Biology I
Chapter 12
DNA, DNA Replication, & Protein Synthesis

The DNA Nerd Herd: Pages 289-294

Watson
Crick
Franklin
Avery
Hershey
Wilkins
Chase
Chargaff
WHAT IS DNA?
DNA is short for "deoxyribonucleic acid." It is the stuff of life—it is the molecule that codes for your phenotype (your physical appearance) and the processes that occur in your body. DNA is found in all organisms, no matter how simple or complex.

This picture is a model of DNA:
DNA is a “double helix” structure—that means that it has two strands that are coiled around each other.

DNA is made of individual subunits called “nucleotides.”

DNA’s two strands are joined together in the center by hydrogen bonds, which are very weak bonds.
Like any huge molecule (and DNA is a huge molecule!), it is made of monomers...DNA’s monomer is called a NUCLEOTIDE.

All DNA nucleotides are the same in their phosphate and deoxyribose (sugar) groups. The only thing that changes is the base. There are four different bases:

1. Adenine (Purine--larger base)
2. Guanine (Purine--larger base)
3. Thymine (Pyrimidine--smaller base)
4. Cytosine (Pyrimidine--smaller base)

Therefore, there are four different kinds of nucleotides...
Notice that the sugars and the phosphates are attached to each other to form the “vertical” lines of the DNA ladder.

Notice that the nitrogenous base is ALWAYS attached to the SUGAR, and that the nitrogenous bases make up the “rungs”

**Complementary Base Pairs**

**ADENINE** will always pair with **THYMINE**

**CYTOSINE** will always pair with **GUANINE**

**CHARGAFF’S RULE:** Page 292

In a DNA molecule, the amount of adenine will always equal thymine, and the amount of cytosine will always equal guanine.

*The DNA structure allows for easy replication.*
A purine will always pair with a pyrimidin.

It is the order that the bases are in that code for genes.

Why Would DNA Need to Make a Copy of Itself?

Before a cell can divide, it needs to replicate its DNA in the S phase of Interphase. This insures that both new daughter cells will have a set of DNA.
DNA REPLICATION

unwound strands produced by breaking of hydrogen bonds between base pairs

new complementary strands made by DNA polymerase adding nucleotides according to rules of base pairing

http://www.johnkyrk.com/DNAreplication.html
DNA REPLICATION: The Process

1. In the nucleus, DNA molecules are broken apart at the hydrogen bonds. The DNA molecule is literally unzipped in many different places along the molecule.

2. Free floating nucleotides in the nucleus attach to the exposed base pairs, creating two new sets of DNA.

PROTEIN SYNTHESIS

A cell will often times get an “order” for a certain amount of a specific protein, just like you order things online or at the store. Protein synthesis is the mechanism by which the cell fills the order for whatever kind of protein it needs.
“The double helix structure explains how DNA can be copied, but it does not explain how a gene works. In molecular terms, genes are coded DNA instructions that control the production of proteins within the cell. The first step in decoding these genetic messages is to copy part of the nucleotide sequence from DNA into RNA, or ribonucleic acid. These RNA molecules contain coded information for making proteins.” Page 300

The formation of proteins happens on the ribosomes, which are outside of the nucleus. The DNA does not leave the nucleus, so it must send a coded messenger, messenger RNA (mRNA) to the outside of the nucleus to code for the proteins that need to be made for the cell. There are several steps involved in the process.

Protein Synthesis =
TRANSCRIPTION

This is the process of copying the code of DNA into mRNA.

mRNA is responsible for taking the DNA code to the ribosomes, the site of protein synthesis.

mRNA is very similar in structure to DNA, but

1) it is single stranded
2) it has ribose as a sugar instead of deoxyribose
3) it has the base uracil instead of thymine.
The Process of Transcription:

1. The enzyme RNA Polymerase binds to the DNA molecule, breaking the bonds between the nitrogenous base pairs.

2. mRNA nucleotides in the nucleus assemble and form a single stranded mRNA molecule, which is complementary to the DNA molecule. Remember, URACIL replaces THYMINE on the RNA nucleotides.

3. The DNA molecule contains sequences of base pairs called promoters. These indicate to the RNA polymerase where to begin the mRNA sequence. Remember, there are 3 billion base pairs on a human genome! There are hundreds of thousands of gene sequences on a DNA molecule that need to be transcripted!

Let’s try a transcription practice strand:

**DNA:** T A C G G A A T C A T T A A G C C G

**mRNA:** A U G ___________________
Now that the mRNA has been coded from the DNA, the mRNA leaves the nucleus and goes to a ribosome outside of the nucleus.

It is time for TRANSLATION to begin. Translation is the synthesis of proteins from the mRNA code.

Proteins are made by joining amino acids into long chains called polypeptides. DNA codes for these amino acids, which are translated into mRNA.

The DNA codes the mRNA into codons, or three base sequences. Each codon represents an amino acid. Thus, it is the sequence of the codons that determines which protein will be formed.

The Process of TRANSLATION:  See page 304

1. After the mRNA moves out of the nucleus to the ribosome, translation can begin.

2. Translation begins at the “START” codon on the mRNA molecule: AUG (methionine). See page 303 for other codons/amino acids.

3. The complementary tRNA (transfer RNA) comes over to the ribosome and binds to the AUG codon. The tRNA molecule has a UAC on it. This code matches with AUG. Since AUG codes for methionine, methionine will be the first amino acid in this particular polypeptide chain. The UAC on the tRNA is called the “anticodon.”
4. The next codon is UUC. The tRNA anticodon that matches with this is AAG. Notice that the amino acid phenylalanine is attached to this tRNA molecule, and will be the next amino acid in the chain. Phenylalanine attaches to the methionine with a peptide bond, and the amino acid is released from the tRNA.

5. The process continues like an assembly line.

6. When the tRNA reaches a STOP codon, the polypeptide chain will remove itself from the mRNA and the protein is completed.

**tRNA: Transfer RNA**

tRNA’s job is to bring the appropriate amino acid to the mRNA strand. tRNA has an “anticodon” on it that matches with the codons on the mRNA.

tRNA is found abundantly in the cytoplasm.
Protein Synthesis Animation:
https://www.youtube.com/watch?v=nHM4UUVHPQM

THE BOTTOM LINE

DNA transcribes its code into mRNA, which travels to the ribosomes. tRNA brings amino acids to the mRNA and those amino acids are put together in a sequence that is dictated by the mRNA. The amino acids bind together and then fold on each other to form a protein.

Time to practice!!
#2 Should read...

Was given credit for discovering that DNA is a double helix and made a 3-dimensional model of the structure of DNA.