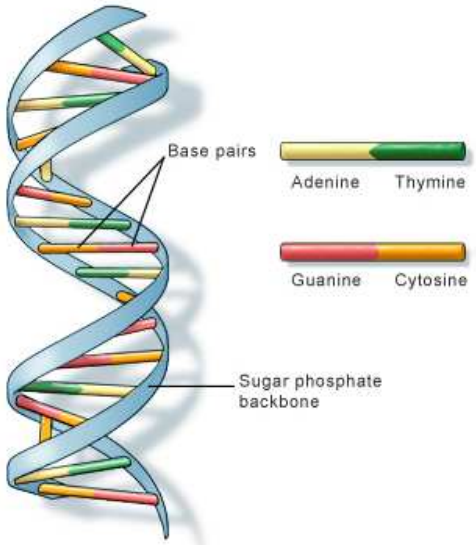
DNA

WHAT IS DNA?

If you have seen images of DNA before, you probably saw it in a shape or form similar to that of a double helix. The "**double helix**" is how DNA is most often found in living cells. In every double helix, there are actually two long strands (filaments) of DNA; you will often hear scientists refer to a double helix as a double-stranded (which has two filaments) DNA molecule.

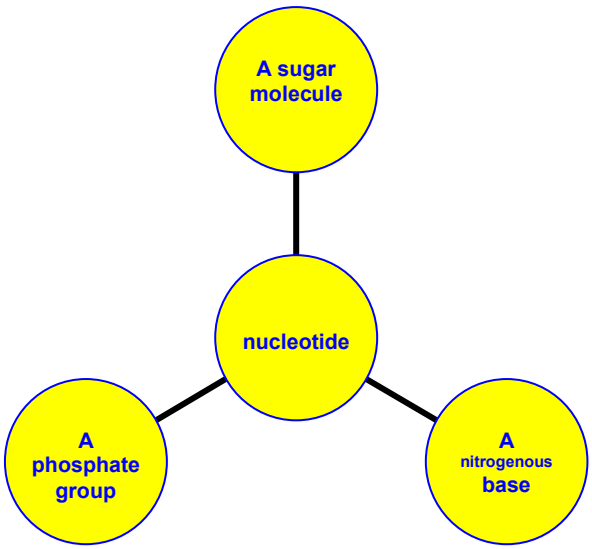


WHAT IS THE STRUCTURE OF DNA?

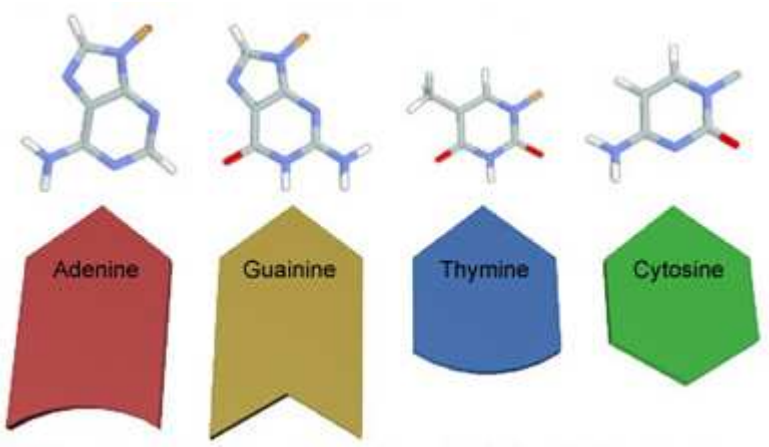
The name DNA stands for deoxyribonucleic acid

By breaking down the name, we can understand the structure of the molecule. DNA is a long string (set) of **nucleotide** units attached to one another.

In a single nucleotide there are three components:



The nitrogenous bases are what make DNA variable. There are 4 different types of bases in DNA:



Each one of the bases is chemically distinguishable (different) from the others; **it is the variability of these bases that constitutes the genetic code**.

Unlike (different from) the four nitrogenous bases, the sugars and phosphates remain the same throughout (everywhere in) the DNA molecule. In a single nucleotide, the sugar is attached at one end to a phosphate group. **Because the sugar of that nucleotide can attach to another phosphate at its other end, we can string together many nucleotides in a long chain**. This gives us a complete DNA molecule: a structural backbone (spinal column) of deoxyribose sugars linked by phosphate groups, with an orderly sequence of nitrogenous bases sticking out (projecting) of the sugars toward the middle of the helix. In terms of our double helix, the single strand provides one-half of the spiraling (which has the form of a spiral) molecule.

WHY IS DNA SO IMPORTANT?

What makes **DNA** so exciting to scientists is that it **shows how living organisms store (keep for future use) information in biological molecules**.

The structural backbone creates a simple, consistent (steady) chain upon which many, many bases can be laid out (placed) in an orderly, linear sequence. If we think of these four bases – A, T, G, and C – as the "letters" of a genetic "alphabet," we have the building blocks necessary to encode lots of information within these relatively compact DNA molecules.

DNA shows how living organisms can pass information to their offspring (descendants). DNA tells us how a child can be born with "his mother's eyes," for example, or "his father's nose."

HOW CAN A DNA MOLECULE EVER PROVIDE ENOUGH INFORMATION FOR A LIVING ORGANISM?

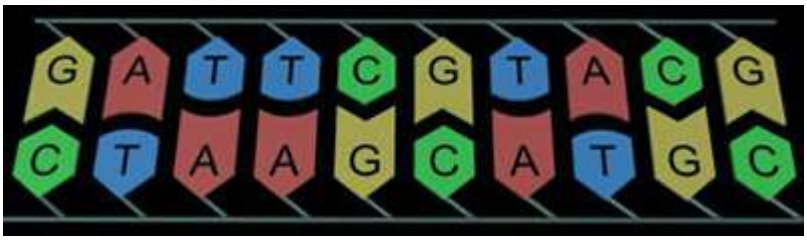
The simple answer is that DNA molecules are very, very long. For example, the DNA molecule of a simple bacteria called *E. Coli* is four million nucleotides long. **We can think of DNA as a "genetic database" for organisms**.

WHAT ARE COMPLEMENTARY STRANDS?

In order to understand the double helix we must first go back to our original DNA strand with its sugar and phosphate backbone. Each connection between a sugar and a phosphate group is at an angle. The end (final) result is a backbone that is curved rather than straight, and hence the DNA chain spirals around itself.

The bases jut (extend) inward (toward the interior) from the backbones, looking almost like **the steps of a spiral staircase**.

The four bases pair up with one another in a particular way: **adenine (A) always pairs with thymine (T), and guanine (G) always pairs with cytosine (C**).



In summary, a double helix of DNA is composed of two spiraling, complementary strands of DNA. Each strand is composed of a sugar and phosphate backbone with varying (different) nitrogenous bases sticking in (inserting) towards (to) the centre. The two strands are joined together at the centre by pairing bases lined up (in the same line) with one another.

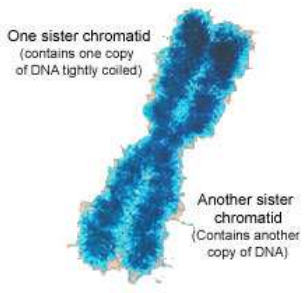
The double helix is important because it preserves all of the information-carrying features of a single DNA strand while at the same time introducing elements that make it easier for living cells to make copies of their DNA.

WHAT IS A CHROMOSOME?

Chromosomes are bundles (masses) of DNA

Most of the time DNA is spread out (distributed) in a large, diffuse mass. When a cell needs to produce more cells, it does so by dividing in two. Before cell division, the DNA condenses into the thick, rod-like (stick) form that we recognize as **chromosomes**. **Chromosomes have several important features (properties).** The DNA packs so tightly (closely) that one can see it under a simple light microscope.

- The DNA of a visible chromosome has already been duplicated, so that each successor cell will have its own copy. This means that, on close inspection, **a cell that is ready to divide will have four strands of DNA, two helices of two strands each**. Each of these double strands of DNA condenses into a single rod called a **sister chromatid**. The two chromatids are therefore exact replicas of one another, and the centre of each is joined together prior to the division of the cell. As a result, **most chromosomes take on the appearance of the letter X**.



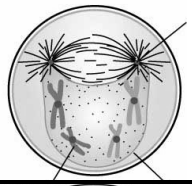
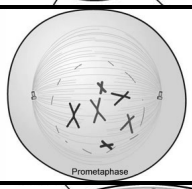
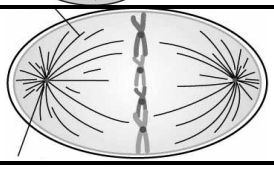
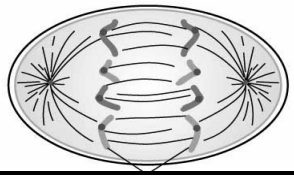
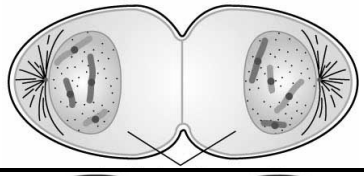
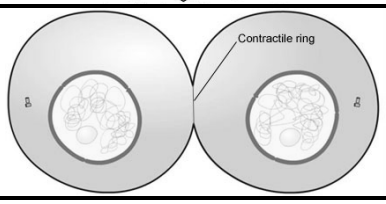
HOW IS DNA PASSED ON TO NEW CELLS?

In earlier sections, we have seen that DNA is a molecule found in living cells that contains the chemical code of heredity. Because all cells, whether they are nerve cells, muscle cells, skin cells, etc., have the same DNA, all of this **DNA must be passed on when cells replicate during the process of cell division**.

Cells start dividing from the time a **zygote** is formed (the single cell that results from the fusion of egg and sperm in animals, or from pollen and ova in plants), allowing (permitting) it to develop and grow. Most of the cells in our body undergo (pass through) a type of division called **mitosis**, in which **one cell fully replicates its DNA and then divides into two identical daughter cells**.

Mitosis: The entire process of cell division including division of the nucleus and the cytoplasm.

Mitosis consists of several programmed stages

Stage number	Stage name	What happens
1	interphase	Interphase is the stage in which the cell spends the most time. You can think of **interphase** as the **preparatory stage of mitosis**.
2	prophase	 During prophase DNA condenses into chromosomes.
3	prometaphase	 During prometaphase the nuclear membrane breaks down.
4	metaphase	 During metaphase the chromosome line up on the equator of the cells.
5	anaphase	 During anaphase the chromosome are pulled to the cell poles.
6	telophase	 During telophase, new nuclear membranes develop around the separated DNA material. The cell starts to divide into two.
7	cytokinesis	 Thanks to a contractile ring, the mother cell is divided into identical daughter cells.

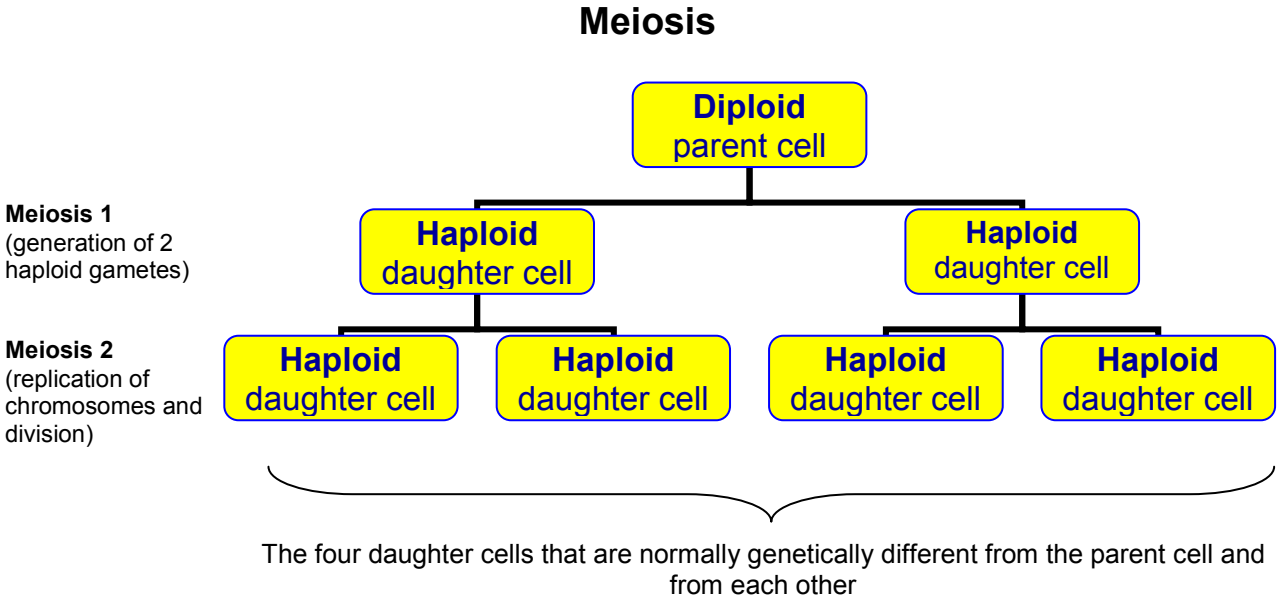
HOW IS DNA PASSED ON TO THE NEXT GENERATION?

When humans reproduce, they pass on their genetic information to their offspring (descendants). However, if each parent passed on his or her entire genetic code, their child would have twice as many (a double number of) chromosomes as each parent. If this pattern (model) were to continue, the number of chromosomes would double each and every generation, which would quickly become unworkable (not practicable) for cells. **In order for a baby to have a non-increasing number of chromosomes, he or she must receive half the normal number of chromosomes from each parent**.

Therefore, the reproductive cells known as eggs in adult females and sperm in adult males (collectively termed **germ cells**) must have only **half the normal number of chromosomes**. **Gametes** have only 23 chromosomes instead of 23 pairs (46 chromosomes total) like the rest of the cells in our body.

- **Haploid cells** (have 23 chromosomes)
- **Diploid cells** (have 46 chromosomes)

Meiosis is process of cell division that reduces the number of chromosomes in reproductive cells from diploid to haploid.



WHAT IS GENETIC VARIATION?

Each of the four daughter cells resulting from meiosis is unique. Unlike the daughter cells resulting from mitosis, the products of meiosis are not identical to each other or to the parent cell.

By creating distinctive germ cells each with only one chromosome of each kind (remember this is called **haploid**) the genetic information of the parent cell is reshuffled (rearranged).

Each daughter cell receives a random mixture of maternal and paternal chromosomes, which leads to **a huge number of possible combinations.**

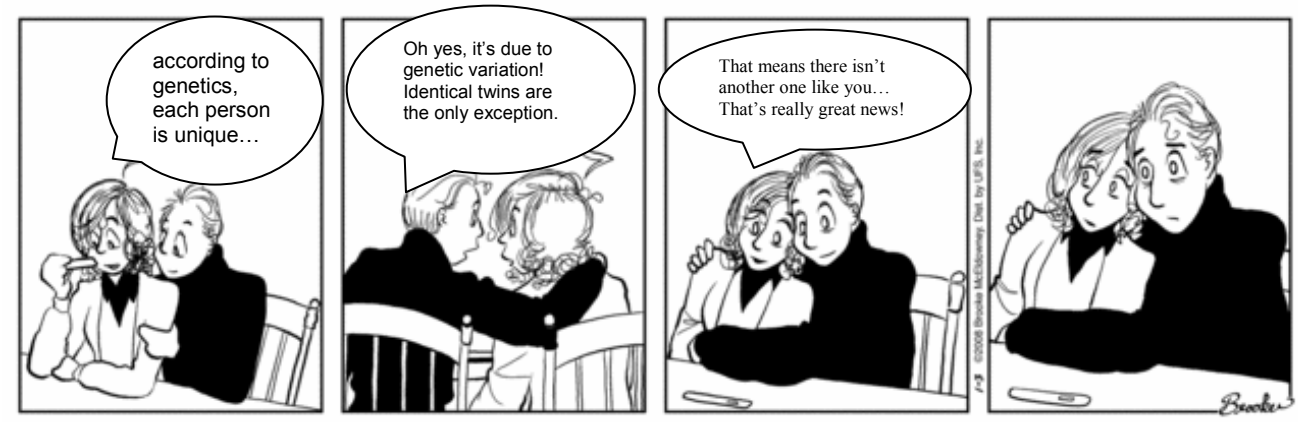
WHY IS GENETIC VARIATION IMPORTANT?

Geneticists generally agree that species, such as humans, that reproduce sexually (and make use of independent assortment and recombination) have a competitive advantage over species that reproduce asexually and basically clone themselves. Sexual reproduction leads to immense **genetic variation**, and therefore immense variation in the individuals that are produced.

Evolutionary theory suggests that when environments (The totality of things around an organism or group of organisms) are highly variable there is an advantage to producing variable offspring: then it is likely that at least some of the offspring will be able to survive the environmental challenges that arise (result).

Mutations, or changes in the genetic code, appear frequently in humans and are an important source of variation.

In conclusion, **genetic variation is crucial to the evolution and survival of all species**. Its advantages to living organisms have encouraged the evolution of complex and elegant processes of chromosome shuffling within dividing cells during the process of meiosis. These same processes also serve to make each of us genetically unique, except in the special case of identical twins.



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