# Applied Genetics

## Section 11.1
## Dihybrid Crosses

### Pre-View 11.1

- **Dihybrid cross** – studying two traits crossed from parent organisms
- **Law of Independent Assortment** – a natural law that explains how traits are inherited independently of other traits

So far we have looked at monohybrid crosses, which only study one trait at a time. Many times scientists study two or more traits at a time. Studying two traits at a time is called a **dihybrid cross**.

When at least two traits at a time are studied, they illustrate the **Law of Independent Assortment**, which means that inheriting one trait doesn't affect the inheritance of another trait. For instance, having brown eyes has nothing to do with having freckles. The genes are inherited independently of each other. Again, Mendel was the first to make these observations, so this law is often called *Mendel's Law of Independent Assortment*. (You'll see later how this "law" isn't always true.)

To show a dihybrid cross, let's pick two different traits, such as handedness and freckles. Being right-handed (R) is dominant over being left-handed (r), and having freckles (F) is dominant over not having freckles (f).

Let's say that both the mother and the father are heterozygous for both traits. We can create a Punnett square of this dihybrid cross to analyze how these traits might appear in their children. The Punnett square is bigger and looks more complicated, but it really isn't difficult to do. Just follow these steps.

**Step 1:** First, pick a parent. The mother is heterozygous for both traits, (RrFf), so she has a dominant R gene and a recessive r gene. She also has a dominant F gene and a recessive f gene. She can pass on each of these traits independently to her children. What are the four possible combinations of these traits? They are RF, Rf, rF, and rf.

1 **RrFf = RF**

2 **RrFf = Rf**

3 **RrFf = rF**

4 **RrFf = rf**

**Step 2:** Next, consider the father. He is also heterozygous for both traits, so the combinations of traits are the same: RF, Rf, rF, and rf.

**Step 3:** Now fill in a Punnet square with these combinations. Since there are four combinations for each parent, the square is 4 × 4 instead of 2 × 2. But you fill it in the same way.

**Mother**

| Father | **RF** | **Rf** | **rF** | **rf** |
|---|---|---|---|---|
| **RF** | RRFF | RRFf | RrFF | RrFf |
| **Rf** | RRFf | RRff | RrFf | Rrff |
| **rF** | RrFF | RrFf | rrFF | rrFf |
| **rf** | RrFf | Rrff | rrFf | rrff |

## Genetic Mutations

Remember, amino acids make up polypeptide chains, polypeptide chains make up proteins, and proteins are a vital component of living materials and carry out vital cellular processes. Remember also that genes in the DNA are made up of nucleotide sequences that are "read" in groups of threes similar to the three-word sentences shown on the previous page. The sequence of the letters in the mRNA determines the amino acid that is added to the polypeptide chain. If one or more amino acids added to that polypeptide chain are wrong, the organism will not be able to build proteins with the correct structure. Look at figure 12-7 to review the different types of gene mutations and how they affect protein production. Notice that the amino acids that make up the protein can change when different gene mutations occur. Gene mutations are sometimes called **point mutations** because the mutation occurs at only one point in the DNA. Insertions or deletions of a single nucleotide are also called **frameshift mutations** because they shift how the codons are read and can result in different amino acids being added to the protein. (Note: Since some nucleotide sequences "code" for the same amino acid, not all gene mutations result in a different amino acid.) Both point mutations and frameshift mutations may also create a stop codon, which will stop protein synthesis. The resulting protein will be shorter than it is supposed to be.

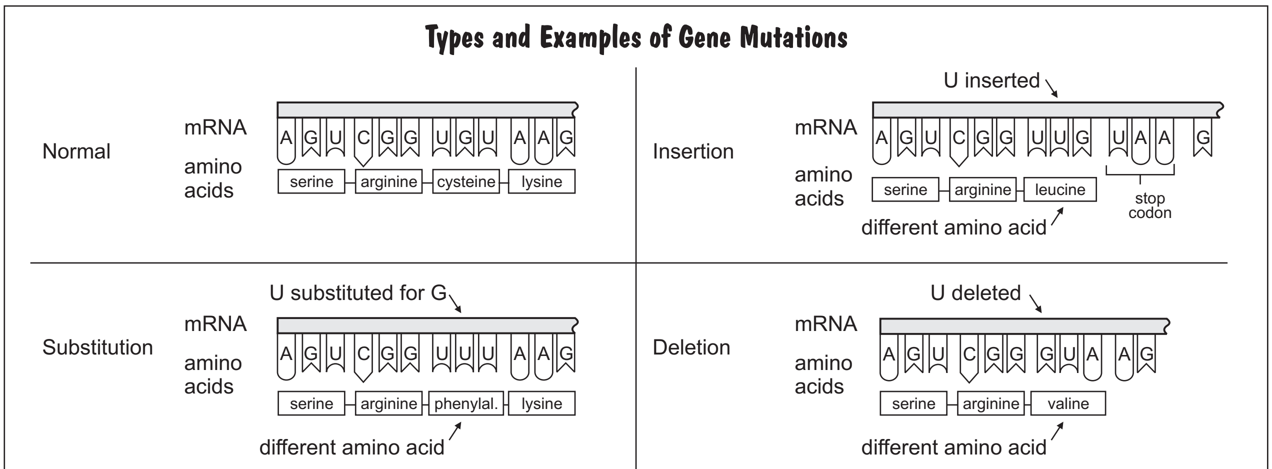

Fig. 12-7

## Chromosome Mutations

The other type of mutation is a **chromosomal mutation**, where the structure or numbers of chromosomes change. The structure of a chromosome can change if a part of a chromosome is broken off or lost during the processes of mitosis or meiosis. The following types of chromosomal mutations can occur by a change in chromosome structure.

- A broken part can sometimes reattach to a sister chromatid and cause **duplication** of genetic information in one chromatid and **deletion** of genetic information in the other.
- If the broken part reattaches backwards, it is called an **inversion**.
- The broken part may also attach to another chromosome and is called **translocation**.

In any of these cases, the genes on the broken portion of the chromosome are now in the wrong place. Figure 12-8 shows the different types of chromosomal mutations.

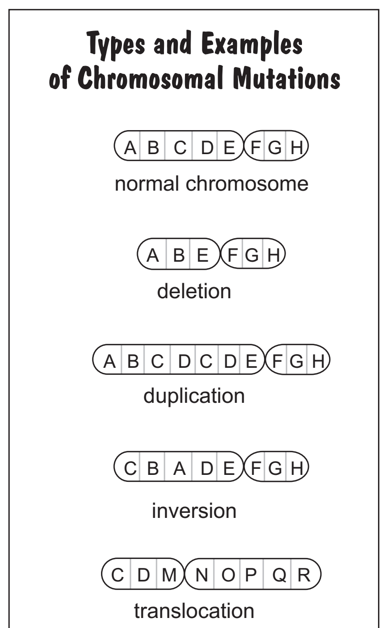

Fig. 12-8

## John Needham and Lazzaro Spallanzani

Francesco Redi's experiment proved to most that large living organisms, like flies, did not come from nonliving things. But about 100 years after Redi, the question over spontaneous generation was still debated, especially when it came to organisms that could now be observed with a microscope.

In 1745, **John Needham** attempted to prove spontaneous generation does occur with microscopic organisms. At the time, it was known that heat kills living organisms. In an experiment, Needham heated chicken broth in a flask to kill all living microscopic organisms. He then let the flask and broth cool and sit. After some time, the broth became cloudy with microorganisms. This experiment gave Needham "proof" that microorganisms were created by the broth.

Another scientist, **Lazzaro Spallanzani**, repeated Needham's experiment, but Spallanzani suspected that the microorganisms were coming from the air. Spallanzani's experiment removed the air from the flask by creating a partial vacuum after the broth had been heated. In Spallanzani's experiment, no microorganisms grew, so he believed his experiment disproved spontaneous generation of microorganisms.

Spallanzani's experiment did not convince everyone because many believed that air was necessary for spontaneous generation to occur. Some believed that all Spallanzani proved was that spontaneous generation could not occur without air.

## Louis Pasteur

Another hundred years passed by before **Louis Pasteur** finally designed an experiment that disproved spontaneous generation once and for all. In the late 1850s, Pasteur performed a variation of Needham's and Spallanzani's experiments. Pasteur sterilized broth by heating it, but he designed and used a special flask. See figure 13-2. The swan-like neck of the flask allowed air to enter, but it trapped microorganisms and other contaminants so that they could not reach the broth. Using this specially-designed flask, Pasteur was able to show that microorganisms lived in the air, but they were not formed by the air. He proved that microorganisms come from other microorganisms, not broth and air.

Pasteur's Swan-necked Flask

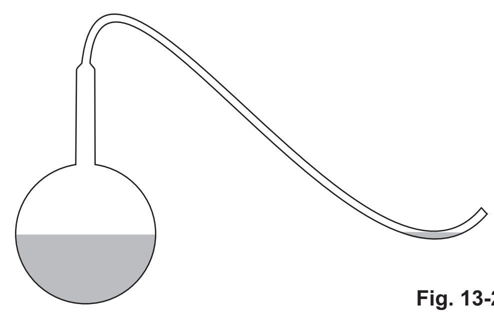

Fig. 13-2

Disproving the idea of spontaneous generation was just one of Pasteur's contributions to science. He is considered the father of microbiology and of immunology. Pasteur was the first to determine that yeast were responsible for fermentation, an important process in the making of beer and wine. He also developed the germ theory, the idea that diseases are caused by microorganisms, and he created vaccines for rabies and anthrax. Pasteur created the process of pasteurization, the heating of milk or other liquids to kill harmful bacteria. His discoveries in microbiology led to antiseptic techniques still used by doctors and nurses today to prevent the spreading of diseases.

## Biogenesis

Pasteur's broth experiment led to the widely-accepted belief that living organisms come only from other living organisms. This belief became known as the law of **biogenesis**, a law that has been firmly established. A scientific law is a general fact of nature. Gravity, for example, is another scientific law.

## Comparative Anatomy

Another way that scientists look for evidence of change in species is by looking at similarities in living organisms.

**Homologous and Analogous structures: Homologous structures** develop from the same tissues as embryos and have similar internal structures. They may look different on the outside, and they may have different functions. For example, if you looked at the forelimb of a bat, a human, a crocodile, and a bird, you would see that they all have the same skeletal structures — humerus, ulna, carpals, and radius — although they have different functions. See figure 14-1. These similarities suggest that they may have had a common ancestor long ago.

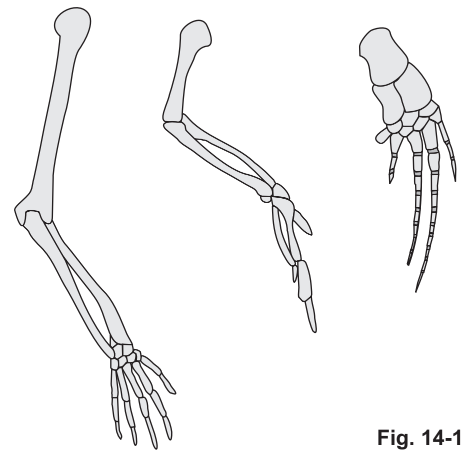

Fig. 14-1

Homologous structures should not be confused with **analogous structures**, structures that have similar functions but are not believed to have evolved from a common ancestor. A bird's wing and a butterfly's wing are analogous structures. Both have the same function, to enable flight, but these two types of wings are structurally very different.

**Vestigial structures:** Sometimes an animal has structures that seem to have no useful purpose now although they resemble structures that are useful in other species. These structures are called **vestigial structures**. The flightless wings of the ostrich, the sightless eyes of the cave salamander, and the pelvis bone found in some whales are considered examples of vestigial structures.

**Embryology:** Embryos of many vertebrates look very similar, especially in the earliest stages of development. These physical similarities suggest that the organisms have genetic similarities as well. By looking at the similarities in embryological development, scientists can determine if two very different species might have had a common ancestor.

## Biogeography

Plate tectonics theory explains that the surface or "crust" of the earth is divided into large plates that float on a semi-molten layer underneath the earth's surface. According to this theory, these plates continually move, and this movement explains earthquake and volcanic activity as well as continental drift. Continental drift is the movement of continents. Scientists believe that all land mass was once consolidated together in a single continent called *Pangaea*. Over time, the different continents have been formed as the plates of the earth drifted apart.

**Biogeography** is the study of how plants and animals are distributed around the world. This distribution depends on the migration ability of a particular species and how plants and animals have been separated from one another over time by continental drift.

Scientists use this distribution of organisms to figure out how and when species may have evolved. For example, some species are isolated to specific continents. Apes, including all fossils of apes, are found only in Africa and Asia. Marsupials, mammals with pouches, are found only in Australia. These species must have been separated from a common ancestor early in their history and then evolved differently. In other cases, species on a nearby island are similar but not exactly the same as those on the nearest mainland. Darwin made many of these observations about species on the Galapagos Islands. The explanation of how these different species may have evolved differently is explained by speciation, which you saw in Section 14.3.