DNA - Transmitter of Genetic Code

DNA is the inherited material responsible for variation. Captive breeding programs enable scientists to control populations of species at risk of extinction. Using modern technology, geneticists and staff from zoos around the world can analyze the genetic code of the species they are trying to save and use it to introduce variation that will help the species survive when the environment changes.

Characteristics are passed on from one generation to another within a species through the genetic code of the parents. This genetic code is called DNA. DNA The blueprint that is passed on from the parents to the offspring is found in a molecule of the cell nuclei. This molecule, *deoxyribonucleic acid*, (DNA) is the inherited material responsible for variation. All living organisms contain DNA in their cells.

DNA and the Genetic Code

The 1962 Nobel Prize
Physiology / Medicine

In the early 1950s, the race to discover the structure of DNA was on. ... "for their discoveries concerning the **molecular structure of nucleic acids** and its significance for information transfer in living material"

Francis Crick

James Watson

Maurice Wilkins

Rosalind Franklin

DNA was discovered prior to 1944. All DNA molecules contain exactly the same chemicals, but the way the chemicals combine determines the characteristics of the organism. **James Watson** and **Francis Crick** unraveled the structure of DNA, revealing the key to the multitude combinations of variation that are possible.

At Cambridge University, graduate student Francis Crick and research fellow James Watson had become interested, impressed especially by Pauling's work. Meanwhile at King's College in London, **Maurice Wilkins** and **Rosalind Franklin** were also studying DNA. The Cambridge team's approach was to make physical models to narrow down the possibilities and eventually create an accurate picture of the molecule. The King's team took an experimental approach, looking particularly at x-ray diffraction images of DNA.

In 1951, Watson attended a lecture by Franklin on her work to date. She had found that DNA can exist in two forms, depending on the relative humidity in the surrounding air. This had helped her deduce that the phosphate part of the molecule was on the outside. Watson returned to Cambridge with a rather muddy recollection of the facts Franklin had presented, though clearly critical of her lecture style and personal appearance. Based on this information, Watson and Crick made a failed model. It caused the head of their unit to tell them to stop DNA research. But the subject just kept coming up.

Franklin, working mostly alone, found that her x-ray diffractions showed that the "wet" form of DNA (in the higher humidity) had all the characteristics of a **helix**. She suspected that all DNA was helical but did not want to announce this finding until she had sufficient evidence on the other form as well. Wilkins was frustrated. In January, 1953, he showed Franklin's results to Watson, apparently without her knowledge or consent. Crick later admitted, "I'm afraid we always used to adopt -- let's say, a patronizing attitude towards her."

Watson and Crick took a crucial conceptual step, suggesting the molecule was made of two chains of nucleotides, each in a helix as Franklin had found, but one going up and the other going down. Crick had just learned of Chargaff's findings about base pairs in the summer of 1952. He added that to the model, so that matching base pairs interlocked in the middle of the double helix to keep the distance between the chains constant.

Watson and Crick showed that each strand of the DNA molecule was a template for the other. During cell division the two strands separate and on each strand a new "other half" is built, just like the one before. This way DNA can reproduce itself without changing its structure -- except for occasional errors, or mutations.

The structure so perfectly fit the experimental data that it was almost immediately accepted. DNA's discovery has been called the most important biological work of the last 100 years, and the field it opened may be the scientific frontier for the next 100. By 1962, when Watson, Crick, and Wilkins won the Nobel Prize for physiology/medicine, Franklin had died. The Nobel Prize only goes to living recipients, and can only be shared among three winners. If she were alive, she would have been included in the prize.

The DNA molecule is like a ladder twisted into a spiral (see image). The sides of the ladder are the same in all DNA molecules, but the rungs are what make the variations. Each rung pairs up two of the following chemicals: guanine (G), cytosine (C), adenine (A) and thiamine (T). The arrangement of these four chemicals creates the code that the cells are able to interpret. This is the genetic code of the organism.

Chromosomes

DNA contains all the instructions, which create the organism's characteristics. The multitude of characteristics for each organism means that there is a lot of DNA in any one cell. This DNA is arranged in the cell in compact packages, called chromosomes. Every human cell contains 46 chromosomes. In order to have a complete human organism, all 46 of the chromosomes must be present. Not all organisms have the same number of chromosomes (Dogs have 78, cats have 38). Every cell of a human contains 23 pairs of chromosomes (dogs 39, cats 19). Not all of the chromosomes from species to species are the same, which accounts for the different characteristics between the species.

Genes

A single **gene** is an uninterrupted segment of DNA, which contains the coded instructions for the organism. Researchers found out that (by working on the fruit fly):

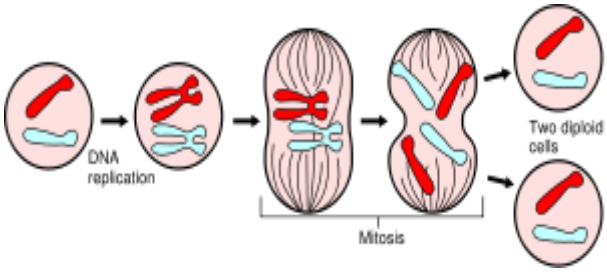
- Genes are located in the chromosomes
- Each chromosome has numerous gene locations
- Genes come in pairs
- Both genes in a pair carry DNA instructions for the same thing
- Specific characteristic genes occupy matching locations on the two chromosomes
- DNA code may not be exactly the same in both locations

Offspring inherit genes from both parents. The genes exist in an array of possible forms that differ as to their exact DNA sequence. These variations in forms are called **alleles**. The ultimate combination of the chromosome pair is what makes the variation possible - combining the different variations of different characteristics to create a unique variation.

Cell Division

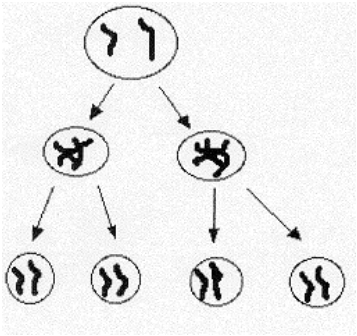
Cell Division and Asexual Reproduction

Asexual reproduction involves only one parent. All of the offspring are genetically identical to the parent. In single celled organisms, **binary fission** enables the parent cell to split its contents equally between the two new cells. Prior to this division, the parent cell duplicates its DNA and when the split takes place each new cell receives a complete exact copy of the DNA, of the parent. In multi-cellular organisms the process that produces two new cells with the same number of chromosomes is called **Mitosis**.



Cell Division and Sexual Reproduction in Plants and Animals

Sexual reproduction usually involves two individual organisms. The offspring that are produced from this union have genetically different characteristics, half from one parent and the other half from the other parent - making a unique offspring. During sexual reproduction, the specialized sex cells (gametes) unite to form a zygote, which develops into the new organism. When a male gamete and a female gamete unite, meiosis takes place. **Meiosis** is a type of cell division that produces cells with only half the DNA of a normal cell. This process involves two cell divisions, not one.



Patterns of Inheritance (Gregor Mendel)

Long before the science of genetics started, people tried to reproduce organisms with only the most preferred traits, by allowing only those organisms with the desirable traits to reproduce. This method was not always successful, but through time (trial and error), this practice of controlled breeding provided scientists with the information to determine which alleles were responsible for specific traits.

Purebred VS Hybrid

To produce purebred organisms, a breeder would choose pure bred parents, those parents whose ancestors have produced only the desired characteristic they want (true-breeding). If a breeder chooses two different 'true-breeds' then a hybrid would be produced.

Dominant Traits

Crossbreeding two different true-breeds will result in all of the offspring having the same characteristic, that is, the dominant trait. Only the DNA instructions for the dominant trait will be carried out.

Recessive Traits

When crossbreeding hybrids, the average results will produce 75% of the offspring with the dominant trait and 25% of the offspring with the recessive trait, because there are only 4 possible combinations. One traits is recessive and therefore the allele is recessive. A recessive trait only appears in the offspring if two recessive alleles are inherited. **[Punnit Squares]**

Other Patterns of Inheritance

- Incomplete dominance occurs because the dominant-recessive pattern does not always prevail. When the alleles are neither dominant, nor recessive, an intermediate trait will occur (combining the two traits).

- Offspring Unlike Either Parent. More than one gene location and more than one allele may be responsible for specific traits. As a result, the complex mixing of the possible combinations for that particular trait may account for the variation of traits an offspring has.

- Environmental Factors can also have a bearing on how DNA is interpreted and developed. Fetal alcohol syndrome can be a direct result of alcohol consumption during the developing stages of the offspring. The 'normal' DNA is affected by the alcohol and will not develop normally. Taking drugs can also affect the DNA during normal development and defects in the organism can occur. (Thalidomide)