**Chapter 8.4 How Proteins are Made**

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| Objectives | Vocabulary |
| * **Compare** the structure of RNA with that of DNA.
* **Summarize** the process of transcription.
* **Relate** the role of codons to the sequence of amino acids that results after translation.
* **Outline** the major steps of translation.
* **Discuss** the evolutionary significance of the genetic code.
 | Ribonucleic acid (RNA)UracilTranscriptionTranslationGene expressionRNA polymeraseMessenger RNA  | CodonGenetic codeTransfer RNAAnticodonRibosomal RNADecoding the Information in DNARibonucleic Acid |

**Decoding the Information in DNA**

* Traits, such as eye color, are determined by \_\_\_\_\_\_\_\_\_\_\_\_\_ that are built according to instructions \_\_\_\_\_\_\_\_ in DNA.
* The instructions for making each protein are contained in small segments of our DNA called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* A single molecule of DNA has thousands of genes lined up like \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_.
* Proteins, however, are not built directly from DNA…ribonucleic acid or \_\_\_\_\_\_\_ is also involved.
* Like DNA, **RNA** is a nucleic acid—a molecule made of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ linked together.
* RNA differs from DNA in \_\_\_\_\_\_ ways
	1. RNA consists of a \_\_\_\_\_\_\_\_\_\_\_\_ strand of nucleotides
	2. In place of thymine, RNA contains the nitrogenous base \_\_\_\_\_\_\_\_\_\_\_\_\_
	3. In place of deoxyribose, RNA nucleotides contain the five-carbon sugar \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_The only difference between the two sugars is that deoxyribose contains one less \_\_\_\_\_\_\_\_\_\_\_
		+ So, deoxyribose is said to be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 

**Types of RNA**

* Additionally, there are three types of RNA
	1. Messenger RNA (\_\_\_\_\_\_\_\_\_)
	2. Transfer RNA (\_\_\_\_\_\_\_\_\_)
	3. Ribosomal RNA (\_\_\_\_\_\_\_\_\_\_)

**Messenger RNA**



* mRNA is a \_\_\_\_\_\_\_\_\_ strand of RNA nucleotides that is used to acquire DNA’s genetic code
* In a eukaryotic cell, mRNA carries the code \_\_\_\_\_\_ of the nucleus in order to make a protein
* Why might it be important for DNA to stay inside of a eukaryotic cell’s nucleus?



**Transfer RNA**

* tRNA loops up on itself to take on a \_\_\_\_\_\_\_\_\_ leaf shape
* This shape is held together by \_\_\_\_\_\_\_\_\_\_\_\_\_ bonds
* It is used to \_\_\_\_\_\_\_\_\_\_\_ amino acids

**Ribosomal RNA**



* rRNA joins with \_\_\_\_\_\_\_\_\_\_\_\_\_\_ to make a structure called a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Free ribosomes are the \_\_\_\_\_\_\_\_\_\_ or location of protein synthesis
* The instructions for making a protein are \_\_\_\_\_\_\_\_\_\_\_ from a gene in DNA to an RNA molecule in a process called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Cells then read the instructions on the RNA molecule to put together the sequence of \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ that make up the protein in a process called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. The entire process by which proteins are made based on the information encoded in DNA is called **gene \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_,** or protein \_\_\_\_\_\_\_\_\_\_\_\_\_.



**Transcription occurs in three steps**

Step 1

 \_\_\_\_\_\_ polymerase, an enzyme that adds complementary RNA nucleotides, binds to a gene’s \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ site. This site on DNA promotes or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the start of transcription

Step 2

RNA polymerase\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the DNA strands

Step 3

As it moves along DNA, RNA polymerase adds \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ RNA nucleotides in order to form \_\_\_\_\_\_\_\_\_\_. Notice that only \_\_\_\_\_\_\_\_\_\_ strand of DNA is used to make RNA…this strand is called the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. As it moves along DNA, RNA polymerase adds \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ RNA nucleotides in order to form \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Notice that only \_\_\_\_\_\_\_ strand of DNA is used to make RNA…this strand is called the \_\_\_\_\_\_\_\_\_\_\_\_\_

* So let’s practice transcribing a strand of mRNA

make complementary mRNA base pairs with the DNA strand below…***Remember…RNA does NOT have thymine!***

DNA 🡪 G C A T A C G T A

RNA 🡪

* In eukaryotic cells, there are typically about \_\_\_\_\_\_ RNA polymerase molecules working on one gene
* The mRNA being transcribed fans out to give the DNA a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ appearance
* Also in a eukaryotic cell, the mRNA has to leave the nucleus and enter the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in order to find a free \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, which is where a protein will be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* How does mRNA get out of the nucleus?
* In prokaryotic cells, transcription occurs in the cytoplasm, and not in a nucleus…why?
1. Compare the structure of RNA with that of DNA
2. Summarize the process of transcription.

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| Objectives |
| * **Relate** the role of codons to the sequence of amino acids that results after translation.
* **Outline** the major steps of translation.
* **Discuss** the evolutionary significance of the genetic code.
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**The Genetic Code: Three-Nucleotide “Words”**

* In order for a protein to be made, the code stored in mRNA must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* The code is stored in a series of \_\_\_\_\_\_\_\_ nucleotide sequences on mRNA called **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
* Each codon codes for a specific \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_ that will be placed in a protein

**Codes in mRNA**

To determine which amino acid is coded for, find the area on the chart where all three of the nucleotides in a codon \_\_\_\_\_\_\_



* Practice…What does AUG code for?
* So AUG is a \_\_\_\_\_\_\_\_ codon, that signals the beginning of translation
	+ It codes for the amino acid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, abbreviated \_\_\_\_\_
	+ It is found at the beginning of most proteins, but is often \_\_\_\_\_\_\_\_\_\_\_ after translation
* What does CCC code for?
* What does GGU code for?
* What does UAU code for?
* What does UGA code for?
	+ UGA is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ codon that terminates protein synthesis
* What are the other two stop codons?
* \_\_\_\_\_ codons signal for the \_\_\_\_\_ amino acids found in proteins

 Why are there so many codons?

* If codons only contained a combination of \_\_\_\_ nucleotides, mathematically there would not be \_\_\_\_\_\_\_\_\_\_\_\_ codons to signal for twenty different amino acids. To determine the amount of nucleotide combinations, you must know how many bases are \_\_\_\_\_\_\_\_\_\_\_\_\_\_ and how many bases will be in a \_\_\_\_\_
* So, how many RNA bases are there?
* If there was only \_\_\_\_ base in a codon, you would raise the number of \_\_\_\_\_\_\_\_\_\_\_\_\_\_ bases to the 1st power

 41 =

* If there are \_\_\_\_ bases in a codon, you raise the number of available bases to the \_\_\_\_\_\_\_\_ power

 42 or 4 x 4 =

* How many different codons are possible if they contain three bases?

* So several different codons code for the \_\_\_\_\_\_\_ amino acid, but each codon only codes for \_\_\_\_\_ specific amino acid

**Translation**

* Translation occurs when the three types of RNA work \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to assemble a protein
* Recall that a ribosome consists of \_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. It also consists of \_\_\_\_\_subunits



* The ribosome will read the codons in \_\_\_\_\_\_ as it passes between the

 two subunits

* The ribosome also contains two different\_\_\_\_\_\_\_, labeled \_\_\_\_and \_\_\_\_

 which hold\_\_\_\_\_\_\_\_\_\_\_\_ RNA molecules

* **Recall that tRNA** molecules are single strands of RNA that \_\_\_\_\_\_\_



up on themselves

* One side of tRNA has an \_\_\_\_\_\_\_\_\_\_\_\_\_\_ site that temporarily

carries a specific \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_

* The other end contains an \_\_\_\_\_\_\_\_\_\_\_\_\_, which is

a series of three nucleotides that will base pair with codons on \_\_\_\_\_\_\_

**Steps of Translation**

**Step 1** Translation begins when the ribosomal subunits, the mRNA, and the tRNA carrying \_\_\_\_\_\_\_\_\_\_\_\_\_ bind together. If the mRNA start codon AUG codes for methionine, what tRNA anticodon will it base pair with?

Notice that the first tRNA molecule attaches to the ribosome at its \_\_\_\_ site

**Step 2** Next, the tRNA carrying the amino acid specified by the codon in the \_\_\_\_ site arrives. If the codon in the A site is UUG, what amino acid does it code for?

 What tRNA anticodon will transfer the amino acid to the ribosome?

**Step 3** A \_\_\_\_\_\_\_\_\_\_ bond forms between the adjacent amino acids. This bond is catalyzed by a substance called \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_. Previously this substance was thought to be an \_\_\_\_\_\_\_\_\_\_\_\_ but current research indicates that it is a \_\_\_\_\_\_ molecule that acts as an enzyme

**Step 4** The tRNA in the P site \_\_\_\_\_\_\_\_\_\_\_ and leaves its amino acid behind. Scientists have recently discovered that there is an additional site, the \_\_\_ site or \_\_\_\_\_\_\_ site, from which the tRNA molecules actually leave

**Step 5** The tRNA in the A site \_\_\_\_\_\_ to the P site and a \_\_\_\_\_\_\_ tRNA molecule brings in another amino acid. If the new codon in the A site reads CAG, what amino acid will it code for?

What tRNA anticodon will bind with it?

**Step 6** Another peptide \_\_\_\_\_\_\_ is formed between the two amino acids, and the tRNA in the \_\_\_\_\_ site detaches and leaves its amino acid behind.

**Step 7** The process is repeated until a \_\_\_\_\_\_\_\_ codon is reached. The ribosome complex falls \_\_\_\_\_\_\_\_\_\_ and the newly made protein is \_\_\_\_\_\_\_\_\_\_\_\_.

* With few exceptions, the genetic code is the \_\_\_\_\_\_\_ in all organisms
	+ For example, the codon GUC codes for the amino acid \_\_\_\_\_\_\_\_\_\_\_ in bacteria, birds, plants, and humans
	+ For this reason, the genetic code is often said to be \_\_\_\_\_\_\_\_\_\_\_\_\_\_
	+ From an evolutionary standpoint, it appears that all organisms share a \_\_\_\_\_\_\_\_\_\_\_\_\_ ancestor with a \_\_\_\_\_\_\_\_\_\_ genetic code
1. **Relate** the role of codons to the sequence of amino acids that results after translation.
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