymerase, and ligase are used.



An RNA nucleotide is made of a sugar (ribose), a phosphate, and a nitrogenous base (A, U, C, G). RNA is usually single-stranded.

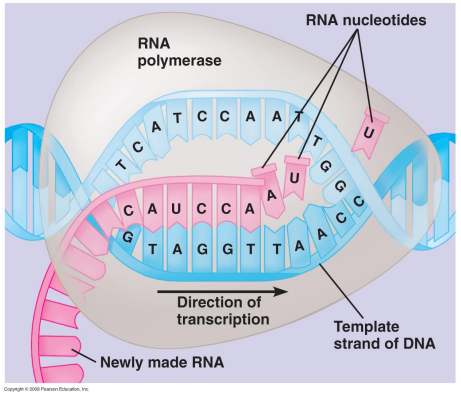


RNA is a single-stranded polynucleotide. It contains uracil instead of thymine.
The main form of RNA is messenger RNA (mRNA).

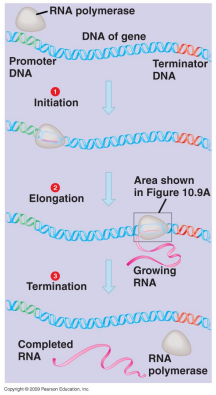


	DNA	RNA
Nitrogenous base	C G A T	C G A U
Sugar	Deoxy-ribose	Ribose

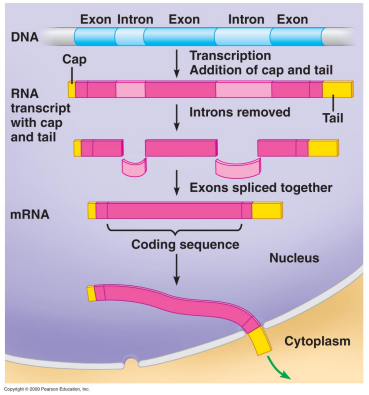
This chart reviews some of the similarities and differences between DNA and RNA.
Another difference is that DNA is double-stranded but RNA is single-stranded.



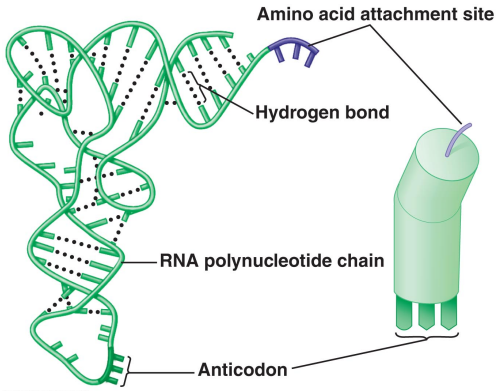
Transcription is the process in which DNA is converted into mRNA. The main enzyme is RNA polymerase, which temporarily separates that DNA strands and then adds the mRNA bases.



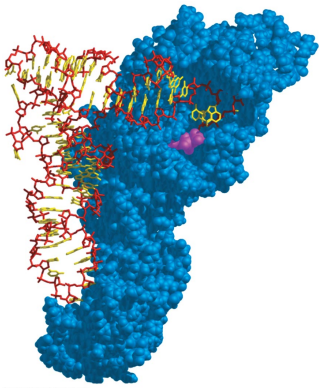
Transcription occurs between the "promoter" and "terminator" sequences of DNA.
RNA polymerase temporarily separates the DNA strands and then adds the mRNA bases.



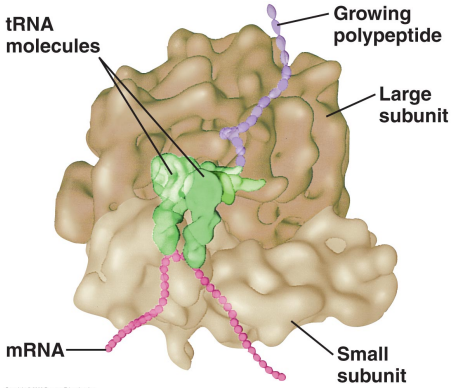
After transcription, the mRNA is modified. It receives a 5' protective cap and a 3' poly-A tail.
The introns are removed (put IN the trash) and the exons remain (they are EXpressed).



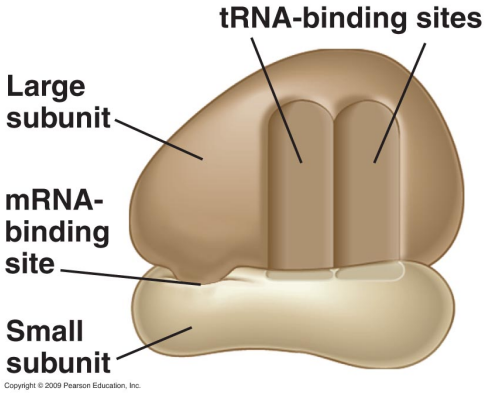
Transfer RNA has a very important role in translation (protein synthesis). tRNA brings the amino acids to the ribosome according to the mRNA sequence and the genetic code chart.



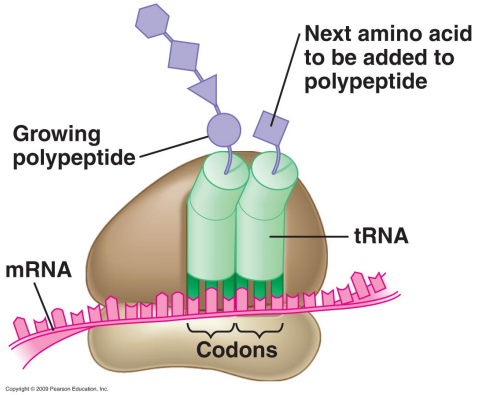
Transfer RNA (tRNA) brings the amino acids to the ribosome according to the mRNA sequence and the genetic code chart.



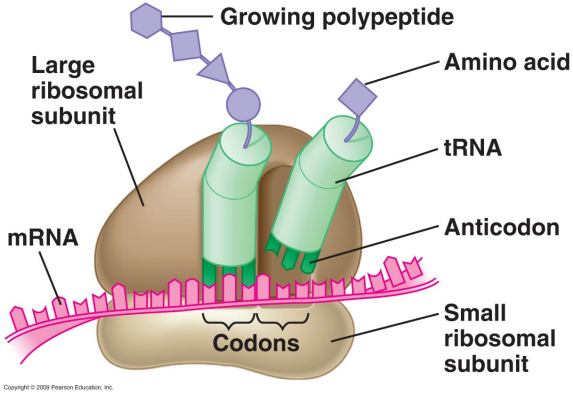
This is a computer model illustrating the 3-dimensional view of a ribosome during translation.



Ribosomes consist of a large subunit and a small subunit.



The mRNA slides between the subunits and the tRNA's bring the correct amino acids over. Notice that the tRNA anti-codon is complementary to the mRNA codon.



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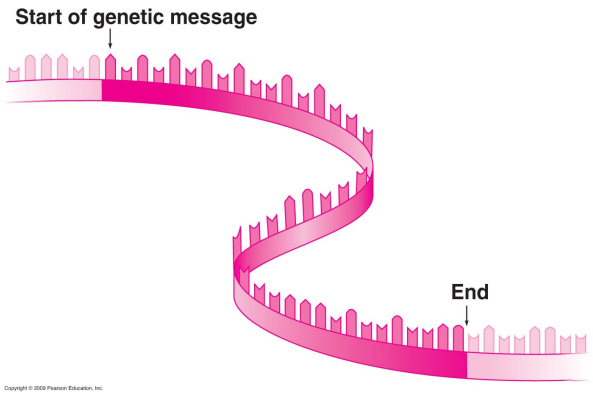
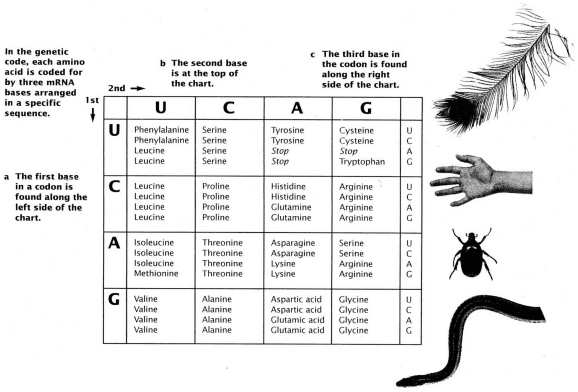


Messenger RNA has special "start" codons and "stop" codons.
These signals mark the beginning and end of the translated mRNA sequence.



In the genetic code, each amino acid is coded for by three mRNA bases arranged in a specific sequence.

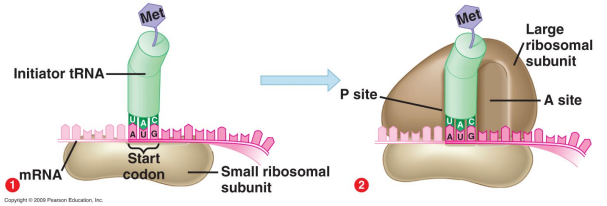
a The first base in a codon is found along the left side of the chart.

b The second base is at the top of the chart.

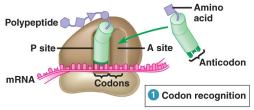
c The third base in the codon is found along the right side of the chart.

1st \ 2nd	U	C	A	G	
U	Phenylalanine Phenylalanine Leucine Leucine	Serine Serine Serine Serine	Tyrosine Tyrosine *Stop* *Stop*	Cysteine Cysteine *Stop* Tryptophan	U C A G
C	Leucine Leucine Leucine Leucine	Proline Proline Proline Proline	Histidine Histidine Glutamine Glutamine	Arginine Arginine Arginine Arginine	U C A G
A	Isoleucine Isoleucine Isoleucine Methionine	Threonine Threonine Threonine Threonine	Asparagine Asparagine Lysine Lysine	Serine Serine Arginine Arginine	U C A G
G	Valine Valine Valine Valine	Alanine Alanine Alanine Alanine	Aspartic acid Aspartic acid Glutamic acid Glutamic acid	Glycine Glycine Glycine Glycine	U C A G

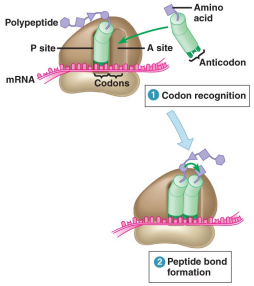
This is the genetic code chart. There is a lot of redundancy (repeated codons) on the chart. This helps protect a cell against point mutations.



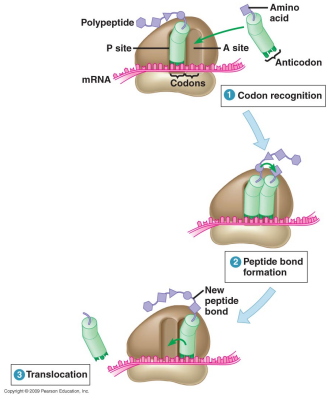
Translation always begins at the start codon, AUG. The first amino acid is always methionine. The first tRNA lands on the "P" site of the ribosome.



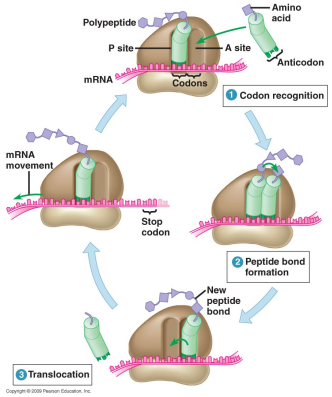
Additional tRNA's land on the "A" site of the ribosome.
The tRNA anti-codon must be complementary to the mRNA codon.



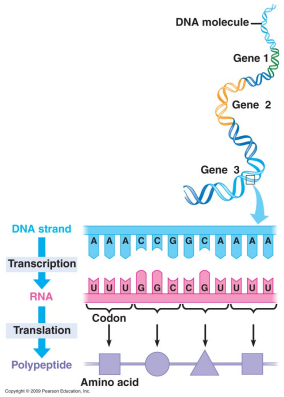
Next, the growing strand of amino acids is transferred onto the amino acid located on the tRNA at the "A" site. The "P" site tRNA no longer contains any amino acids.



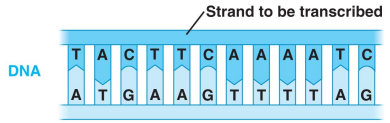
The tRNA in the "P" site exits the ribosome through the "E" site. The "A" site tRNA slides over to the "P" site. Note that the "E" site is not shown, but is to the left of the "P" site.



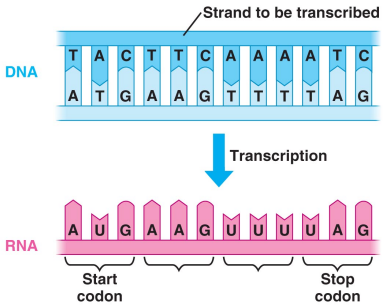
The tRNA with the growing chain of amino acids is now in the "P" site. A new tRNA will land in the "A" site and the process will continue until a stop codon is reached.



To review, the genetic process is:
DNA → mRNA → PROTEIN → TRAIT



Transcription converts the DNA to mRNA.
Translation converts the mRNA into a protein.



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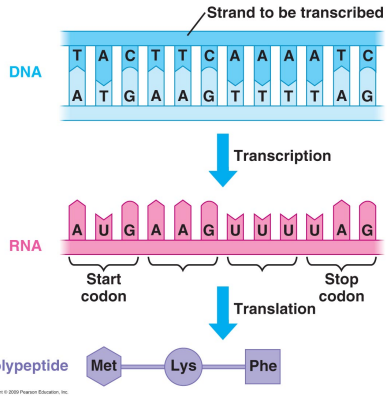

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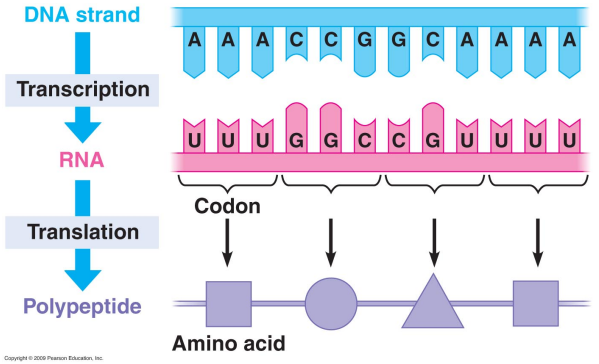

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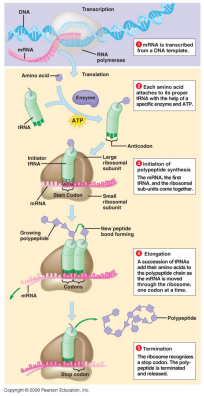
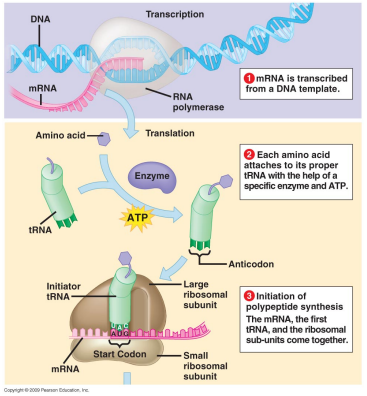


This is a more detailed review of transcription and translation.



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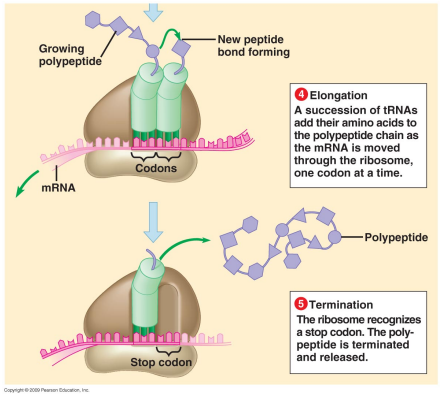

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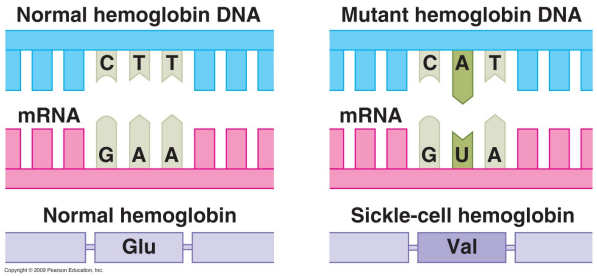
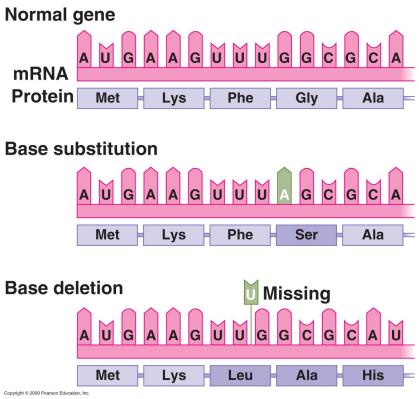
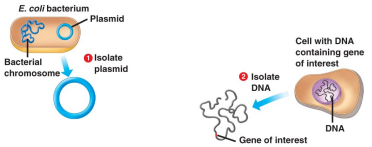


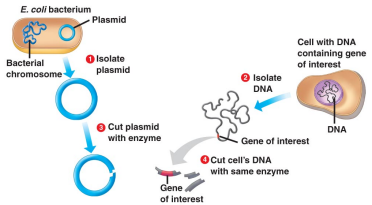
Sickle-cell anemia is a genetic trait caused by a point (substitution) mutation.
A point mutation occurs when one DNA nucleotide is substituted for another.



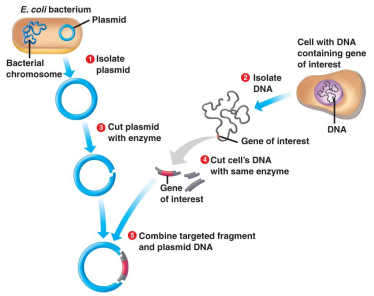
A frame-shift mutation occurs DNA nucleotides are added or deleted. This changes the "reading frame" for the ribosome and all of the amino acids after the mutation will be incorrect.



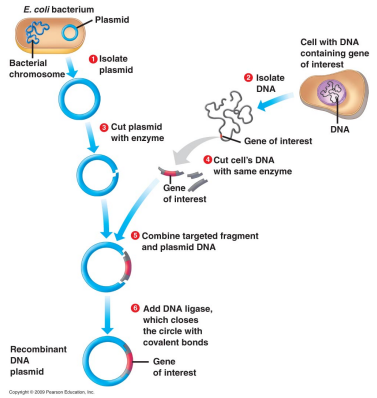
GENETIC ENGINEERING: A plasmid is a special, round bacterial chromosome that is capable of receiving DNA from an outside source, such as a different organism.



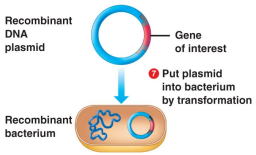
GENETIC ENGINEERING: A restriction enzyme is used to cut both the plasmid and the gene of interest. The "sticky ends" allow the gene to fit perfectly into the plasmid.



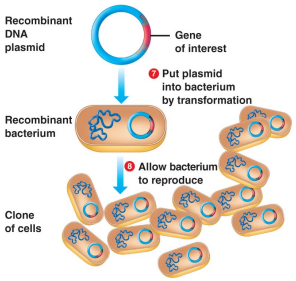
GENETIC ENGINEERING:
The gene of interest is inserted into the plasmid with a lock-and-key fit.



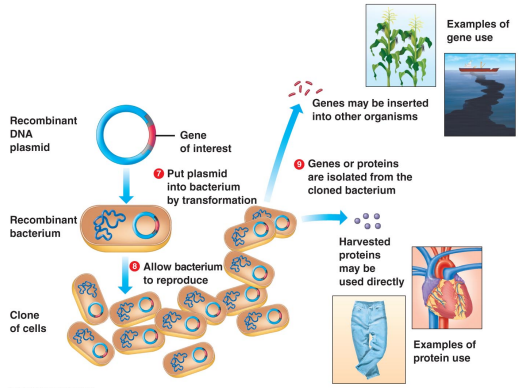
GENETIC ENGINEERING: The enzyme ligase is used to create the covalent bonds which attach the gene to the plasmid. The plasmid is now referred to as recombinant DNA.



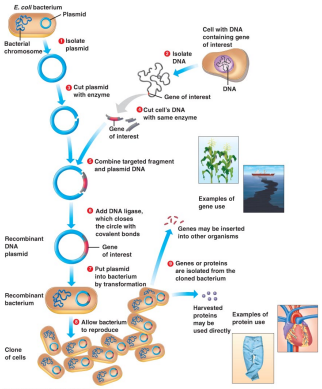
GENETIC ENGINEERING: The bacteria absorbs the recombinant plasmid through a process called transformation. The gene of interest is now part of the bacterial DNA.



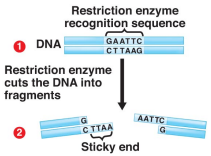
GENETIC ENGINEERING: As the bacteria reproduce through binary fission, each new cell will contain the recombinant DNA.



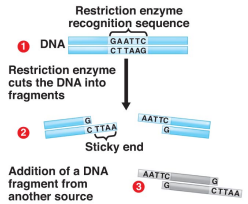
GENETIC ENGINEERING: The bacteria perform transcription and translation. The proteins produced from the recombinant DNA can be extracted and used by humans.



GENETIC ENGINEERING: In summary, restriction enzymes allow a gene to be cut, placed into a bacterial chromosome, and used to genetically engineer all sorts of things.



This is how the restriction enzyme works to create the "recombinant" DNA molecule. Notice how the "sticky ends" allow for a lock-and-key fit between the host DNA and the DNA fragment.



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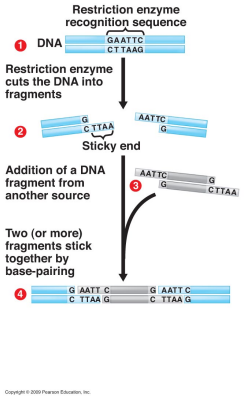

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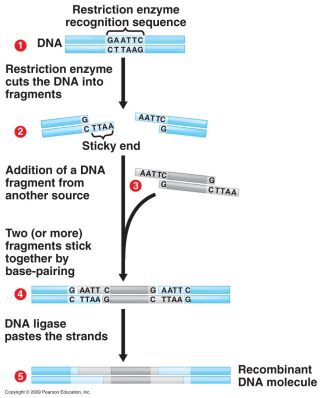

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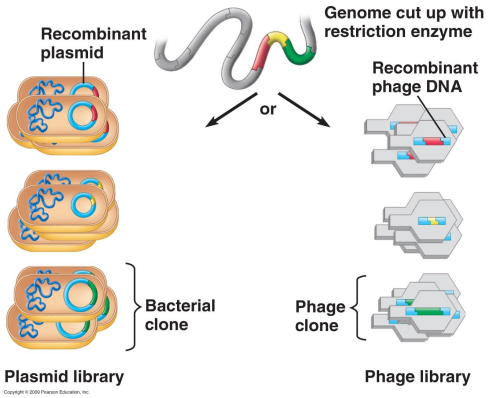
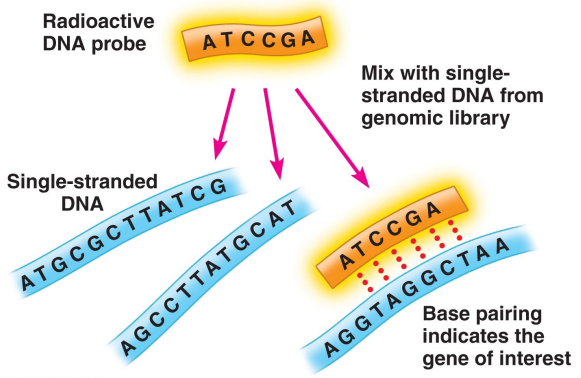
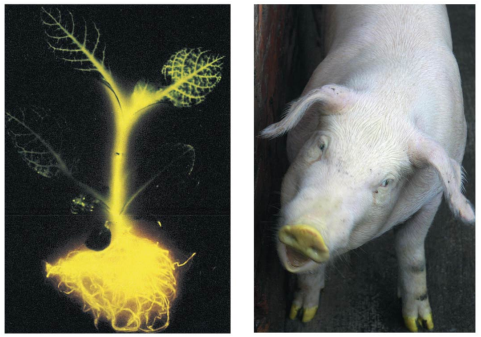


Genetically engineered DNA be placed into bacteria or into lytic viruses. Scientists store gene samples in the form of plasmid libraries (bacteria) and phage libraries (lytic viruses).



Radioactive DNA probes are used to identify a matching (complementary) strand of DNA. Scientists use this technique in the laboratory to identify samples of DNA.



(a) Tobacco plant expressing a firefly gene (b) Pig expressing a jellyfish gene

It is possible to genetically alter both plants and animals so that they express genes from other species.

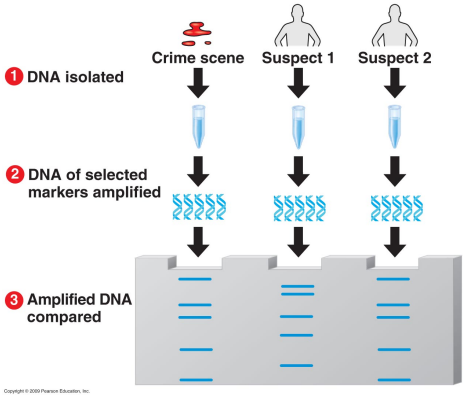
These sheep have been altered to produce a human blood protein in their milk.

TABLE 12-6 SOME PROTEIN PRODUCTS OF RECOMBINANT DNA TECHNOLOGY

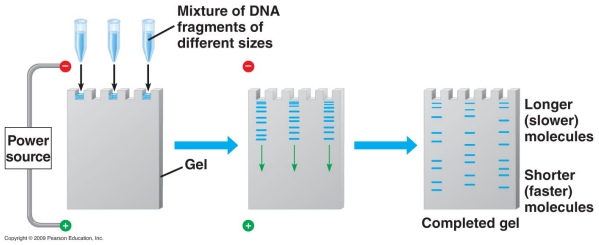
Product	Made In	Use
Human insulin	*E. coli*	Treatment for diabetes
Human growth hormone (HGH)	*E. coli*	Treatment for growth defects
Epidermal growth factor (EGF)	*E. coli*	Treatment for burns, ulcers
Interleukin-2 (IL-2)	*E. coli*	Possible treatment for cancer
Bovine growth hormone (BGH)	*E. coli*	Improving weight gain in cattle
Cellulase	*E. coli*	Breaking down cellulose for animal feeds
Taxol	*E. coli*	Treatment for ovarian cancer
Interferons (alpha and gamma)	*S. cerevisiae; E. coli*	Possible treatment for cancer and viral infections
Hepatitis B vaccine	*S. cerevisiae*	Prevention of viral hepatitis
Erythropoietin (EPO)	Mammalian cells	Treatment for anemia
Factor VIII	Mammalian cells	Treatment for hemophilia
Tissue plasminogen activator (TPA)	Mammalian cells	Treatment for heart attacks and some strokes

This chart lists some of the proteins made using genetic engineering.
E. coli is one of the organisms most frequently used for genetic engineering.

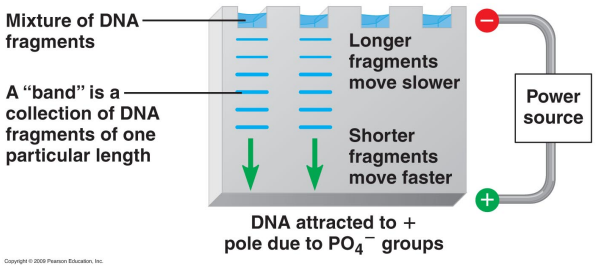
Human insulin is now made by bacteria. In the past, diabetics had to take cow insulin.



DNA profiling is an extremely accurate way of determining "who did it" at a crime scene.



Gel electrophoresis is used to create a DNA profile (also called a DNA fingerprint). The pattern of the strands is indicative of the size of the DNA fragments.



Gel electrophoresis works by moving small fragments of DNA faster than large fragments. Since DNA has negatively charged phosphate groups, the fragments are attracted to the positive end of the power source.

STOP!
You are done with this chapter. ☺