Measuring Up – Lesson # 8 “DNA”

**You will learn that DNA contains the genetic information that an organism passes on to its offspring. You will also examine the structure of a DNA molecule and see how DNA makes a copy of itself before a cell divides.**

The **DNA structure** consists of different building blocks that are put together to make a larger molecule that looks like a twisted ladder. The structure is known as a double helix.

A **nucleotide** is a building block of DNA. It is made of a sugar, a phosphate group, and a base.

**Replication** is the process by which a DNA molecule makes an exact copy of itself.

GUIDED INSTRUCTION: Directions – Read the following information and answer the questions.

One question that scientists had long asked is why offspring look like their parents. After all, everyone recognized that dogs always have puppies, and that cats always have kittens. Scientists, however, recognized that there must be something inside cells that carries specific instructions from one generation to the next. Today we know that these instructions make up the genetic information of an organism and that these instructions determine the traits of an organism.

Most scientists suspected that proteins carried the genetic information because proteins can be quite complex. Proteins are made from amino acids, and the 20 amino acids can be arranged in a great variety of ways to make a protein. Just think how many words are formed from just the 26 letters of the alphabet. Scientists reasoned that the genetic information must be complex because of all the traits an organism can have. Proteins seemed to be the logical choice. Few scientists suspected that DNA carried the genetic information. Compared to proteins, DNA is a rather simple molecule. Yet, DNA turned out to be the molecule that carries the genetic information. Once DNA was identified as the molecule involved in heredity, scientists raced to determine its structure. Today we know that the **DNA structure** consists of various building blocks that are arranged to form larger molecules. DNA was first isolated from cells in 1869. By the 1950’s, scientists had determined that **nucleotides** are the building blocks of DNA.

GUIDED QUESTION: (1) Why were proteins and not DNA considered to carry the genetic information?

A nucleotide consists of a sugar called deoxyribose and a phosphate group, which consists of a phosphorous atom surrounded by oxygen atoms. A nucleotide also contains a nitrogen-containing base. There are four nitrogen-containing bases in DNA – adenine, thymine, guanine, and cytosine. Because there are four nitrogen-containing bases, there are also four different DNA nucleotides. These also are called adenine, thymine, guanine, and cytosine nucleotides. These four nucleotides are usually abbreviated A, T, G, and C respectively. In addition, to the nucleotides, all four nucleotides contain the same sugar and phosphate group. These same components make up the genetic code of all organisms. You can see the structures of the four DNA nucleotides below. (See workbook page 53)

GUIDED QUESTION: (2) Identify the three parts of a DNA **nucleotide**.

GUIDED QUESTION: (3) What do the letters A, T, G, and C represent when referring to the **DNA structure**?

Notice in the diagram that A and G are slightly larger than T and C with respect to the sizes of their nitrogen-containing bases. This fact would be an important clue as to how these four nucleotides are assembled to make a DNA molecule. Another clue came in 1950 when Edwin Chargaff discovered that the amount of A equals the amount of T in the DNA of an organism. Similarly, the amount of G equals the amount of C. This observation is sometimes written mathematically as A=T and G=C. In other words, if you know the amount of G in an organism’s DNA, then you know the amount of C that is also present. The reverse is also true.

GUIDED QUESTION: (4) What were two clues used to determine the structure of the DNA molecule?

In 1953, two scientists, James Watson and Francis Crick, put together all the pieces of the puzzle to determine the structure of the DNA molecule. They arranged the nucleotides into a structure called a double helix. Think of a double helix as a twisted ladder. Each side of the ladder consists of a chain of deoxyribose sugars and phosphate groups joined to one another in an alternating pattern. The two chains of alternating sugars and phosphates form the sides of the DNA molecule. The ste4ps of the ladder are made of two bases, which are always formed of A-T and G-C pairs. The sides and steps are twisted to form the double helix. You can see the illustration that the double helix actually consists of two DNA strands that are twisted around each other. (See workbook picture on bottom of page 53)

GUIDED QUESTION: (5) What term is used to describe the structure of a DNA molecule?

Watson and Crick recognized that their double helix model could explain how a complete set of genetic instructions is passed on when a cell undergoes mitosis. Each chromosome makes a copy before mitosis begins. This means that each DNA molecule must be copied. The process of copying DNA is known as **replication**. Watson and Crick predicted how replication occurs.

GUIDED QUESTION: (6) What is **replication**?

Step 1 – The double helix unwinds, and the two strands that make up the double helix separate. Each strand then contains an unpaired nucleotide. The process is aided by enzymes, which break the bonds that link the nitrogen bases between the two strands. Additional enzymes prevent the double helix from twisting back into shape.

Step 2 – A different kind of enzyme attaches and moves along each DNA strand. As it does this, nucleotides from within the cell are added to the exposed rungs of the ladder. New pairs form with the exposed nucleotides on each separated strand. If the unpaired nucleotide is A, then only T can form a pair with it. If the unpaired nucleotide is G, then only C can pair with it.

Step 3 – The enzyme remains attached to the DNA strand until all of the DNA is copied. It then detaches. The process has produced two DNA molecules. Each is mad eup of an original strand and a new strand. The two DNA molecules are identical to each other and to the original strand. These steps are summarized in the illustration. (See workbook picture page 54)

GUIDED QUESTION: (7) What would be the sequence of **nucleotides** that pair with GCA?

Replication is not a simple process that begins at one end of a DNA molecule and finishes at the other end. Rather, it occurs simultaneously at various places along the DNA molecule. In addition, mistakes are made. Fortunately, enzymes correct almost all these mistakes.

SHORT ANSWER QUESTIONS: Directions – Answer the following questions

1. The structure of the DNA molecule is built based on a base-pairing rule. What is this rule?
2. When must the process of replication in a cell be complete? EXPLAIN the reason for your answer?
3. What is the shape of a DNA molecule? How do base pairs fit into the shape?
4. Describe the contribution that Watson and Crick made to understanding the structure of the DNA molecule.

APPLY THE TEKS: Directions – Read the paragraph, study the diagram (See workbook page 56), and answer the questions.

The same four nucleotides make up the DNA of all organisms, including both prokaryotes and eukaryotes. The table below (See workbook page 56) shows the relative proportions (percentage) of each nucleotide in various organisms.

1. Which organism has the greatest difference in the relative proportions of nucleotides compared to human DNA?
2. Do the data in this table support the conclusion that a particular base pair combination is found in more complex organisms? EXPLAIN your answer.
3. Which organism is closest to having an equal percentage of each DNA nucleotide?
4. What conclusion can you make from the data in this table?

STAAR PRACTICE: Directions – Read each question and choose the best answer.

1. Assume that the DNA of an organism contains 20% adenine (A). What percentage of guanine (G) would be in this DNA?
   1. 20% b. 30% c. 60% d. 80%
2. Which of the following represents the building block of a DNA molecule?
   1. Nitrogen-containing base
   2. Phosphate group
   3. Deoxyribose sugar
   4. Nucleotide
3. What would you expect to find in all organisms?
   1. The same genetic information
   2. The same sequence of DNA nucleotides in the DNA molecules
   3. The same percentages of DNA base pairs
   4. The same four DNA nucleotides
4. When DNA replicates, what would be the sequence of nucleotides made from the following sequence: GCTATG
   1. CGATAC b. GCTATG c. CCTATC d. GCATTG
5. What must happen first when DNA replicates?
   1. G must pair with C
   2. G must pair with T
   3. G must separate from C
   4. G must separate from T

CUMULATIVE REVIEW: Directions – Read each question and choose the best answer.

1. A DNA nucleotide consists of three smaller units. Which type of biomolecule represents one of these smaller units?
   1. Carbohydrate
   2. Lipid
   3. Protein
   4. Nucleic acid
2. In which organelle does DNA replication occur?
   1. Cell membrane
   2. Cell wall
   3. Ribosome
   4. Nucleus
3. Errors that are made in replication are usually corrected. What process does this illustrate?
   1. Respiration
   2. Transport
   3. Homeostasis
   4. Fermentation
4. Replication produces two DNA molecules from one DNA molecule. What process does this represent?
   1. Catalysis
   2. Homeostasis
   3. Transport
   4. Synthesis