CHAPTER 12- PROTEIN SYNTHESIS

KENNEDY
BIOL. 1AB

I. ONE GENE- ONE ENZYME

- A. BEADLE/TATUM EXPERIMENTED WITH ULTRAVIOLET RADIATION AND BACTERIA.
- THEY FOUND THAT THE RANDOM MUTATIONS CAUSED BY THE RADIATION PREVENTED THE BACTERIA FROM PRODUCING ALL THE ENZYMES NEEDED FOR SURVIVAL.
- EACH GENE THAT WAS MUTATED, RESULTED IN ONE MORE MISSING PROTEIN.

RNA/DNA

- 1. IN RNA THYMINE IS REPLACED WITH URACIL.
- 2. DEOXYRIBOSE IS REPLACED WITH RIBOSE.
- 3. DNA IS DOUBLE STRANDED AND RNA IS SINGLE STRANDED

From DNA to Protein

Genes and Proteins

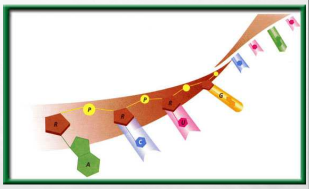
You learned earlier that proteins are polymers of amino acids.

The sequence of nucleotides in each gene contains information for assembling the string of amino acids that make up a single protein.

From DNA to Protein

RNA

RNA like DNA, is a nucleic acid. RNA structure differs from DNA structure in three ways.

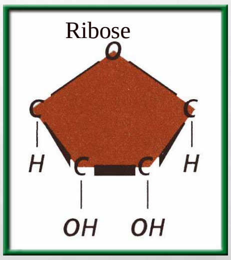


First, RNA is single stranded—it looks like one-half of a zipper —whereas DNA is double stranded.

From DNA to Protein

RNA

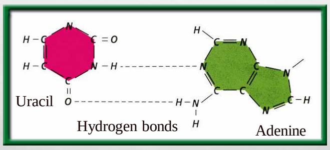
The sugar in RNA is ribose; DNA's sugar is deoxyribose.



From DNA to Protein

RNA

Both DNA and RNA contain four nitrogenous bases, but rather than thymine, RNA contains a similar base called uracil (U).



Uracil forms a base pair with adenine in RNA, just as thymine does in DNA.

From DNA to Protein

RNA

DNA provides workers with the instructions for making the proteins, and workers build the proteins.

The workers for protein synthesis are RNA molecules.

From DNA to Protein

RNA

DNA provides workers with the instructions for making the proteins, and workers build the proteins.

The workers for protein synthesis are RNA molecules.

They take from DNA the instructions on how the protein should be assembled, then—amino acid by amino acid—they assemble the protein.

From DNA to Protein

RNA

There are three types of RNA that help build proteins.

Messenger RNA (mRNA), brings instructions from DNA in the nucleus to the cell's factory floor, the cytoplasm.

On the factory floor, mRNA moves to the assembly line, a ribosome.

From DNA to Protein

RNA

The ribosome, made of ribosomal RNA (rRNA), binds to the mRNA and uses the instructions to assemble the amino acids in the correct order.

From DNA to Protein

RNA

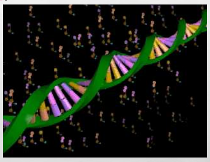
Transfer RNA (tRNA) is the supplier. Transfer RNA delivers amino acids to the ribosome to be assembled into a protein.

Click image to view movie

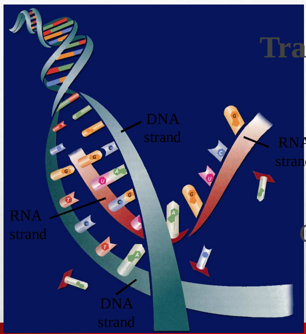
From DNA to Protein

Transcription

In the nucleus, enzymes make an RNA copy of a portion of a DNA strand in a process called transcription.



From DNA to Protein



Transcription

A

B

C

From DNA to Protein

Transcription

The main difference between transcription and DNA replication is that transcription results in the formation of one single-stranded RNA molecule rather than a double-stranded DNA molecule.

From DNA to Protein

RNA Processing

Not all the nucleotides in the DNA of eukaryotic cells carry instructions—or code—for making proteins.

Genes usually contain many long noncoding nucleotide sequences, called introns, that are scattered among the coding sequences.

From DNA to Protein

RNA Processing

Regions that contain information are called exons because they are *ex*pressed.

When mRNA is transcribed from DNA, both introns and exons are copied.

The introns must be removed from the mRNA before it can function to make a protein.

From DNA to Protein

RNA Processing

Enzymes in the nucleus cut out the intron segments and paste the mRNA back together.

The mRNA then leaves the nucleus and travels to the ribosome.

From DNA to Protein

The Genetic Code

The nucleotide sequence transcribed from DNA to a strand of messenger RNA acts as a genetic message, the complete information for the building of a protein.

As you know, proteins contain chains of amino acids. You could say that the language of proteins uses an alphabet of amino acids.

From DNA to Protein

The Genetic Code

A code is needed to convert the language of mRNA into the language of proteins.

Biochemists began to crack the genetic code when they discovered that a group of three nitrogenous bases in mRNA code for one amino acid. Each group is known as a codon.

From DNA to Protein

The Genetic Code

Sixty-four combinations are possible when a sequence of three bases is used; thus, 64 different mRNA codons are in the genetic code.

From DNA to Protein

The Genetic Code

The Messenger RNA Genetic Code

First Letter	Second Letter				Third Letter
	U	C	A	G	
U	Phenylalanine (UUU)	Serine (UCU)	Tyrosine (UAU)	Cysteine (UGU)	U
	Phenylalanine (UUC)	Serine (UCC)	Tyrosine (UAC)	Cysteine (UGC)	C
	Leucine (UUA)	Serine (UCA)	Stop (UAA)	Stop (UGA)	A
	Leucine (UUG)	Serine (UCG)	Stop (UAG)	Tryptophan (UGG)	G
C	Leucine (CUU)	Proline (CCU)	Histadine (CAU)	Arginine (CGU)	U
	Leucine (CUC)	Proline (CCC)	Histadine (CAC)	Arginine (CGC)	C
	Leucine (CUA)	Proline (CCA)	Glutamine (CAA)	Arginine (CGA)	A
	Leucine (CUG)	Proline (CCG)	Glutamine (CAG)	Arginine (CGG)	G
A	Isoleucine (AUU)	Threonine (ACU)	Asparagine (AAU)	Serine (AGU)	U
	Isoleucine (AUC)	Threonine (ACC)	Asparagine (AAC)	Serine (AGC)	C
	Isoleucine (AUA)	Threonine (ACA)	Lysine (AAA)	Arginine (AGA)	A
	Methionine; Start (AUG)	Threonine (ACG)	Lysine (AAG)	Arginine (AGG)	G
G	Valine (GUU)	Alanine (GCU)	Aspartate (GAU)	Glycine (GGU)	U
	Valine (GUC)	Alanine (GCC)	Aspartate (GAC)	Glycine (GGC)	C
	Valine (GUA)	Alanine (GCA)	Glutamate (GAA)	Glycine (GGA)	A
	Valine (GUG)	Alanine (GCG)	Glutamate (GAG)	Glycine (GGG)	G

From DNA to Protein

The Genetic Code

Some codons do not code for amino acids; they provide instructions for making the protein.

More than one codon can code for the same amino acid.

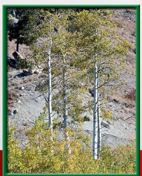
However, for any one codon, there can be only one amino acid.

From DNA to Protein

The Genetic Code

All organisms use the same genetic code.

This provides evidence that all life on Earth evolved from a common origin.



III. TRANSCRIPTION

- THIS IS THE PROCESS OF READING THE DNA TO MAKE MRNA.

1. MRNA

- IS AN EXACT COPY OF DNA, BUT IT IS CAPABLE OF LEAVING THE NUCLEUS
- IT IS ALSO READ IN THE PRODUCTION OF PROTEIN.

A. COPIES DNA

- COPIES OF DNA ARE MADE BY UNWINDING, UNZIPPING, AND PAIRING COMPLEMENTARY BASES.
- RNA PRODUCTION IS VERY SIMILAR.

B. JUST LIKE REPLICATION EXCEPT:

- THE RNA THAT IS PRODUCED WILL BE SINGLE STRANDED, CONTAIN URACIL, AND RIBOSE SUGAR.

1. ONE STRAND

- THE SINGLE STRAND OF MRNA WILL LEAVE THE NUCLEUS WITHOUT ANY COILING, BUT THAT DOESN'T MEAN THAT IT REMAINS UNMODIFIED.

2. RNA NUCLEOTIDES

- THE NUCLEOTIDES INVOLVED WITH RNA ARE:
  - ADENINE
  - GUANINE
  - CYTOSINE
  - URACIL

3. DNA (TRIPLET) MATCHES WITH MRNA (CODON)

- EVERY THREE BASES ON THE DNA STRAND TRANSLATES TO A THREE BASE SEQUENCE ON THE RNA STRAND CALLED A CODON.
- EACH CODON CODES FOR A SPECIFIC AMINO ACID

4. MRNA STRAND TO CYTOPLASM

- ONCE FORMED THE MRNA LEAVES THE NUCLEUS THROUGH THE POROUS NUCLEAR MEMBRANE.

5. *POST TRANSCRIPTIONAL MODIFICATION

- AS IT LEAVES IT IS MODIFIED FOR RAPID AND ORDERLY READING IN THE CYTOPLASM.

A. EXONS

- THESE ARE THE PART OF THE MRNA STRAND THAT WILL BE READ AND USED TO MAKE PROTEIN.
- THEY MUST BE SEPARATED FROM THE NON-CODING PARTS OF THE MRNA

B. INTRONS

- THESE ARE THE NON-CODING PART OF THE MRNA, THEY ARE REMOVED FROM THE STRAND DURING POST-TRANSCRIPTIONAL MODIFICATION.
- THERE FUNCTION IS NOT CLEARLY UNDERSTOOD.

From DNA to Protein

Translation: From mRNA to Protein

The process of converting the information in a sequence of nitrogenous bases in mRNA into a sequence of amino acids in protein is known as translation.

Translation takes place at the ribosomes in the cytoplasm.

In prokaryotic cells, which have no nucleus, the mRNA is made in the cytoplasm.

From DNA to Protein

Translation: From mRNA to Protein

In eukaryotic cells, mRNA is made in the nucleus and travels to the cytoplasm.

In cytoplasm, a ribosome attaches to the strand of mRNA like a clothespin clamped onto a clothesline.

From DNA to Protein

The role of transfer RNA

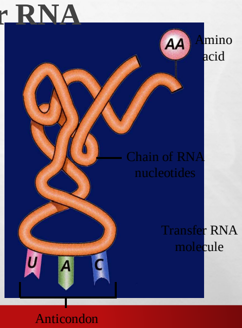
For proteins to be built, the 20 different amino acids dissolved in the cytoplasm must be brought to the ribosomes.

This is the role of transfer RNA.

From DNA to Protein

The role of transfer RNA

Each tRNA molecule attaches to only one type of amino acid.



From DNA to Protein

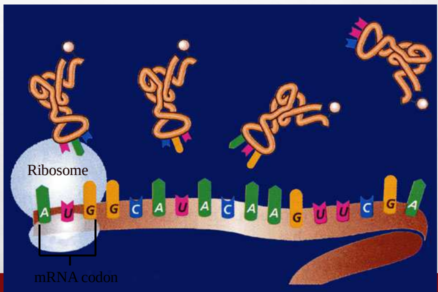
The role of transfer RNA

As translation begins, a ribosome attaches to the starting end of the mRNA strand. Then, tRNA molecules, each carrying a specific amino acid, approach the ribosome.

When a tRNA anticodon pairs with the first mRNA codon, the two molecules temporarily join together.

From DNA to Protein

The role of transfer RNA



From DNA to Protein

The role of transfer RNA

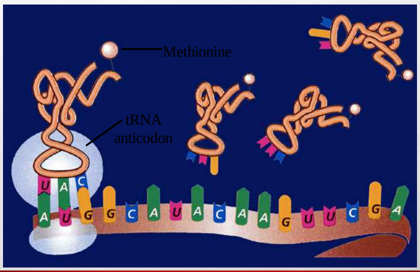
Usually, the first codon on mRNA is AUG, which codes for the amino acid methionine.

AUG signals the start of protein synthesis.

When this signal is given, the ribosome slides along the mRNA to the next codon.

From DNA to Protein

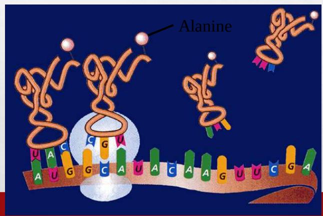
The role of transfer RNA



From DNA to Protein

The role of transfer RNA

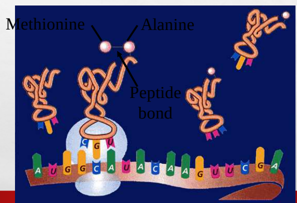
A new tRNA molecule carrying an amino acid pairs with the second mRNA codon.



From DNA to Protein

The role of transfer RNA

The amino acids are joined when a peptide bond is formed between them.



From DNA to Protein

The role of transfer RNA

A chain of amino acids is formed until the stop codon is reached on the mRNA strand.

IV. TRANSLATION

- A. DEFINITION - THIS IS THE POINT AT WHICH THE MODIFIED MRNA IS READ AND PROTEIN IS MADE.

B. ORDER OF THE BASES

- THE ORDER OF THE BASES DETERMINE THE AMINO ACID THAT WILL BE CALLED FOR AND DELIVERED.

C. MRNA STRAND/RIBOSOME

- IN ORDER FOR TRANSLATION TO BEGIN, THE MRNA MUST FIRST BE PICKED UP BY A RIBOSOME.
- THAT RIBOSOME CAN BE EITHER FREE FLOATING OR ATTACHED TO THE ENDOPLASMIC RETICULUM.

D. RRNA MATCHES CODON/TRNA (ANTICODON)

- THE RRNA MATCHES THE CODON AND ANTICODONS AND THEN HELPS IN THE BONDING OF THE AMINO ACIDS

E. COMPLIMENTARY CODON/ANTICODON

- THE CODON AND ANTICODON CONSIST OF COMPLIMENTARY BASES. THE BASES CAN BE MATCHED TO SPECIFIC AMINO ACIDS.

F. TRNA/AMINO ACIDS

- EACH TRNA CARRIES WITH IT A SPECIFIC AMINO ACID.

Genetic Changes

Section Objectives:

Categorize the different kinds of mutations that can occur in DNA.

Compare the effects of different kinds of mutations on cells and organisms.

Genetic Changes

Mutations

Organisms have evolved many ways to protect their DNA from changes.

In spite of these mechanisms, however, changes in the DNA occasionally do occur.

Any change in DNA sequence is called a mutation.

Mutations can be caused by errors in replication, transcription, cell division, or by external agents.

Genetic Changes

Mutations in reproductive cells

Mutations can affect the reproductive cells of an organism by changing the sequence of nucleotides within a gene in a sperm or an egg cell.

If this cell takes part in fertilization, the altered gene would become part of the genetic makeup of the offspring.

Genetic Changes

Mutations in reproductive cells

The mutation may produce a new trait or it may result in a protein that does not work correctly.

Sometimes, the mutation results in a protein that is nonfunctional, and the embryo may not survive.

In some rare cases a gene mutation may have positive effects.

Genetic Changes

Mutations in body cells

What happens if powerful radiation, such as gamma radiation, hits the DNA of a nonreproductive cell, a cell of the body such as in skin, muscle, or bone?

If the cell's DNA is changed, this mutation would not be passed on to offspring.

However, the mutation may cause problems for the individual.

Genetic Changes

Mutations in body cells

Damage to a gene may impair the function of the cell.

When that cell divides, the new cells also will have the same mutation.

Some mutations of DNA in body cells affect genes that control cell division.

This can result in the cells growing and dividing rapidly, producing cancer.

Genetic Changes

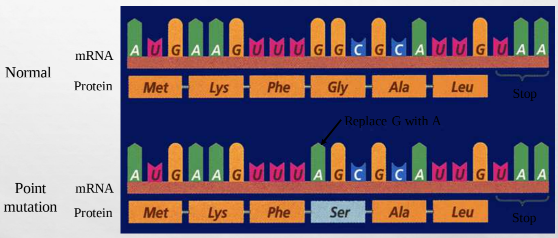
The effects of point mutations

A point mutation is a change in a single base pair in DNA.

A change in a single nitrogenous base can change the entire structure of a protein because a change in a single amino acid can affect the shape of the protein.

Genetic Changes

The effects of point mutations



From DNA to Protein

The Genetic Code

The Messenger RNA Genetic Code

First Letter	Second Letter: U	C	A	G	Third Letter
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	Valine (GUC)	Alanine (GCC)	Aspartate (GAC)	Glycine (GGC)	C
	Valine (GUA)	Alanine (GCA)	Glutamate (GAA)	Glycine (GGA)	A
	Valine (GUG)	Alanine (GCG)	Glutamate (GAG)	Glycine (GGG)	G

Genetic Changes

Frameshift mutations

What would happen if a single base were lost from a DNA strand?

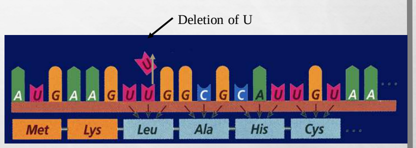
This new sequence with the deleted base would be transcribed into mRNA. But then, the mRNA would be out of position by one base.

As a result, every codon after the deleted base would be different.

Genetic Changes

Frameshift mutations

Frameshift mutation



Genetic Changes

Frameshift mutations

This mutation would cause nearly every amino acid in the protein after the deletion to be changed.

A mutation in which a single base is added or deleted from DNA is called a frameshift mutation because it shifts the reading of codons by one base.

Genetic Changes

Chromosomal Alterations

Changes may occur in chromosomes as well as in genes.

Alterations to chromosomes may occur in a variety of ways.

Structural changes in chromosomes are called chromosomal mutations.

Genetic Changes

Chromosomal Alterations

Chromosomal mutations occur in all living organisms, but they are especially common in plants.

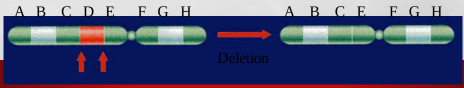
Few chromosomal mutations are passed on to the next generation because the zygote usually dies.

Genetic Changes

Chromosomal Alterations

In cases where the zygote lives and develops, the mature organism is often sterile and thus incapable of producing offspring.

When a part of a chromosome is left out, a deletion occurs.

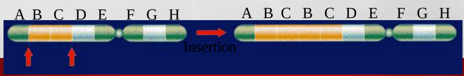


Genetic Changes

Chromosomal Alterations

When part of a chromatid breaks off and attaches to its sister chromatid, an insertion occurs.

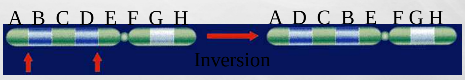
The result is a duplication of genes on the same chromosome.



Genetic Changes

Chromosomal Alterations

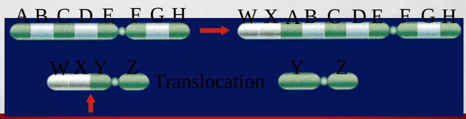
When part of a chromosome breaks off and reattaches backwards, an inversion occurs.



Genetic Changes

Chromosomal Alterations

When part of one chromosome breaks off and is added to a different chromosome, a translocation occurs.



Genetic Changes

Causes of Mutations

Some mutations seem to just happen, perhaps as a mistake in base pairing during DNA replication.

These mutations are said to be spontaneous.

However, many mutations are caused by factors in the environment.

Genetic Changes

Causes of Mutations

Any agent that can cause a change in DNA is called a mutagen.

Mutagens include radiation, chemicals, and even high temperatures.

Forms of radiation, such as X rays, cosmic rays, ultraviolet light, and nuclear radiation, are dangerous mutagens because the energy they contain can damage or break apart DNA.

Genetic Changes

Causes of Mutations

The breaking and reforming of a double-stranded DNA molecule can result in deletions.

Chemical mutagens include dioxins, asbestos, benzene, and formaldehyde, substances that are commonly found in buildings and in the environment.

Chemical mutagens usually cause substitution mutations.

Genetic Changes

Repairing DNA

Repair mechanisms that fix mutations in cells have evolved.

Enzymes proofread the DNA and replace incorrect nucleotides with correct nucleotides.

These repair mechanisms work extremely well, but they are not perfect.

The greater the exposure to a mutagen such as UV light, the more likely is the chance that a mistake will not be corrected.

I. START/STOP CODONS

- THERE ARE ALSO SPECIFIC START AND STOP CODONS ON THE MRNA STRAND.
- THEY START OR STOP PROTEIN PRODUCTION.
- EXAMPLE: UAA,UAG,UGA = STOP ; AUG = START