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# DNA -- The Double Helix

#### What is DNA?

We all know that elephants only give birth to little elephants, giraffes to giraffes, dogs to dogs and so on for every type of living creature. But why is this so? The answer lies in a molecule called deoxyribonucleic acid or DNA. DNA is the basic substance of heredity and contains the instructions needed for an organism to develop, survive and reproduce. DNA is what makes each species unique. DNA, along with the instructions it contains, is passed from adult organisms to their offspring during reproduction. All living organisms contain DNA.

#### Where is DNA found?

In organisms called eukaryotes, DNA is found inside a special area of the cell called the nucleus. Because the cell is very small, and because organisms have many DNA molecules per cell, each DNA molecule must be tightly packaged. This packaged form of DNA is called a chromosome. Chromosomes are found in the nucleus of eukaryotic cells. Remember that prokaryotic cells do not have a membrane-bound nucleus. They do have DNA, but it is simply found floating in the cytoplasm in the area near the center of the cell referred to as the nucleoid region.

Who discovered DNA?

The Swiss biochemist Frederich Miescher first observed DNA in the late 1800s. But nearly a century passed from that discovery until researchers unraveled the structure of the DNA molecule and realized its central importance to biology. For many years, scientists debated which molecule carried life's biological instructions. Most thought that DNA was too simple a molecule to play such a critical role. Instead, they argued that proteins were more likely to carry out this vital function because of their greater complexity and wider variety of forms. The importance of DNA became clear in 1953 thanks to the work of James Watson, Francis Crick, Maurice Wilkins and Rosalind Franklin. By studying X-ray diffraction patterns and building models, the scientists figured out the double helix structure of DNA - a structure that enables it to carry biological information from one generation to the next.

#### What is the DNA double helix?

Scientist use the term "double helix" to describe DNA's winding, two-stranded chemical structure. This shape - which looks much like a twisted ladder - gives DNA the power to pass along biological instructions with great precision. To understand DNA's double helix from a chemical standpoint, picture the sides of the ladder as strands of alternating sugar and phosphate groups - strands that run in opposite directions. Each "rung" of the ladder is made up of two nitrogen bases, paired together by hydrogen bonds. The four types of nitrogen bases found in DNA are: adenine (A), thymine (T), guanine (G) and cytosine (C). Because of the highly specific nature of this type of chemical pairing, base A always pairs with base T, and likewise C with G. So, if you know the sequence of the bases on one strand of a DNA double helix, it is a simple matter to figure out the sequence of bases on the other strand. The order, or sequence, of these bases determines what biological instructions are contained in a strand of DNA. For example, the sequence ATCGTT might instruct for blue eyes, while ATCGCT might instruct for brown. The complete DNA instruction book, or genome, for a human contains about 3 billion bases and about 20,000 genes on 23 pairs of chromosomes.

## DNA is Organized Into Chromosomes

The long molecules of DNA in your cells are organized into pieces called chromosomes. Humans have 23 pairs of chromosomes or 46 chromosomes. Other organisms have different numbers of pairs - for example, chimpanzees have 24 pairs. The number of chromosomes doesn't determine how complex an organism is - bananas have 11 pairs of chromosomes, fruit flies have only 4 and the organism with the most chromosomes is a species of fern that has 630 chromosome pairs.

Chromosomes are Organized Into Genes

Chromosomes are further organized into short segments of DNA called genes. Each gene codes for a specific trait. If you imagine your DNA as a cookbook, then your genes are the recipes. Written in the DNA alphabet - A, T, C, and G - the recipes tell your cells how to function and what traits to express. The size of a gene may vary greatly, ranging from about 1,000 nitrogen base pairs to 1 million base pairs in humans. For example, if you have curly hair, it is because the genes you inherited from your parents are instructing your hair follicle cells to make curly strands.

Genes Make Proteins

Cells use the recipes written in your genes to make proteins - just like you use recipes from a cookbook to make dinner. Proteins are the complex molecules that do much of the work in your cells and your body as a whole. Some proteins give cells their shape and structure. Others help cells carry out biological processes like digesting food or carrying oxygen in the blood. Using different combinations of the As, Cs, Ts and Gs, DNA creates the different proteins - just as you use different combinations of the same ingredients to make different meals.

How Does DNA copy itself?

DNA's unique structure enables the molecule to copy itself during cell division. When a cell prepares to divide, the DNA helix splits down the middle and becomes two single strands. These single strands serve as templates for building two new, double-stranded DNA molecules - each a replica of the original DNA molecule. In this process, an A base is added wherever there is a T, a C where there is a G, and so on until all of the bases once again have partners. DNA needs to copy itself when a cell divides, so that the new cells each contain a copy of the DNA. Without these instructions, the new cells wouldn't have the correct information.

What is Messenger RNA?

We know the nucleus controls the cell's activities through the chemical DNA, but how?  It is the sequence of bases that determine which protein is to be made.  The sequence is like a code that we can now interpret.  The sequence determines which proteins are made and the proteins determine which activities will be performed.  This is how the nucleus is the control center of the cell.  The only problem is that the DNA is too big to go through the nuclear pore, so a chemical is used to read the DNA in the nucleus.  That chemical is messenger RNA.   The messenger RNA (mRNA) is small enough to go through the nuclear pores.  It takes the "message" of the DNA to the ribosomes and "tells them" what proteins are to be made.  Recall that proteins are the body's building blocks. Imagine that the code taken to the ribosomes is telling the ribosome what is needed - like a recipe. Messenger RNA is similar to DNA, except that it is a single strand, and it has no thymine. Instead of thymine, mRNA contains the base Uracil. In addition to that difference, mRNA has the sugar ribose instead of deoxyribose. RNA stands for Ribonucleic Acid.

The Future of DNA

Although much work remains in genetics, it has become apparent that a cell has the ability to turn off most genes and only work with the genes necessary to do its job.  We also know that a lot of DNA apparently is nonsense and codes for nothing.  Scientists finished mapping the entire Human Genome in 2003. With this knowledge, scientists are now researching ways that they can change a person’s DNA in order to help cure genetic diseases.