Genes: The Heredity Code

Glossary

TERM	DEFINITION
DNA	
enzyme	*a substance that acts as a catalyst for chemical reactions in living things*
gene	
allele	*an alternate form of a specific gene*
homozygous	
heterozygous	
dominant gene	
recessive gene	
genotype	
phenotype	
meiosis	*a type of cell division that yields four haploid daughter cells*

Objective

In this lesson, you will ____

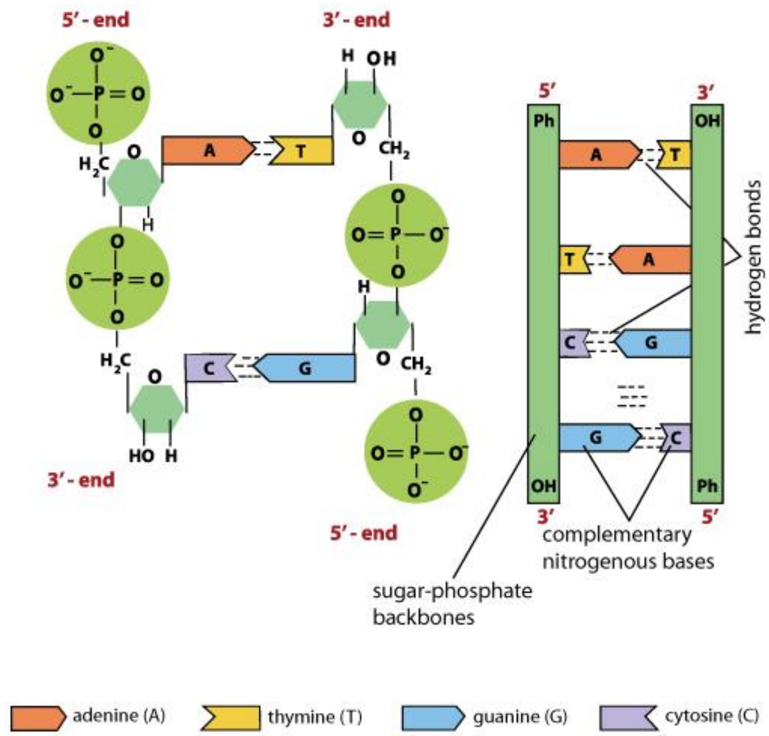
____.

DNA Replication

To pass on genetic information from parent to offspring or to grow new cells, a cell has to replicate its ________. DNA replication occurs near the end of ____________________, before cell division begins.

DNA Structure

> A DNA molecule consists of ________ polynucleotide strands that are wound around each other to form a double ________.



- Each nucleotide is made of a five-carbon sugar (____________________), a phosphate group, and a ____________________ ________. The base can be a purine (____________ and ____________) or a pyrimidine (____________ and ____________).
- The _______________ group and the sugar form the backbone; the bases form the _____.
- The two strands are connected by ________________ bonds between the bases. A purine always pairs with a ____________________.

> Adenine pairs with ____________, and guanine pairs with ____________. This pairing is called _________________ base pairing. The sequence of one strand determines the sequence of the ____________ ____________.

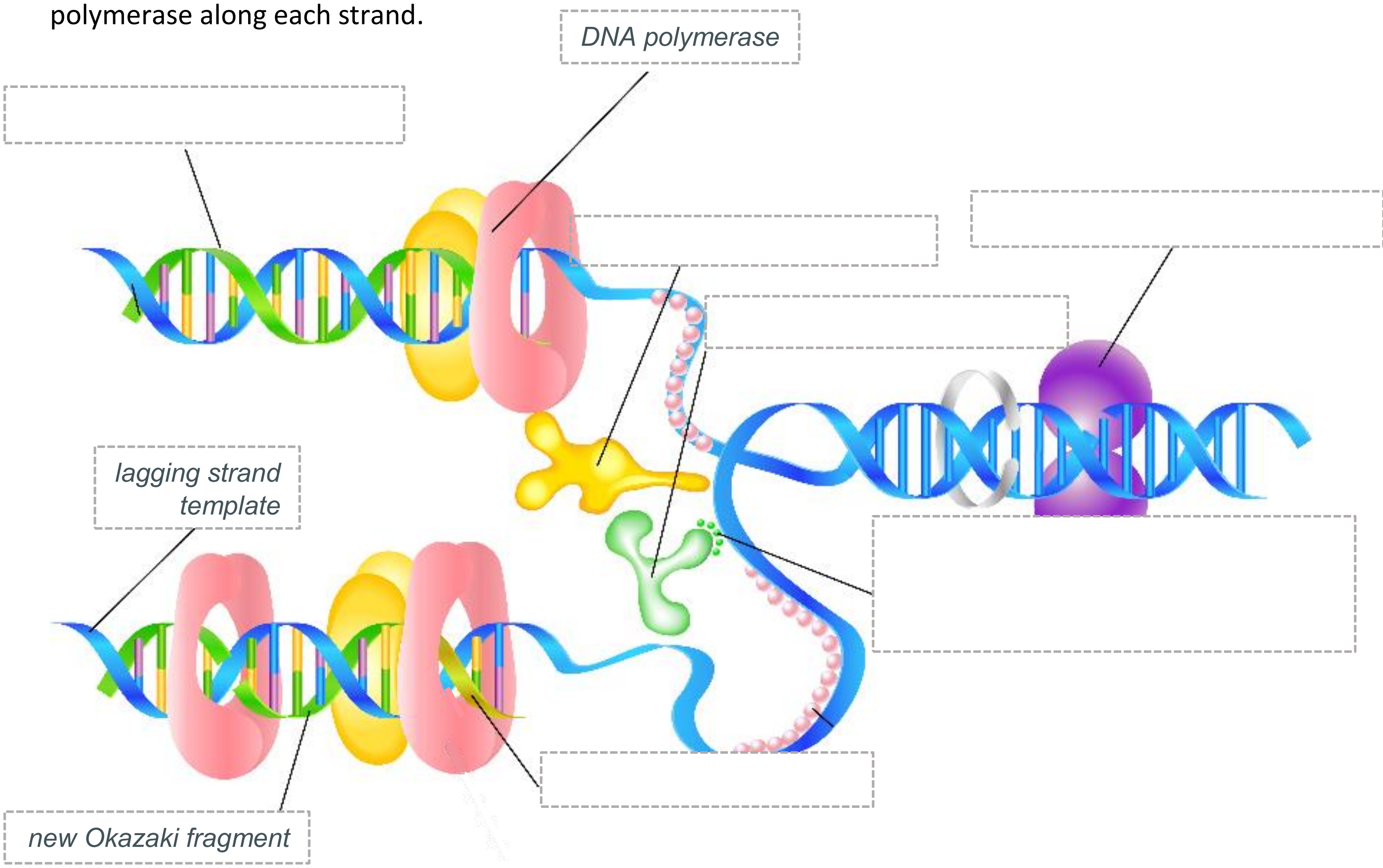
- The two strands are antiparallel, which means they run in ________________ ___________________.
- The five carbons in deoxyribose are numbered such that the 3′ (read as 3 ________) carbon has an OH group (called a hydroxyl) and the 5′ (read as ____ ________) carbon is attached to the ________________ group. Adjacent nucleotides in a strand are held together by a bond between these groups.

Semiconservative Replication

When DNA is replicated, the two strands separate. Both strands then serve as a ________________ for the construction of two new ________________________ strands. Because each of the two new molecules maintains, or conserves, one “old” strand of DNA, this process is called _______________________ replication. Replication has three main steps:

- **Unwinding**: An enzyme called ________ ________________ unwinds the DNA for replication. As the DNA unwinds, a Y-shaped structure called the ________________________ ________ is formed. Unwinding can create tension in the DNA. The enzyme ________________________ relieves this tension by creating small nicks in the DNA strands, which allow the strands to rotate freely. These nicks are sealed later.

- **Base Pairing:** The replication enzyme, ______ _____________, can add new nucleotides only to the 3′ end of a DNA strand. The enzyme RNA primase makes short segments (about 5 to 10 nucleotides long) called ______ ____________, which attach to the initiation points. These primers act as starting points for DNA polymerase along each strand.



On the strand that opens in the 5′ to 3′ direction, only one primer is needed. DNA polymerase can add nucleotides continuously along this strand, called the _______________ strand.

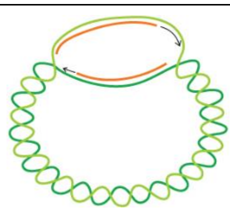
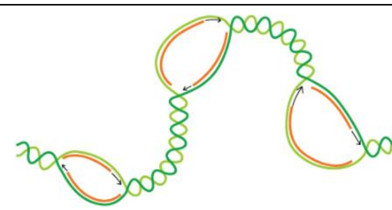
On the strand that opens in the 3′ to 5′ direction, however, multiple primers are needed. DNA polymerase works out from these primers in segments called ________________ ________________. This strand is made one fragment at a time, so it takes longer to replicate. It is called the ______________ strand.

- **Joining:** Once both the leading strand and the lagging strand have been replicated, there is some cleanup work to do. DNA polymerase removes the ______ ________ and replaces them with ______ _____________________. An enzyme called ______ ________ seals the nicks between the new DNA and the __________ ______________.

Now there are two copies of the DNA. Before cell division can take place, the cell must make sure the new strands don't contain any errors. This way, each daughter cell receives the ________ ________ of the DNA, with all the _________ it needs to make all its proteins.

Prokaryote and Eukaryote DNA Replication

The cellular structures of prokaryotes and eukaryotes differ, so there are also differences between the processes they use for DNA replication.

Prokaryotes	Eukaryotes
• *circular DNA* •	• • *several origins of replication on each chromosome*
• *no nucleus, so replication takes place in the cytoplasm*	•
•	• *simultaneous replication at several locations along the chromosome*
	

Mendel and Gene Expression

To understand why we inherit the traits we do, we need to go back to the 1800s and look at the work of Gregor Mendel.

Mendelian Genetics

Gregor Mendel, an Austrian monk, was one of the first scientists to systematically study patterns of inheritance. He studied the appearance and distribution of several traits in pea plants, including seed ________, seed ________, and ____________ color. Mendel studied plants that self-pollinate, meaning the ____________ from the anther of a flower is transferred to the stigma of the ________ flower or another flower of the ________ ________. He also cross-pollinated the plants, transferring the pollen of one flower to a flower from a different plant.

F1 and F2 Generations

In one experiment, Mendel allowed yellow-seeded plants and green-seeded plants to ______-____________. He observed that yellow-seeded plants only produced offspring with ____________ ________, and green-seeded plants only produced offspring with ____________ ________. Mendel then cross-pollinated the plants. The offspring of this cross, called the F1 or ________ ____________ generation, had all ____________ seeds. However, when he allowed these plants to self-pollinate, their offspring (the ____ generation) had both ____________ seeds and ____________ seeds! About three times as many plants had yellow seeds as had green seeds; that is, yellow seeds and green seeds were present in a ____ : ___ ratio.

Mendel repeated this experiment, looking at other traits of the pea plant, including flower ________, pod ________, and seed ____________. Only ________ trait appeared in the F1 generation, and the traits appeared in a ____ : ___ ratio in the F2 generation.

Mendel described his results in terms of dominant and recessive traits. Today, we know that ___________ are responsible for traits in offspring. The two forms of each gene are called ____________. If an organism has identical alleles for a gene, it is called ____________________ for that gene. If it has different alleles, it is called ________________________, or hybrid. Often, if a gene has two alleles, one allele can suppress the expression of the other allele. The ________________ gene has the ability to mask the effect of the ____________________ gene.

In Mendel's pea plants, the ○ green ○ yellow seed color is ○ dominant ○ recessive and the ○ green ○ yellow seed color is ○ dominant ○ recessive.

A dominant allele is represented by a ________________ letter, and a recessive allele is represented by a ____________________ letter. For seed color, ____ could represent yellow and ____ could represent green.

The ________________ of an organism is its genetic makeup, the set of alleles it has inherited. This determines its ____________________, its observable characteristics. If an organism's genotype includes at least one dominant allele, then it will have the dominant phenotype:

- Seeds with genotype YY (__________________ dominant) will have a ○ yellow ○ green phenotype.
- Seeds with genotype Yy (________________________) will have a ○ yellow ○ green phenotype.
- Seeds with genotype yy (homozygous _________________) will have a ○ yellow ○ green phenotype.

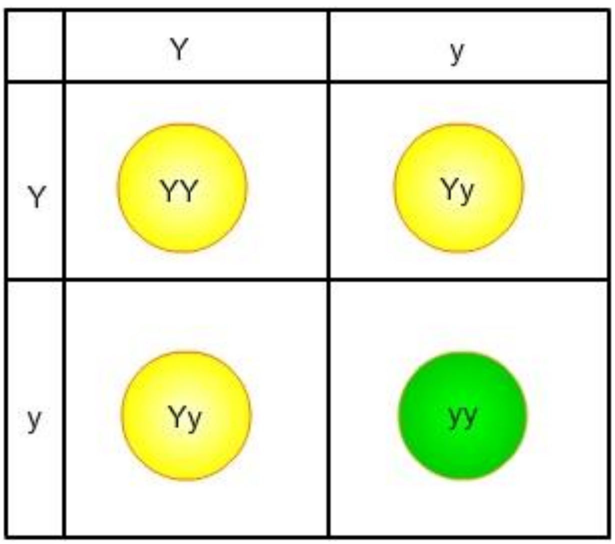
Law of Segregation

To explain the phenotypic ratio he observed in the F2 generation, Mendel proposed the ________ of ____________________. The alleles for a trait separate during meiosis, so each gamete receives only ____ allele. Then, during fertilization, the alleles unite to form the ________________ of the organism.

Monohybrid Crosses

Recall that another name for a heterozygote is a hybrid. A monohybrid cross involves mating organisms that have ________________ ____________ for a particular trait (in other words, they are heterozygous for that trait). According to the law of segregation, when a heterozygous cell of genotype Yy undergoes meiosis, one gamete will receive the ________________ allele (Y), and one will receive the __________________ allele (y).

Because fertilization is a ____________ event, the alleles can recombine in any of three possible ways: the offspring can be homozygous dominant, heterozygous, or homozygous recessive. This is easiest to see in a Punnett square, a diagram that scientists use to model the outcome of a cross. The genotypes of the P generation are placed on the outsides of the grid; the inner squares show the genotypes of the offspring.



The Punnett square shows both the genotypic and the phenotypic ratios for the offspring. For this cross, the three ____________________ (YY, Yy, and yy) are present in a ___ : ___ : ___ ratio. The two ____________________ (yellow and green) are present in a ___ : ___ ratio.

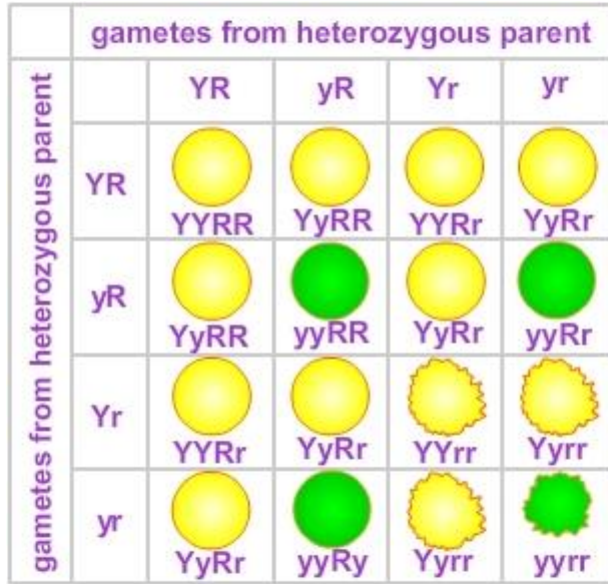
Keep in mind that a Punnett square illustrates only the ______________________ of each offspring inheriting a particular trait. In this case, there is a ________ chance that an offspring of this cross will have green seeds.

Dihybrid Crosses

Once Mendel felt he understood the inheritance patterns of a single trait, he wanted to determine the patterns when two or more traits are involved. He wanted to know whether offspring inherit these traits independently of each other or as a single factor.

Law of Independent Assortment

The results of his two-trait experiment led Mendel to propose the law of independent assortment. As expected, when he crossed homozygous plants with round, yellow seeds with homozygous plants with wrinkled, green seeds, all of the offspring (F1 generation) had ________, ____________ seeds. These plants were ___________________ for both traits, or dihybrid.



When these plants self-pollinated, he observed all four of the possible phenotypes (round and yellow, ________ and ________, ________________ and ____________, and wrinkled and green) in a ____ : ____ : ____ : ____ ratio.

The Punnett square for this cross shows that this ratio would be possible only if the alleles separate __________________ during gamete formation. This is the law of independent assortment: ____________ for ________________ genes separate ____________________ during gamete formation.

Careers in Science: Epigeneticist

Epigenetics is the study of ____________________ ________ ____________________. It helps determine which genes are ____________ and which genes are ________________. Genes may be “on” or “off” because of modifications that alter the gene without changing the DNA sequence.

Summary

How do the process of DNA replication and the laws of inheritance help cells and individuals pass on their traits?