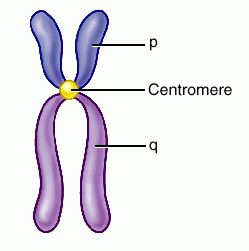
# Chapter 9 – DNA, RNA, and Proteins

1. \_\_\_\_\_ are made of \_\_\_\_\_.
   1. The \_\_\_\_\_ wraps around \_\_\_\_\_ called \_\_\_\_\_ to form beads on a string or \_\_\_\_\_.
   2. The chromatin \_\_\_\_\_ into a fiber and continues to coil around itself.
   3. The condensed and coiled \_\_\_\_\_ fibers become a section of a \_\_\_\_\_.
2. Definitions
   1. \_\_\_\_ is a \_\_\_\_\_ stranded molecule that contains \_\_\_\_\_ information about function and development of all living things.
   2. A \_\_\_\_\_ is a segment of \_\_\_\_\_ that codes for a \_\_\_\_\_ (polypeptide).
   3. A \_\_\_\_\_ is a molecule of DNA that contains many genes.
      1. Segments of \_\_\_\_\_ DNA (strings of \_\_\_\_\_) that code for various \_\_\_\_\_ in between non-coding DNA.
      2. Most easily seen during \_\_\_\_\_ of mitosis.
      3. Formed when DNA compacts into coils around proteins called \_\_\_\_\_.

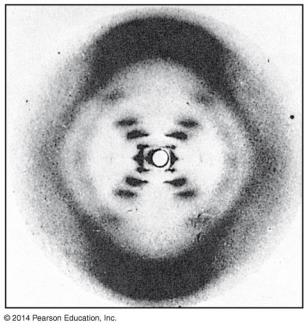


The general shape of an eukaryotic chromosome

p arm 🡪 \_\_\_\_\_

q arm 🡪 \_\_\_\_\_

1. History of DNA
   * 1. DNA scientists
        1. Friedrich \_\_\_\_\_ (Swiss, 1869)
           1. Experimented and isolated a new molecule - \_\_\_\_\_ - from the cell nucleus.
           2. He determined that nuclein was made up of \_\_\_\_\_, oxygen, \_\_\_\_\_ and \_\_\_\_\_ and there was an unique ratio of phosphorus to nitrogen.
           3. Nuclein, found in the \_\_\_\_\_, is now known as \_\_\_\_\_.
           4. He extracted and observed DNA from \_\_\_\_\_ cells.
           5. Miescher, himself, believed that \_\_\_\_\_ were the molecules of heredity.
        2. DNA is a double \_\_\_\_\_
           1. American James D. \_\_\_\_\_ journeyed to Cambridge University in England, where the more senior Francis \_\_\_\_\_ was studying protein structure with a technique called X-Ray \_\_\_\_\_.



While visiting the laboratory of Maurice \_\_\_\_\_ at King’s College in London, Watson saw an X-ray image of DNA produced by Wilkins’s colleague, Rosalind \_\_\_\_\_.

* + - 1. Watson and Crick put it all together
      2. 3-D structure of DNA = \_\_\_\_\_ \_\_\_\_\_
      3. Basic components were
      4. \_\_\_\_\_
      5. \_\_\_\_\_
      6. \_\_\_\_\_ bases
      7. Franklin’s X-ray crystallography photos
      8. C\_\_\_\_\_ Rule (Erwin Chargaff)
      9. A nucleotide:
      10. A \_\_\_\_\_ base - organic
      11. A \_\_\_\_\_ 🡪 \_\_\_\_\_ - organic
      12. \_\_\_\_\_ group - inorganic
      13. Watson and Crick Model of DNA
          1. A double helix looks like a \_\_\_\_\_.
          2. Backbone of the ladder

\_\_\_\_\_

\_\_\_\_\_ groups

Joined by \_\_\_\_\_.

* + - * 1. Rungs of the ladder

Two \_\_\_\_\_ bases that pair across the center of the helix.

Joined by weak \_\_\_\_\_ bonds

* + 1. Watson and Crick realized that \_\_\_\_\_ consisted of \_\_\_\_\_ polynucleotide strands wrapped into a Double \_\_\_\_\_.
    2. The \_\_\_\_\_ -\_\_\_\_\_ backbone is on the outside.
    3. The \_\_\_\_\_ bases are perpendicular to the backbone in the interior.
    4. Specific pairs of bases give the helix a uniform shape:
    5. \_\_\_\_\_ pairs with \_\_\_\_\_, forming \_\_\_\_\_ hydrogen bonds
    6. \_\_\_\_\_ pairs with \_\_\_\_\_, forming \_\_\_\_\_ hydrogen bonds
    7. Two families of bases:
    8. \_\_\_\_\_ & \_\_\_\_\_ are \_\_\_\_\_
    9. \_\_\_\_\_ & \_\_\_\_\_ are \_\_\_\_\_
  1. Sugar-Phosphate ‘Backbone’ – Covalently bonded
  2. \_\_\_\_\_ Rule:
  3. # A = # T \_\_\_\_\_ always pairs with \_\_\_\_\_
  4. #C ≡ # G \_\_\_\_\_ always pairs with \_\_\_\_\_
  5. Structure of DNA

In 1962, the Nobel Prize in Physiology or Medicine was awarded to James D. \_\_\_\_\_, Francis \_\_\_\_\_, and Maurice \_\_\_\_\_.

Rosalind \_\_\_\_\_ probably would have received the prize as well but for her death from cancer in 1958.

Nobel Prizes are never awarded posthumously.

* + 1. The Watson-Crick Model gave new meaning to the words \_\_\_\_\_ and \_\_\_\_\_. It showed:
    2. The structure of \_\_\_\_\_
    3. How DNA could carry genetic information and \_\_\_\_\_ it
    4. The \_\_\_\_\_ information in a chromosome is encoded in the \_\_\_\_\_ sequence of DNA.

1. DNA R\_\_\_\_\_
   1. Parameters
      * 1. When does it occur?

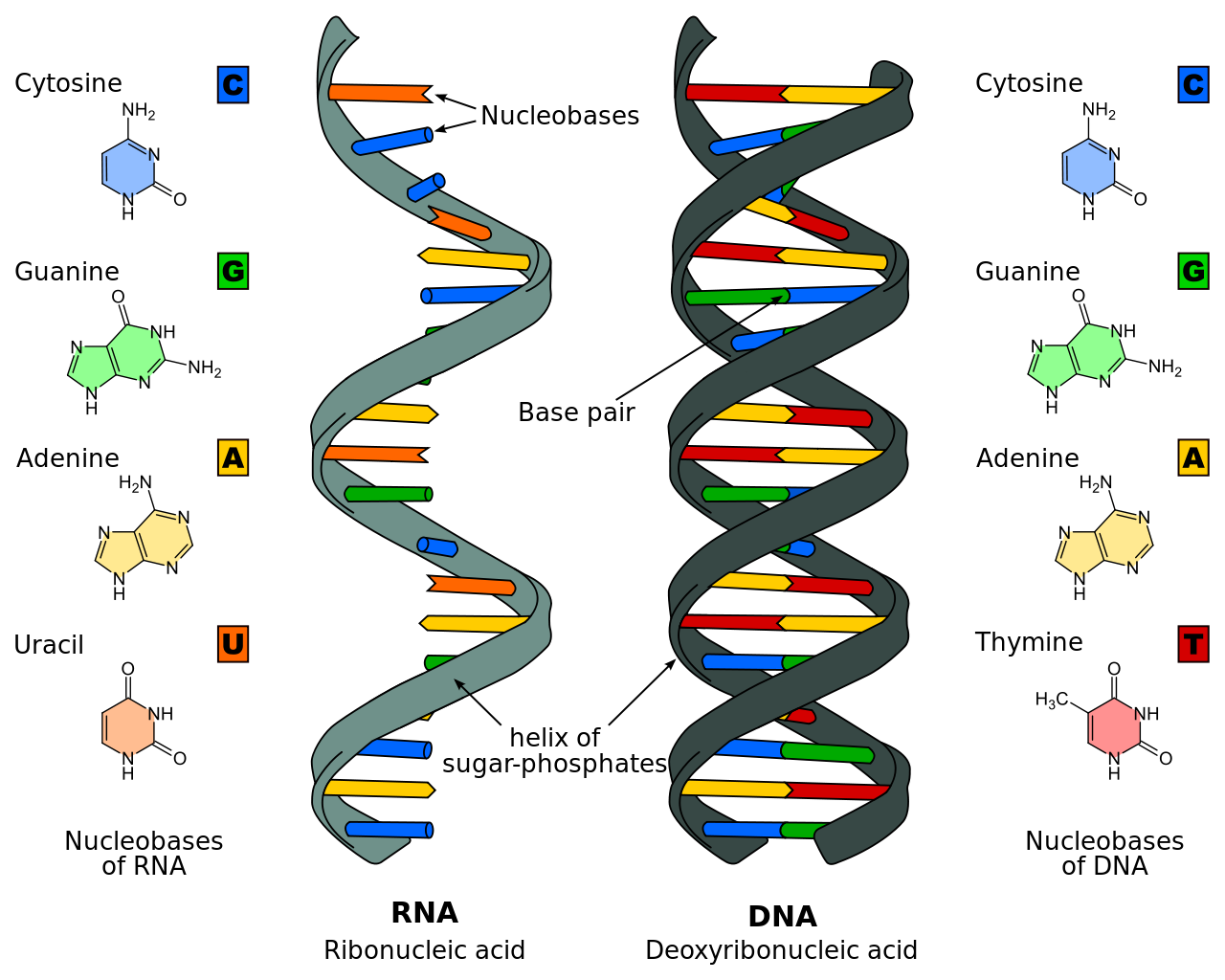
* End of \_\_\_\_\_ (S)
  1. Why does this occur?
* Need to make another \_\_\_\_\_ of \_\_\_\_\_ for the \_\_\_\_\_ cell
  1. How does this occur?
  2. \_\_\_\_\_ -\_\_\_\_\_ Replication
  3. Each copy contains one \_\_\_\_\_ strand and one \_\_\_\_\_ -synthesized strand.
     1. Steps Involved in DNA in *Semi-Conservative Replication*
* What tells the DNA to do this? \_\_\_\_\_
  + - * 1. Step 1: \_\_\_\_\_
        2. Step 2: \_\_\_\_\_

The DNA is \_\_\_\_\_ and \_\_\_\_\_ into \_\_\_\_\_ strands during the \_\_\_\_\_ phase of the cell cycle.

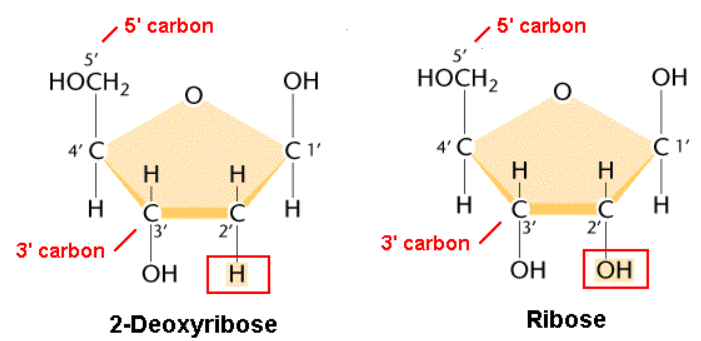
When? \_\_\_\_\_

* + - * 1. Step 3: \_\_\_\_\_
* Semi-conservative, meaning that the “\_\_\_\_\_” DNA molecules each consist of one \_\_\_\_\_ strand and one \_\_\_\_\_ strand.

1. DNA and RNA are \_\_\_\_\_ of \_\_\_\_\_



* 1. The full name for DNA is \_\_\_\_\_ \_\_\_\_\_, with \_\_\_\_\_ referring to DNA’s location in the \_\_\_\_\_ of eukaryotic cells.
  2. \_\_\_\_\_ (ribonucleic acid) is unlike DNA in that it
  3. uses the sugar \_\_\_\_\_ (instead of deoxyribose in DNA)



* 1. has a nitrogenous base \_\_\_\_\_ (U) instead of Thymine (T)
  2. RNA is \_\_\_\_\_ -stranded; DNA is double-stranded

1. Genes
2. Genes control \_\_\_\_\_ Traits through the Synthesis of \_\_\_\_\_
3. DNA specifies \_\_\_\_\_ by dictating Protein Synthesis
4. \_\_\_\_\_ are the links between \_\_\_\_\_ (genetic make-up) and \_\_\_\_\_ (appearance).
5. The molecular chain of command is from
6. \_\_\_\_\_ in the \_\_\_\_\_ to RNA
7. \_\_\_\_\_ in the \_\_\_\_\_ to \_\_\_\_\_
   * + 1. \_\_\_\_\_ Expression
8. The DNA molecule, with its \_\_\_\_\_ nitrogenous bases, is the \_\_\_\_\_ for all \_\_\_\_\_ that are made in a cell.
9. Genes make up a portion of the \_\_\_\_\_ strand. A gene is the \_\_\_\_\_ that controls the production of specific \_\_\_\_\_, such as \_\_\_\_\_, structural proteins, etc.
   1. Proteins are the link between \_\_\_\_\_ and \_\_\_\_\_ of an organism.
   2. The proteins that are made will determine the \_\_\_\_\_ of the offspring.
10. Gene Expression:
    1. The process by which \_\_\_\_\_ directs the \_\_\_\_\_ of \_\_\_\_\_.
    2. The expression of genes includes two stages:

* \_\_\_\_\_ and \_\_\_\_\_

Protein Synthesis

* 1. Overview

A. \_\_\_\_\_ contains the \_\_\_\_\_ information

B. Every \_\_\_\_\_ of an organism is controlled by \_\_\_\_\_

C. Genes control \_\_\_\_\_ Traits through the Synthesis of \_\_\_\_\_

1. \_\_\_\_\_ is the synthesis of \_\_\_\_\_ under the direction of \_\_\_\_\_.

2. \_\_\_\_\_ is the synthesis of \_\_\_\_\_ under the direction of \_\_\_\_\_.

3. \_\_\_\_\_ provide the instructions for making specific Proteins.

**Protein synthesis**

C. Genes – Cracking the Code

1. The genetic code was discovered by Marshall \_\_\_\_\_ and J. Heinrich \_\_\_\_\_ in 1961.

2. The genetic code was based on \_\_\_\_\_,sequences of three bases that form a unit of the genetic \_\_\_\_\_ in DNA that determines a specific \_\_\_\_\_ \_\_\_\_\_.

3. Amino acids are used to make \_\_\_\_\_.

D. Genetic Information written in \_\_\_\_\_ is \_\_\_\_\_ into \_\_\_\_\_ Acid Sequences

1. The sequence of \_\_\_\_\_ in DNA provides a code for constructing a \_\_\_\_\_.

a. Protein construction requires a conversion of a \_\_\_\_\_ sequence to an \_\_\_\_\_ \_\_\_\_\_ sequence.

b. \_\_\_\_\_ rewrites the \_\_\_\_\_ code into \_\_\_\_\_, using the same nucleotide “language.”

2. \_\_\_\_\_ is the process of forming a strand of RNA from a strand of DNA.

a. This process occurs in the \_\_\_\_\_ (eukaryotic cells).

b. Since prokaryotes do not have a nucleus, the process occurs in their \_\_\_\_\_.

c. The \_\_\_\_\_ must make RNA to send to the \_\_\_\_\_ to tell the \_\_\_\_\_ how and which proteins to make.

d. The RNA molecule is a faithful copy of a gene’s protein building instructions. This type of RNA is called \_\_\_\_\_ RNA (\_\_\_\_\_).

e. An enzyme called RNA \_\_\_\_\_ catalyzes this reaction.

f. The purpose of transcription is to copy one \_\_\_\_\_ from the \_\_\_\_\_ molecule.

II. Transcription

A. Steps of transcription

1. RNA \_\_\_\_\_ (enzyme) \_\_\_\_\_ the \_\_\_\_\_ strands.

a. One strand of DNA is used as a template.

b. New nucleotides are inserted according to the base pairing rules.

c. When transcribing RNA, Adenine pairs with \_\_\_\_\_; Cytosine pairs with guanine.

d. This continues until the end is reached.

e. As the RNA polymerase moves along the DNA molecule, \_\_\_\_\_ bonds between the two \_\_\_\_\_ of \_\_\_\_\_ are reformed.

f. A \_\_\_\_\_ stranded \_\_\_\_\_ molecule has been transcribed.

B. Purpose of Transcription

1. The purpose of transcription is \_\_\_\_\_ to copy the entire length of the DNA molecule but to copy only small portions – a \_\_\_\_\_ worth

2. to be sent to the \_\_\_\_\_ as the instructions for \_\_\_\_\_ synthesis.

III. Eukaryotic RNA Processing and Editing

* + 1. Once the RNA is transcribed it is not yet ready to be sent out of the \_\_\_\_\_. It must \_\_\_\_\_ before it is ready to serve its purpose.
    2. The mRNA is a copy of a \_\_\_\_\_ section of the DNA
    3. This RNA contains sections called \_\_\_\_\_ and other sections called \_\_\_\_\_.
       1. Introns are sequences of \_\_\_\_\_ bases that are \_\_\_\_\_ involved in the making of the protein.

1. These need to be \_\_\_\_\_ of the RNA before the RNA goes to the ribosomes.
   * + 1. \_\_\_\_\_ are the sequences of nitrogen bases that \_\_\_\_\_ involved in the making of the protein.
       2. When mRNA is formed, both the \_\_\_\_\_ from the DNA.
       3. However, the introns are \_\_\_\_\_ of the RNA while the RNA is still inside the \_\_\_\_\_.
       4. The remaining exons are \_\_\_\_\_ by the enzyme \_\_\_\_\_ to form the final RNA.
       5. Finally, \_\_\_\_\_ are added to form the final RNA molecule.
          1. The cap and tail help to identify the “\_\_\_\_\_” of the RNA from the “\_\_\_\_\_”.
          2. The cap and tail help the ribosome to identify the \_\_\_\_\_ of the instructions and the \_\_\_\_\_ of the instructions.
       6. If introns are not needed and will be cut out of the RNA, why are they there in the first place?
          1. When introns are present in genes, it allows a \_\_\_\_\_ to code for more than one type of \_\_\_\_\_, depending on which segments are treated as introns and which are treated as exons.
          2. When particular segments are cut out, one type of \_\_\_\_\_ might result. If different segments are cut out, a different type of protein would result.
     1. mRNA Transcript

* mRNA leaves the nucleus through its \_\_\_\_\_ and goes to the \_\_\_\_\_.

IV. The Genetic \_\_\_\_\_

* + - 1. Overview
      2. Proteins:
         1. Proteins are made by joining together long chains of \_\_\_\_\_.
         2. The order in which the amino acids are joined determines the type of \_\_\_\_\_ that is made.
      3. The “language” of mRNA instructions is called the \_\_\_\_\_ \_\_\_\_\_.
      4. The genetic code is read \_\_\_\_\_ at a time.
      5. Each group of three nitrogen bases is called a \_\_\_\_\_.
      6. A codon is a group of three nitrogen bases that specifies \_\_\_\_\_.

B. Genetic Information written in \_\_\_\_\_ is \_\_\_\_\_ into \_\_\_\_\_ \_\_\_\_\_ Sequences

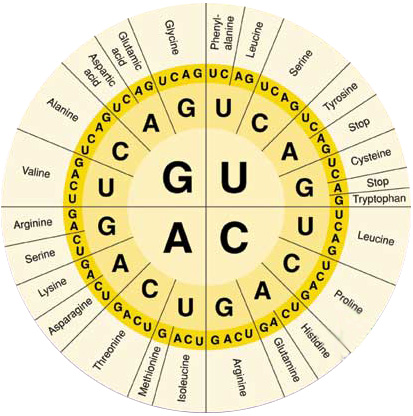
1. The flow of information from \_\_\_\_\_ to protein is based on a \_\_\_\_\_ Code.
2. The genetic instructions for the amino acid sequence of a \_\_\_\_\_ chain (primary structure of a protein) are written in DNA and RNA as a series of non-overlapping three-base “words” called \_\_\_\_\_.
3. \_\_\_\_\_ involves switching from the nucleotide “language” to the \_\_\_\_\_ \_\_\_\_\_ “language.”
4. Each amino acid is specified by a \_\_\_\_\_.
   1. \_\_\_\_\_ codons are possible
   2. Some amino acids have more than \_\_\_\_\_ possible codon

C. The Genetic Code is the amino acid translations of each of the nucleotide triplets.

1. \_\_\_\_\_ Nucleotides specify One Amino Acid.
2. Sixty-one codons correspond to amino acids.
3. \_\_\_\_\_ codes for \_\_\_\_\_ and signals the \_\_\_\_\_ of translation.
4. Three “\_\_\_\_\_” codons signal the \_\_\_\_\_ of translation.

D. Characteristics of the Genetic Code

1. \_\_\_\_\_, with more than one codon for some amino acids
2. \_\_\_\_\_, in that any codon for one amino acid does not code for any other amino acid
3. nearly \_\_\_\_\_, in that the genetic code is shared by organisms from the simplest bacteria to the most complex plants and animals.



V. Translation

A. Protein Synthesis

1. The synthesis of proteins is called \_\_\_\_\_.
2. The cell must translate the base sequence of an \_\_\_\_\_ molecule into the \_\_\_\_\_ sequence of a protein.
3. The site of translation, or \_\_\_\_\_, is the \_\_\_\_\_
4. The \_\_\_\_\_ facilitates the orderly linking of amino acids into \_\_\_\_\_.
5. During translation, the cell uses information from \_\_\_\_\_ to produce \_\_\_\_\_.

B. \_\_\_\_\_ RNA Molecules serve as Interpreters during Translation

1. Transfer RNA (\_\_\_\_\_) molecules function as an interpreter, converting the genetic message of mRNA into the language of proteins.
2. Transfer RNA molecules perform this interpreter task by:
3. picking up the appropriate \_\_\_\_\_ \_\_\_\_\_
4. using a special \_\_\_\_\_ of bases, called an \_\_\_\_\_, to recognize the appropriate \_\_\_\_\_ in the mRNA.

C. Transfer RNA

1. The function of tRNA is to \_\_\_\_\_ amino acids from the \_\_\_\_\_ amino acid pool to a \_\_\_\_\_.
2. Transfer RNA molecules are \_\_\_\_\_ all the same. Each type of tRNA molecule links a particular \_\_\_\_\_ codon with a particular amino acid.
3. As a tRNA arrives at a ribosome, it carries a \_\_\_\_\_ amino acid at one end.
4. At the other end is a nucleotide triplet called an \_\_\_\_\_.
5. These \_\_\_\_\_ bases are the “ANTICODON”.
6. Each tRNA is used repeatedly to locate a particular \_\_\_\_\_ \_\_\_\_\_ and deposit it at the \_\_\_\_\_.
7. It then \_\_\_\_\_ the ribosome to go and find another amino acid.

D. Ribosomes build \_\_\_\_\_

1. Translation occurs on the \_\_\_\_\_ of the Ribosome:
2. Ribosomes coordinate the \_\_\_\_\_ of polypeptides
3. Ribosomes have two \_\_\_\_\_: small and large.
4. Each subunit is composed of \_\_\_\_\_ RNAs and \_\_\_\_\_.
5. Ribosomal subunits come together during translation
6. Ribosomes have \_\_\_\_\_ sites for mRNA and tRNAs.

E. Three steps of translation

1. \_\_\_\_\_: start codon (AUG)

2. \_\_\_\_\_: amino acids linked

3. \_\_\_\_\_: stop codon (UAG, UAA, or UGA)

F. \_\_\_\_\_ - mRNA Joins the Ribosome

1. The large subunit and small subunit join with the mRNA

1. The \_\_\_\_\_ carrying the \_\_\_\_\_ UAC fits in the P site to \_\_\_\_\_ translation.
2. \_\_\_\_\_ bonds form between UAC and AUG (\_\_\_\_\_ Codon).

G. \_\_\_\_\_

1. The next anticodon sits in the A site to start elongation.
2. \_\_\_\_\_ bonds form between the \_\_\_\_\_ and the \_\_\_\_\_ bases.
3. \_\_\_\_\_ Bonds from between the two \_\_\_\_\_ \_\_\_\_\_ forming a chain of 2 amino acids.
4. The mRNA moves over one codon moving the \_\_\_\_\_ \_\_\_\_\_ of the ribosome.
5. The next tRNA moves into place.
6. \_\_\_\_\_ bonds form between the two amino acids, forming a chain of 3 amino acids.
7. The mRNA moves over one codon moving the tRNA out of the ribosome.
8. The next tRNA moves into place.
9. Peptide bonds form between the two amino acids, forming a chain of 5 amino acids.
10. The mRNA moves over one codon moving the tRNA out of the ribosome.
11. The next tRNA moves into place.
12. Peptide bonds form between the two amino acids, forming a chain of 5 amino acids.

H. \_\_\_\_\_

1. When the terminator codon is reached the amino acid linking \_\_\_\_\_.
2. There are NOT \_\_\_\_\_ that match with UAG, UAA and UGA
3. This ends the polypeptide \_\_\_\_\_.

I. End Product – The \_\_\_\_\_!

1. The end products of protein synthesis is the \_\_\_\_\_ structure of a protein
2. A sequence of \_\_\_\_\_ \_\_\_\_\_ bonded together by \_\_\_\_\_ bonds

VI. The Flow of Genetic Information in the cell is \_\_\_\_\_ *→* \_\_\_\_\_ *→* \_\_\_\_\_

1. \_\_\_\_\_ can be divided into four steps, all of which occur in the Cytoplasm:
2. Amino acid attachment
3. I\_\_\_\_\_ of polypeptide synthesis
4. E\_\_\_\_\_
5. T\_\_\_\_\_

B. P\_\_\_\_\_ Cells

1. DNA → RNA → Protein
2. \_\_\_\_\_ nuclear membrane
3. In Prokaryotes, translation can begin \_\_\_\_\_ transcription is complete.
4. Because there is no \_\_\_\_\_ membrane

C. E\_\_\_\_\_ Cells

1. DNA → RNA → Protein
2. nuclear membrane
   1. transcription in \_\_\_\_\_
   2. translation in \_\_\_\_\_

D. \_\_\_\_\_ Sequences after protein synthesis

* 1. Added to proteins in the \_\_\_\_\_ \_\_\_\_\_ after they are synthesized by the \_\_\_\_\_.
  2. Direct a small number of nucleotides that are added to a protein in the ER.
  3. Tell the cell \_\_\_\_\_ the protein is to be taken after it is made.

VII. \_\_\_\_\_ Expression

* + - * 1. When a gene is expressed, it means that the \_\_\_\_\_ the gene codes for is \_\_\_\_\_.
        2. When a gene is expressed, the trait the gene codes for is \_\_\_\_\_ in some way.
        3. All cells of the same organism contain the same \_\_\_\_\_ in their DNA.
        4. In multicellular organisms not all genes are expressed by \_\_\_\_\_.
        5. Not all areas of the DNA that code for proteins are \_\_\_\_\_ into mRNA.
        6. If they were, then every cell would have the same exact function and make the same exact proteins.
        7. Each cell knows exactly what type of cell it is and which proteins it should make.
        8. This allows cells to be grouped into tissue and organ systems.

**RNA**

**DNA**

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