

## 22. Biological Sciences

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Workshops on human genetics and dendrochronology were presented as introductions to biological processes that are fundamental to growth yet poorly understood by laypersons. The following supports the learning of particular Illinois state biology standards.

### Human Genetics

The inheritance of genetically determined characteristics or traits, especially in humans, is an interesting topic for both middle and high school students. Several examples, involving both autosomal as well as sex-linked characteristics or traits, can be examined and analyzed in a classroom situation. Tracing the origin of a set of easily identifiable phenotypes (observable physical traits) through parents, grandparents, and great grandparents often creates a fun-filled and exciting adventure for students.

Genetically, normal human beings possess 46 chromosomes within their somatic (body) cells. Of these, two will involve the presence of two X chromosomes in females and a Y and X chromosome in males. In both females and males, the Y and X chromosomes are commonly referred to as the sex chromosomes. In general, sex-linked inheritance refers to the inheritance of those genes that are located only on the X chromosome. The Y chromosome, when present, determines maleness and is passed from males to males.

### *Workshops*

In a classroom setting, one can easily demonstrate the inheritance of a particular trait by examining the student population. The occurrence of a widow's peak (determined by a dominant allele) can be established easily among male students by examining their hairlines. Another frequently studied trait involves the occurrence of attached earlobes (a recessive trait). If students know their blood types, teachers can determine the frequency of the four recognized blood types among students and use the information to explain multiple allelism involved in the inheritance of the ABO blood type in humans.

Once such traits have been identified and properly analyzed, students can assemble a very simple pedigree chart based on an examination of their immediate family members. Tracing the origin of a given inherited characteristic can also lead to classroom projects involving household pets such as dogs, cats, guinea pigs, or gerbils. In addition, one may create a wide variety of hypothetical genetic problems for students to explore. Such simple exercises seem to be of great interest to students at all levels; they can be an important tool when students are exposed to the basic principles of Mendelian genetics.

Understanding the transmission and inheritance of sex-linked genes in humans is more difficult. Once again, students should be reminded that sex-linked genes are located on the X

chromosome of both females and males. Consequently, the male will pass his X-chromosome-linked genes to his daughters, while the female will pass her X-chromosome-linked genes to her daughters and sons. The most often studied sex-linked genes in humans are those responsible for hemophilia and colorblindness (Atherly, Girton & McDonald, 1999). Establishing the occurrence of colorblindness can be done in the classroom through the use of slides depicting different color-coded numbers. Colorblind individuals will always see an entirely different set of numbers than the others. Such an exercise is always fun for students and will be of assistance to them in understanding the unique features of sex-linked inheritance.

Students can also examine the occurrence and inheritance of several unique genetic disorders in the human population. Such disorders are always associated with changes in the sequence of the nucleotides in DNA (the genetic material of organisms) and are frequently induced by an exposure to mutagenic agents, many of them chemicals commonly present in the environment. Among the genetic disorders, several are relatively common and have serious effects. Sickle cell anemia, for example, which affects approximately one out of 400 African Americans, is caused by the substitution of a single amino acid in the hemoglobin protein molecule of red blood cells, also known as erythrocytes (Becker, Kleinsmith & Hardin, 2003). In a sample of blood taken from such individuals, a given percentage of the erythrocytes will be sickle-shaped when examined under a light microscope (Campbell & Reece, 2000). Individuals afflicted with sickle cell anemia often reveal signs of fatigue and are incapable of performing tasks that require strenuous physical activity.

Mutations targeting the DNA molecule can also be caused by ultraviolet radiation. Since sunlight is an excellent source of ultraviolet radiation, and students of all ages love to acquire a deep and lasting tan, the formation of ultraviolet-induced pyrimidine dimers (usually two thymines) in DNA, and the association of such dimers with the possible onset of skin cancer, will generate an immediate interest. Showing and explaining to students the formation of thymine dimers in DNA will also facilitate their understanding of the chemical makeup of DNA and the way the nucleotides are arranged. Additionally, students will better appreciate the advice given to them regarding the skin-cancer risks associated with excessive and cumulative exposure to sunlight. Coverage of this topic may also incorporate the importance of the ozone layer in protecting organisms, including humans, from the harmful effects of ultraviolet radiation. Students should be made aware of the fact that emission of chlorofluorocarbons (CFCs) from such sources as refrigerants and propellants in spray cans can greatly damage the ozone layer. A continued release of CFCs from industrial sources would eventually cause a thinning or depletion of the ozone layer, allowing more ultraviolet radiation to reach our planet's surface. This, in turn, would significantly increase radiation-induced mutation rates in all living organisms, including humans.

## Dendrochronology

Dendrochronology involves the study of secondary xylem (wood) produced by woody plants (Schweingruber, 1988). Typically, all elements of the secondary xylem are derived from a lateral meristem called the vascular cambium. The secondary xylem consists of two distinct regions, heartwood and sapwood (Northington & Schneider, 1996). The heartwood is centrally

located and is generally dark colored, while the sapwood surrounds the heartwood and is light colored.

In general, the width of the heartwood significantly exceeds the width of the sapwood. For example, if a tree is determined to be 50 years old, roughly the first 38 to 40 years of annual growth would make up the heartwood, while the most recent growth of roughly the last 10 to 12 years would make up the sapwood. As a tree ages, the innermost annual rings of sapwood eventually become heartwood. When a tree is cut down, concentric rings (termed annual rings) can be observed in the secondary xylem. Every annual ring (representing a given year's growth) of both heartwood and sapwood is made up of the spring (early) wood and summer (late) wood. Since the spring (early) wood is deposited first during a given growing season, it will be situated toward the center of the tree, while the summer (late) wood will be situated toward the periphery within each formed annual ring (Mauseth, 1991).

Students can examine and analyze wood samples of living and even fossilized trees and acquire basic knowledge concerning the unique growth patterns of woody plants. The examination of a cross-section or a thin core of secondary xylem can reveal the age of a tree, distinguish seasonal variations in precipitation, establish the occurrence and frequency of fires, determine competition from adjacent trees, and provide information on soil fertility. Additionally, analysis of wood samples of markedly different tree species gives students a hands-on opportunity to compare variations in structural and growth characteristics from year to year. Anthropologists and crime investigators often obtain important information from the examination of wood samples.

### *Results*

Teachers attending the biology workshops were very favorably impressed with the content of the presentations on human genetics and dendrochronology. Participants requested and received copies of the slides testing for colorblindness and reported that the test was ideal for the teaching units on genetics and inheritance. They were very interested in the analysis of annual rings in wood, which was a relatively inexpensive way to involve students in understanding growth and development in plants.

### *Bibliography*

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