



Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Heredity And Environment

Curriculum Unit 90.06.04
by Carolyn N. Kinder

Have you ever wondered why people resemble their parents? The answer to this and other questions about inheritance lies in a specialized branch of biology called genetics. Geneticist found that most aspects of life have a hereditary basis and that many traits can appear in more than one form. For instance, human beings have blond, or red, or brown, or black hair. They may have one of several different types of blood, one or several colors of skin. Their ear lobes may be attached or free. They may or may not be able to manufacture certain enzymes. Some of these traits are much more important to the life of the individual than others, but all of them are hereditary. The geneticist is interested not only in the traits of man but in those of all other organisms as well.

The study of inheritance depends on the differences as well as the similarities between parents and offspring over several generations.

Heredity is very complex, and a geneticist cannot possibly analyze all the traits of an organism at once. Instead, he studies only a few traits at a time. Many other traits are present. As the geneticists work out the solution to each hereditary mystery, the geneticist must not forget that all organisms live in a complex environment. The environment may affect the degree to which a hereditary trait develops. The geneticist must try to find out which of the many parts of the environment may affect his results.

The factors must be kept as constant as possible by using controlled experiments. Only then can he tell that the differences observed are due to heredity.

Heredity determines what an organism may become, not what it will become. What an organism becomes depends on both its heredity and environment.

The modern science of genetics started with the work of Gregor Mendel. He found that a certain factor in a plant cell determined the traits the plant would have. Thirty years after his discovery this determines was given the name gene. Of the traits Mendel studied, he called dominant those that showed up in the offspring and recessive those that did not. The question I will ask is: how much of the variability observed between different individuals is due to hereditary differences between them, and how much to differences in the environments under which the individuals developed?

In most organisms, including man, genetics information is transmitted from mother to daughter cells and from one generation to the next by deoxyribonucleic acid (DNA).

Knowledge of the heredity or inheritance of plants and animals is important in many phases of our life.

The question I will ask is: How much of the variability observed between different individuals is due to hereditary differences between them, and how much to differences in the environments under which the individuals developed?

The purpose of designing a unit on “Heredity And Environment” is to help students learn more about themselves. They will learn why they develop into the kind of individual they are.

The unit will discuss heredity traits and environmental conditions, chromosomes, DNA, studies of identical twins, and several diseases linked to heredity and environment.

The students will do some hands on activities by constructing a model which represents DNA. They will explore plants with the exact same heredity and plants with different heredity. They will change the conditions in the environment to see the way the plant organisms with the same heredity may develop differently in different environments and why organisms with different heredity develop in the matter in which they do. Heredity is not the only thing that effects development. The environment also has an important effect.

The unit can be taught to students in grades five through eight. The science and math teachers are encouraged to use a team teaching approach. Other features that will be included in the unit are content, lesson plans, resources, reading list and a bibliography.

Genes and DNA

DNA, short for deoxyribonucleic acid, makes up the genes that transmits hereditary traits. The DNA molecule looks like a long, twisted rope ladder. This is called the double helix. The ladder is made up of two coiled strands with rungs between them. The rungs are composed of pairs of chemicals in different combinations. Each combination carries instructions like the dot and dashes of the Morse Code. Each gene in the body is a DNA section with full set of instructions for guiding the formation of just one particular protein. The different proteins made by the genes direct the body’s functions throughout a person’s life.

DNA is made of six parts: a sugar, a mineral (phosphate), and four special chemicals called bases. These bases are represented as A;T;C; and G. Sugar and phosphate form the chains, or sides, of the staircase. The A;G;C and T bases form the steps. See figure 1. Each step is made of two pieces, which are always paired the same way. The A base always pairs with the T base. And the G base always pairs with the C base.

Figure 1. DNA Structure

(figure available in print form)

DNA Reproduces Itself

Two new identical DNAs are immediately formed. The A,G,C, and T bases on each chain attract loose bases found floating within the nucleus. Ts attract As and Cs attract Gs. The two new DNAs are just like the original DNA. Each strand directs the synthesis of a complementary strand. The replication of DNA is the key to heredity, the passing of traits from parents to offspring. DNA replication results in the formation of new reproductive cells. It also results in the formation of new cells, which is important for the growth of an organism. See Fig. 2.

Figure 2.

(figure available in print form)

Watson-Crick—DNA Replication-Redrawn from version in Levine, *Genetics*, Holt, Rinehart, Winston, 1968.

Chromosomes

Genes and chromosomes provide the genetic link between generations. Chromosomes are strands of DNA and protein found in the nucleus of virtually every cell, but with few exceptions seen only during the process of cell division. The number of chromosomes in a cell is characteristic of the species. Some have very few, whereas others may have more than a hundred. Ordinarily, every cell in the body of an organism contains the same number of chromosomes. The most important exception is found in the case of gametes where half the usual number is found. Human beings have 46 chromosomes in each cell, with the exception of the spermatozoa in males and the ova in females, each of which has 23 chromosomes. Human chromosomes occur in pairs, the total 46 consisting of 23 pairs; 22 pairs of autosomes which are non-sex determining chromosomes. The member of a pair are essentially identical, with the exception of sex chromosomes in males, and each pair is different from any other pair. Plants and animals inherit chromosomes from their parents. Each plant and animal cell has a set of chromosomes. Chromosomes, then, control the heredity of an organism. They carry the blueprint that determines what kind of organism will develop.

Some Relationship Between Heredity And Environment

Organisms can transmit some hereditary conditions to their offspring even if the parents do not show the trait. In the small, familiar fruit fly, *Drosophila*, there is a hereditary trait in which the wings curl up sharply if the flies are raised at a temperature of 25 degrees Celsius. If, however, the flies are raised at a lower temperature, such as 16 degrees Celsius then the trait rarely appears. The wings seem to be straight, and the flies look normal. The genetic trait is there, however, and will reappear in the next generation if the temperature returns to 25 degrees Celsius. See fig. 3. A similar type of inheritance appears in plants. In some types of corn the kernels will remain yellow until they are exposed to sunlight. Once exposed, the kernels become various shades of red and purple. Some traits do not appear to be affected by the environment. One of the first hereditary traits studied in humans was polydactyly. An individual with polydactyly has more than ten fingers or toes. See fig. 4. This trait does not seem to be affected by the environment at all. Other human traits like color blindness, baldness, blood type, skin color, the ability to taste certain substances, the presence or absence of hairs on the middle of the fingers, and free or attached ear lobes do not seem to be influenced by the environment.

(figure available in print form)

Figure 3—This diagram shows how temperature affects curly-wing trait in *Drosophila*. If the third generation of curly-winged flies had been raised in 16°C environment. Source: Redrawn from *Biological Science*, Houghton, Mifflin Co., Boston, 1963, p. 379.

Figure 4—An example of polydactyly. Extra digits on either hands or feet are almost always abnormal in structure.

(figure available in print form)

Source: *Biological Science*, Houghton Mifflin Co., Boston, 1963. p. 380.

A common cited example of an environmental effect on phenotype is the coloring of Siamese Cats, although these cats have a genotype for dark fur, the enzymes that produce the dark coloring function best at temperatures below the normal body temperature of the cat. Siamese Cats are noted for the dark markings on their ears, nose, paws, tail, and all areas that have a low body temperature. If the hair on the cat's belly is shaved and an ice pack is applied, the replacement hair will be dark. Likewise, a shaved tail, kept at higher

than normal temperatures, would soon be covered with light colored fur. These changes are temporary, however, unless the ice pack or heat source is maintained permanently.

The most celebrated effect of an environmental agent directly affecting the unborn, is that produced by the rubella virus. This German measles virus is capable of crossing the placenta from mother to child, and the prenatal infection, if it occurs early enough, may result in deafness and other damage to the child. Similarly, maternal infection with the rare protozoan parasite *Toxoplasma* can cause serious congenital defects in the fetus, and the same has been suspected for Asian influenza.

Another environmental factor is anoxia. Anoxia is a natural hazard of childbirth, and in most cases the infant makes a normal adjustment to it. When infants suffer from delayed respiration or asphyxia during birth, it is widely accepted that this is responsible for later difficulties such neurologic abnormalities.

Warburton and Fraser have emphasized that the development of a fetus depends on a precise and extremely intricate system of interactions between two sets of hereditary factors and two environments, all acting at the same time on the growing baby. The mother and the fetus each have their own environment and their own genotype.

Identical Twins

It is difficult to sort out the effect of genetic inheritance from the effect of the environment, particularly in human genetics. Studies of identical twins provide geneticists with the opportunity to examine the influences of heredity (nature) and environment (nurture). The study of twins offer bountiful material with which to study many of the most detailed aspects of human heredity.

Identical twins develop when the cells arising from a single fertilized egg separate and two complete embryos form. These embryos have exactly the same genetic information. If identical twins exhibit the same expression of a trait, then it would appear that the trait is heavily influenced by the environment. The message from such studies is that both genes and environment are important.

In your case, you may often have thought, how would you with your given heredity have turned out under different conditions? Or, under the same conditions, to what extent might you have been different with a slightly different heredity?

The only way it could be answered or, at least, partly answered is if there were two of you to start with and each were exposed to different conditions; or if you started life with somebody else at the same time within the same mother, and after you were both born, developed under approximately the same conditions. Is either of these situations at all possible? Yes, for nature has most thoughtfully provided us with twins. For the first experiment we have identical twins; for the second, "fraternal" twins. The two types differ in this way. Identical twins are the product of a single fertilized egg which, shortly after it begins to grow, splits in half to form two individuals. Each has exactly the same hereditary and factors, so among other things, identical twins must always be of the same sex.

Fraternal twins, on the other hand, are the product of two entirely different eggs simultaneously matured by the mother and fertilized, approximately at the same time, by two entirely different sperms. They carry quite different genes, and need be no more alike than any other non twin siblings in the same family, as often as not, in fact, being of opposite sex.

In other words, identical twins are from the standpoint of heredity, exactly the same individual in duplicate.

Fraternal twins are two entirely different individuals who merely through chances were born together. See fig. 5.

By comparing the twins with regards to many characteristics known to be definitely inherited or influenced by heredity, they can tell whether or not the degree of resemblance or correlation is high enough to stamp them as identical among the characteristics used for comparison are blood groups, blood pressure, pulse, respiration, and brain wave patterns, eye color, and vision, palm, sole and finger patterns: skin color, hair color, hair form and various minor hereditary abnormalities where present. The correlation in those characteristics is so much greater between any two identical twins that there is virtually no possibility of confusing their relationship.

Figure 5—How Twins are produced

(figure available in print form)

Source: Redrawn from *Science*, Silver Burdett, 1965, p. 132.

In as much as identical twins have exactly the same heredity, whatever differences there are between them must be due to environment. But when identical twins are reared in different environments, there being instances of such separation in infancy and nonetheless develop marked similarities of any kind, these might be ascribed to heredity.

The study of fraternal twins takes a different direction. In their case, as they have much more similar environment in prenatal life and often thereafter than singly born individuals, the question is how much more alike this will tend to make them.

If heredity were everything, then identical twins would be exactly the same in all respects, even if reared apart. But a number of studies show that they are never exactly alike, even though they do have remarkable similarities in most respects.

On the other hand, if environment were everything, then fraternal twins, reared under the same conditions, would also be alike, regardless of how different were their genes. But here we find that although they show a closer resemblance to each other than do non-twin brothers and sisters, "fraternal", even when of the same sex are very much alike than are "identical" reared apart.

Thus, the various studies of twins have comprised an important source of evidence for geneticists. No identical twins are really identical because they cannot possibly have had identical environments, even before birth.

If all human traits behaved in the clear-cut mendelian fashion that albinism and Huntington's chorea do, twin studies would not be necessary as an aid in unraveling the complications that the environment often superimposes upon a mendelian pattern of heredity. There seems to be a rule that the most common defects have the largest environmental component, which makes it difficult to tell whether their hereditary basis for the abnormality is a simple dominant or recessive. The environment acts to suppress the expression of the abnormal gene in some cases but fails to do so in others! It can be appreciated that this unpredictable behavior of environmental factors would upset the classic orderly mendelian ratios, especially if they are the complicated ones that result when more than one gene pair is involved.

Pairs of twins are useful in detecting the relative effectiveness of heredity and environment upon the expression of a disease or trait. If a trait is highly hereditary, both members of a pair of identical twins will be

expected to show the trait. If one identical twin shows the trait and the other member of the pair does not, the disagreement must be due to environmental differences between the two twins, because the genes of one are exactly the same as the genes of the other.

We know that the heredity of blood groups behaves according to the mendelian rules and that environment seems to have no affect on the kind of blood group a person has. Identical twins both have exactly the same blood group. Tuberculosis is a good example of a disease in which an hereditary susceptibility and an environmentally favorable situation are both necessary for the appearance of the active disease. A comparison of the behavior of identical and fraternal, and for susceptibility to tuberculosis, where heredity and environment share the responsibility, is given in table I. Notice how different the picture is for the two traits.

In table I it can be seen that both members of the 125 pairs of identical twins agreed in having the same blood groups. The 91 pairs of fraternal twins showed 60 pairs in which both members had the same blood groups and 31 pairs in which the two members had different blood groups. The different in susceptibility to tuberculosis of the two members of identical twins pairs is interesting. In 68 cases both got the disease but 29 cases one of the identical twins got the disease while the other twin remained free of it. It is striking that there could have been sufficient difference in the environments of the two members of the identical twin pairs to cause one member to remain free of it. Both must have been genetically susceptible, as one of them was, but their environments differed enough so that one got the disease and the other did not.

Table I

| | <i>Identical</i> | <i>Twin Pairs</i> | <i>Fraternal</i> | <i>Twin Pairs</i> |
|--------------------------------|------------------|-------------------|------------------|-------------------|
| | <i>Agree</i> | <i>Disagree</i> | <i>Agree</i> | <i>Disagree</i> |
| Type of Blood Group | 125 | 0 | 60 | 31 |
| Susceptibility to Tuberculosis | 68 | 29 | 45 | 99 |

The contrast in Agreement and Disagreement between the Members of Twin Pairs, Identical and Fraternal; for the Blood Group and Susceptibility to Tuberculosis.

Genetic Disorders

Multifactorial disorders arise from the action of at least several genes and their interaction with the environment. Heart disease, which is one of the leading cause of death in the United States today. This disease has been linked with smoking, diets high in cholesterol and saturated animal fats, stress, and lack of exercise. It is not clear that dietary control is a practical solution to the problem. If the difficulties of overcoming one's genotype by dietary manipulations are too great, the program will have little effect. Unfortunately, we do not know how strong the control of the genotype may be. There appears to be a genetic predisposition to hypertension (high blood pressure), which also is associated with heart disease. Hypertension is easy to diagnose and usually can be controlled by drugs, diet, and exercise. Awareness of the genetic predisposition to many common, multifactorial disorders and knowledge of your own hereditary history can help you make sound life style choices.

The chromosomes in our cells are not affected by any change that takes place within our body cells. This means that no change that we make in ourselves or that is made in us in our lifetimes can be passed on to our children through the process of biological heredity. Such changes made in a acquired characteristics.

Cancer is another type of genetic disorder. A cancer is a clone of cells growing without normal morphogenetic controls in a living host. In man, the difficulty arises because for common cancers we also always expect and find important environmental factors involved in their onset.

Heredity and Environment Pre-Post Test

CHOOSE THE BEST ANSWER:

1. Genetics is the study of
 - a. digestion b. growth c. heredity
2. All the traits a living thing inherits are called its
 - a. chromosomes b. heredity c. genes
3. Genes are located on
 - a. chromosomes b. RNA c. cell walls
4. Replication means
 - a. reproduction b. mutation c. DNA splitting in two
5. Identical Twins develop from
 - a. two different fertilized eggs b. the same fertilized egg c. meiosis
6. DNA is found in the
 - a. nucleus b. mitochondria c. ribosomes
7. Mendel gave us the laws of
 - a. circulation b. heredity c. gravity
8. An organism is the product of its
 - a. heredity b. environment c. heredity an environment
9. Human sex chromosomes normally have
 - a. 23 single chromosomes b. 23 pairs of chromosomes c. 46 pairs of chromosomes

10. The father of genetics is
a. Mendel b. Fraser c. Wurburton

Lesson Plan I

Nature or Nurture

Objective *To get students to see that they are alike and different in many ways.*

You and your classmates are alike in many ways. You are also different in size, shape, talents, and interests. How many of these similarities and differences are entirely genetic? How many can you control in some way?

For each trait given below, record a measurement taken now or a description of yourself. Try to decide how much of the trait is determined by genetics and how much by interactions with your environment.

| TRAIT DESCRIPTION | MEASUREMENT/ OR GENETIC/ OR ENVIRONMENT | EVIDENCE THAT TRAIT CAN/ CANNOT CHANGE |
|---------------------------------|---|--|
| RT.-handedness | | |
| LT.-handedness | | |
| PULSE RATE | | |
| NUMBER OF FINGERS ON RIGHT HAND | | |
| NUMBER OF WORDS READ PER MINUTE | | |
| SHOE SIZE | | |

TALKATIVENESS

ABILITY TO PLAY

THE PIANO

Lesson Plan II

Dominant or Recessive

Objective *The student will find out about some traits that are inherited. If the student shows a dominant trait, there will be at least one dominant gene. If it is a recessive trait, two recessive genes.*

Directions *Fill in the chart with the traits that you have. You may need a mirror to help you.*

(figure available in print form)

Circle dominant if you inherited a dominant trait. Circle recessive if you have inherited a recessive trait.

Lesson Plan III

DNA

Objective *The student will learn how to construct a model of DNA question: Why is DNA replication an essential step in cell division?*

Strategy *The student will use several hands-on approach to making a model of DNA. (Refer to Genetics Concepts Experiment Kit from Lab Aids, YNHTI)*

Resource *“DNA Made Easy”*

Lesson Plan IV

Extra Research

Tay-Sachs disease, sickle cell disease, Turner’s syndrome, Down’s syndrome, cystic fibrosis, and PKU (phenylketonuria) are genetic disorders. Research one of these diseases using genetics books in your school library. Prepare a report stating your findings. Teacher will assist students in the library or suggest where books may be found.

Lesson Plan V

Class Trip

Objective *The student will visit a seed and plant store to observe plants that are similar in genotype that look alike. They will see plants of the same genotype that look different. They will observe that environment has an impact on genes expression.*

Strategy *We will create a bulletin board displaying the variety of plants due to environmental effects, as well as, the hereditary effect. The students will do a series of experiments with plants grown in the classroom. Student observations will be recorded in his/her lab journal.*

Lesson Plan VI

Objective *The students will write a genotype for each person.*

Pedigree for Nearsightedness

A pedigree is a diagram showing the phenotype for a certain group of related organisms. Scientists use pedigree; to help them figure out the genotypes of an organism. The pedigree below shows a trait carried through a family. The squares represent males; the circles represent females. In this pedigree, the recessive trait for nearsightedness, or myopia, is shown. The shaded areas show a person who has both recessive genes for nearsightedness. On the line below each person, write his or her genotype. Let N = dominant gene for normal vision and n = recessive for nearsightedness.

(figure available in print form)

Reading List For Students

Bernstein, Leonard., et al. *Concepts and Challenges in Life Science* . New Jersey: Cebco Standard Pub., 1979. (Very readable for students, excellent illustrations and questions for students)

Cobb, Vicki. *Cells* . New York: Franklin Watts, 1970. This book gives the student a chance to look at many different types of cells)

Dunbar, Robert E. *Heredity*. New York: Franklin Watts, 1978. (Basic book on inheritance and DNA)

Facklam, Margery and Howard. *From Cell to Clone*. New York: Harcourt Brace Jovanovich, 1979. (Explains why the discovery of DNA is important to modern day science)

Lesser, Milton S. *The Meaning of Life* . New York: Amsco School Pub., 1975. (Elementary descriptions of cell structures)

Morrison, Velma Ford. *There's Only One You; The Story of Heredity* New York: Julian Messner, 1978. (Good book which describes family trees)

Pfeiffer, John. *The Cell* . New York: Time-Life Books, 1964. (Excellent color illustrations of many different types of cells)

Silverstein, Alvin and Virginia. *The Code of Life* . New York: Atheneum, 1972. (Excellent book, extremely useful, very readable for all ages and interests, detailed information about DNA and RNA)

Smith, Herbert A., et al. *Exploring Living Things* .Illinois: Laidlaw Brothers Pub., 1980. (Excellent student text with many illustrations on cell reproduction)

Webster, Vera., et al. *Life Science* . New Jersey: Prentice Hall, 1980. (Excellent student text with detailed DNA structure diagrams, very readable)

Teacher's Resource Bibliography

Engel, Leonard, *The New Genetics* , Doubleday and Co., Inc., Garden City, New York, 1966. (Deals with some of the latest finds in the field of genetics.)

Gabriel, Mordecai L., (ed), *Great Experiments in Biology* , Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1955. (A presentation of scientific writings in the original including those of the great geneticist, Hermann J. Muller.)

McKusick, Victor A., *Human Genetics*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1964. (One of a few authoritative books available to the layman, written in a readable style and incorporating the latest findings.)

Milunsky, Audrey, *Know Your Genes* , Avon Books, New York, 1979. (A clear, accurate, and readable book on medical genetics; hereditary disorders, genetic counseling, prenatal diagnosis, sex selection, twins, and more. Ethical, moral, and legal issues are given thoughtful consideration.)

Peters, James A., *Classic Papers in Genetics* , Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1959. (Several original papers from the outstanding men of genetics including Mendel up to those of the present day.)

Scheinfeld, Amram, *Your Heredity and Environment* , J. B. Lippincott Co., Philadelphia, 1964. (Explains how heredity works to produce a unique individual and the effect of the environment on the person.)

Sullivan, Navin, *The Message of the Genes*, Basic Books, Inc., Publishers, New York, 1967. (A lucid account of the mechanisms of heredity showing that today's molecular biologists have arrived at a clear understanding of life itself.

Swanson, Carl R., *The Cell* , Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1964. (A discussion of the structure of cells, and the tools involved in the investigations of cells.)

Magazine Articles

Bank, Arthur, Mears, J. Gregory and Ramirez, Francisco, "Disorders of Human Hemoglobin", *Science*, L, February, 1980.

Chedd, Graham, "Genetic Gibberish in the Code of Life", *Science*, November, 1981, pp. 50-55.

Cohen, Stanley N., "The Manipulation of Genes", *Scientific American*, July, 1975. (A summary of recombinant DNA techniques by one of the main innovators.)

McKusick, Victor A., "The Royal Hemophilia", *Scientific American*, August, 1965. (An account of the gene for hemophilia and how it is found in the royal families of Europe.)

Patrusky, Ben, "How Do Cells Know What To Become?", *Science*, May, 1981.

Audio Visual Materials

35-mm Transparencies

Elementary Genetics Set, Carolina Biological Supply Company, Burlington, North Carolina. (Uses inheritance of kernel color and texture in maize to explain dominance, recessiveness, and the simple Mendelian ratios resulting from monohybrid and digybrid crosses, 55 slides with narrative cassette.)

Filmstrip

Elementary Genetics Set, Carolina Biological Supply Company, Burlington, North Carolina. (Uses inheritance of kernel color and texture in maize to explain dominance, recessiveness, and the simple Mendelian ratios resulting from monohybrid and dihybrid crosses, 55 slides with narrative cassette.)

Video and 16-mm Programs

Genetics, Carolina Biological Supply Company, Burlington, North Carolina. (Heredity is used to show how anatomical and physiological traits are produced. One example used is how we become right or left-handed, a trait inherited as a simple autosomal dominant gene. Polydactylism (many fingers or toes) and blood groups (A80) in humans are used to further illustrate inheritance.

Computer Software

Genetics, Apple II (32k) Diskette. (Covers results of various crosses of peas, fruit flies, and sex-linked diseases. Question/information format.)

Linkover, Apple II (48k) Diskette. (Allows students to plan and execute a program of experiments to draw a genetic map of a single chromosome. Interaction format.)

Other Resources For Information And Materials

National Genetics Foundation, Incorporated

9 West 57th Street

New York, New York 10019

Telephone: 212-759-4432

The March of Dimes Birth Defects Foundation National Headquarters

Box 2000

White Plains, New York 10602

or local March of Dimes chapter

National Clearinghouse for Human Genetic Diseases for the Department of Health, Education, and Welfare, Bureau of Community Health Services, Genetic Services Program

Resource List

Lab Materials

Resource: Genetic Concepts, Kit, Cat. # 70 Description: Gameto discs

Source: Lab Aids, Inc., Ward's Catalog Location: Yale New Haven Teachers Institute

53 Wall Street

New Haven, CT.

Telephone: 432-1080

Resource: Gene Kit, M89101/7

Description: Pop-it Beads and Linkers

Source: Phillip Harris, Biologicals, Ltd. (Ward's Catalog) Location: Yale New Haven Teachers Institute

53 Wall Street

New Haven, CT.

Telephone: 432-1080

Resource: DNA Made Easy

Description: Plastic DNA and RNA Building Blocks;

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Transcription, Translation

Source: National Teaching Aids, Inc. (Ward's Catalog) Location: Yale New Haven Teacher Institute

Wall Street

New Haven, CT.

Telephone: 432-1080

Speakers

Genetic professionals to speak on selected topics on Medical Genetics.

Contact: Yale Genetics

Dr. Greta Seashore

Field Trip Sites In Connecticut

Denison Pequotsepos Nature Center

Mystic, CT. 06355

The Nature Center for Environmental Activities, Inc.

10 Woodside Lane

Westport, CT. 06880

The Stamford Museum and Nature Center

39 Scofieldtown Road

Stamford, CT 06903

West Rock Nature Recreation Center

Box 2969

New Haven, CT 06515

Norma Terris Human Education and Nature Center Salem Road

East Haddam, CT. 06423

Roaring Brook Nature Center

70 Gracy Road

Canton, CT 06010

Bibliography

Adcraft, Patrice G. and Teresi, Dick, *Omni's Future Medical Almanac* , McGraw-Hill Book Co., New York, 1987, pp 243-272.

Asimov, Isaac, *The Genetic Code*, New York: Signet Classics, New Jersey: New American Library, 1962.

Balzer, Levon, *Life Science* , Scott Foresman and Co., Glenview, Ill., 1983, pp 372-388.

Biological Science Curriculum Study, *Biological Science* , Houghton Mifflin Co., Boston, 1963, pp 374-404.

Borch, Ernest, *The Code of Life* , New York: Columbia Press, 1965.

Dawkins, Richard, *The Selfish Gene* , New York and Oxford: Oxford University Press, 1979.

Milunsky, A., *Know Your Genes* , Avon, N.Y., 1979.

Motulsky, Vogel, *Human Genetics, Problems and Approaches*: Springer-Verlag Berlin Heidelberg, 1986, printed in Germany.

Rothwell, Norman, *Understanding Genetics* , New York: Oxford University Press, 1979.

Scheinfeld, Amram, *Your Heredity and Environment* , J.B. Lippincott Co., Philadelphia, 1964.

Sussman, Maurice, *Developmental Biology* , Prentice Hall, N.J., 1973.

Winchester, A.M., *Heredity* , New York, Barnes and Noble, 1977.

Woese, Carl R., *The Genetic Code* , New York: Harper and Rowe, 1967.

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