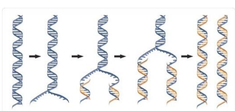
Heredity

All living things share similar genetic information.

DNA contains all the genetic information to replicate an organism.

DNA is a double stranded molecule in the form of a double helix. The DNA molecules (46 strands for humans) within each cell of an organism make up its genome.

During replication, all DNA molecules in the cell can unzip in small sections at a time. The unzipped portion separates into two strands each of which serves as a template to make two new single strands of DNA that pair with the original strands. Once the process is complete there are two DNA molecules, each with an old strand and a new strand of DNA.



When DNA does not make exact copies during replication, mutations can occur that may affect the resulting proteins in a beneficial, harmful, or silent way.
MS-LS3-1

During protein synthesis, a portion of a molecule of DNA can unzip in small sections at a time. The unzipped portion serves as a template to make a single stranded molecule called RNA. This is known as transcription.

There are different types of RNA.

Other types of RNA are used by scientist in CRISPR (a gene editing technology) and have the potential to cure diseases.

Messenger RNA molecules (mRNA) have the instructions to make proteins, which are chains of amino acids.

Transfer RNA molecules (tRNA) have the ability to bond to specific amino acids (designated by their structure) and transport them.

mRNA vaccines saved many live during the COVID pandemic and are the future of vaccination.

Each tRNA, one after another, transports its specific amino acid, attaches to mRNA and drops off its amino acid. This process of forming a protein is called translation.

Proteins determine body structure and function.

Genes are small sections of DNA.

Genes are passed down from parent to offspring, which is known as heredity.

Typically, organisms have 2 copies of each gene (genotype), which, along with the environment, determine the organism's traits (phenotype).
3-LS3-2

Some phenotypes are influenced by more than one gene (ex: height). In these cases, the environment still plays a factor.

The two copies of each gene, alleles, can be the same (ex: AA or aa) or different (ex: Aa).

More than two alleles for a gene may be present in the population as a whole, resulting in more variations of a trait (ex: hair color can be red, brown, blonde, etc.).

Mating can redistribute allele frequencies in the offspring and, therefore, in the overall population.

The dominant variation will be expressed when one or both alleles of its associated form is present in the organism (ex: AA or Aa).

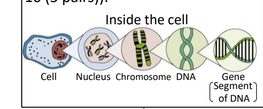
The recessive variation will only be expressed if both alleles of its associated form are present in the organism (ex: aa).

Most allele relationships are more complicated than simple inheritance patterns (dominant/recessive).

Co-dominance is where two different alleles are active, and both of their variations are expressed (ex: blood type AB).

Incomplete dominance is when an offspring receives two different alleles and the variation expressed is a blend of the original variations (ex: white + red = pink snapdragon flowers).

Chromosomes are composed of DNA (the genetic material) tightly wound around proteins. Chromosomes are located in the nucleus of a cell. Organisms of the same species have the same number of chromosomes (ex: humans 46 (23 pairs) or fruit flies 10 (5 pairs)).



The passing down of chromosomes (reproduction) can occur via two mechanisms.

Sexual reproduction is when each parent passes on a copy of one of each pair of chromosomes to their offspring.
MS-LS3-2

Offspring from sexual reproduction are similar to, but not exactly like, their parents and siblings.
1-LS3-1, 3-LS3-1

Asexual reproduction is when a parent passes on a copy of their chromosomes to their offspring.
MS-LS3-2

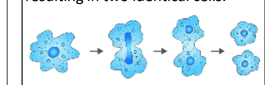
Offspring from asexual reproduction are the same as their parents and siblings.

For sexual reproduction you need a male gamete (ex: sperm) and a female gamete (ex: egg) to combine. Gametes can be formed when reproductive cells divide.

When a cell is not dividing, the DNA, composed of 46 molecules of different lengths, and protein are not packaged into chromosomes. Instead, they are loosely associated and are called chromatin. The chromatin makes the DNA more accessible and allows for DNA replication.

When a cell divides for proliferation or for asexual reproduction, two cells are formed with identical sets of chromosomes.

Asexual reproduction for single-celled organisms can occur via binary fission where a cell duplicates its DNA and divides, resulting in two identical cells.

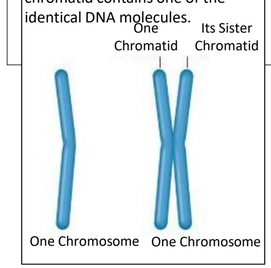


Reproductive Cell Mechanism:
Chromosomes (sister chromatids) that came from the mother, pair with their similar chromosomes that came from the father to form 23 homologous pairs. These pairs can exchange genetic information via crossing over (recombination) and then are pulled apart. This results in two cells each having 23 chromosomes which may have a new combination of the original genetic information in them.

If a cell has a membrane- bound nucleus, depending on the type of cell (reproductive or body), there are two mechanisms to produce new cells. Cells can only perform one of the two mechanisms.

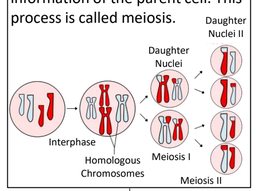
In preparation for cell division, the chromatin tightly coils to make 46 chromosomes in humans. Each chromosome contains two identical DNA molecules, but the DNA molecules of each chromosome are unique.

The chromosomes then separate into sister chromatids held together at one location. These are still known as chromosomes (you now have 92 chromatids, but still have 46 chromosomes). Each sister chromatid contains one of the identical DNA molecules.



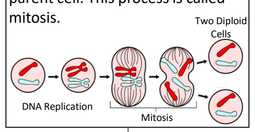
Within each of these two new cells the chromosomes (sister chromatids) randomly line up and are pulled apart. They are now referred to as separate chromosomes. The cell then divides resulting in two new cells each having 23 chromosomes.

This process results in four haploid reproductive cells (gametes). These contain only half of the genetic information of the parent cell. This process is called meiosis.



Male and female gametes combine (fertilization) to create a diploid cell with a mixture of parental DNA.

Body Cell Mechanism:
Chromosomes (sister chromatids) randomly line up and are pulled apart. They are now referred to as separate chromosomes. The cell then divides resulting in two cells each having 46 chromosomes. These "daughter" cells have identical genetic information as the parent cell. This process is called mitosis.



Mitosis results in two diploid body cells. These contain a complete set of 46 chromosomes.