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Heredity: Your Connection To The Past

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The most astounding creations in this world are the living plants and animals around us. Thousands of new facts are discovered and discussed about the human race in laboratories throughout the world every day. Believe it or not, we are on the threshold of a new era as biologists and other scientists make discoveries that will change the way we live. Although we find scientific explanations to the many questions, we still have many unanswered questions in our minds. It is a natural phenomenon that we want to increase our knowledge of how this world came to be. It is even more surprising that life continues to reproduce its kind with the same or identical traits from generations before. When we begin to take a close look at traits of plants and animals, it is mind boggling to note which ones are inherited and which ones are not. Even more puzzling is the fact that a trait appears when you thought that it had faded or perhaps been lost forever. We are all familiar with the basic ideas of heredity which were first brought to light by Gregor Mendel, an Austrian monk, more that one hundred years ago. During those times, society grew their own crops and Mendel began to experiment with pea pods. He noted that there were amazing likenesses about those plants which came from the same seed. We can use the term purebred when we refer to plants and animals which are reproduced from the same seeds. Usually there are no deviations from the characteristics or qualities of those traits.

During the development of this unit, I will put emphases on purebred, dominant traits, recessive traits, inheritance, generations, and any other traits which would lend themselves to problem-solving using scientific methods in a mathematical process.

Things are happening so fast in science these days that it is very difficult for people to keep up. As the teaching of this unit unfolds and is completed, it is my hope that at least 1% of the population involved will be motivated to choose and pursue a career in science connected with genetics. There is an abundance of knowledge to be gained, transmitted, and translated to the people of today’s inquisitive society.

This unit has been broken down into seven specific topics. The suggested course of study is to be used in the presentation and completion of this unit.

FIRST WEEK: Introduce the ABC’s of Genetics. During this time the students will take a close look at the results of Gregor Mendel’s experiments with the peas during the 19th century.

SECOND WEEK: Introduce the process of reproduction. During this time the students will learn that all living things start from a single cell.

THIRD WEEK: Introduce genes and traits. During this time the students will learn how each member of their family differs from the others. They may resemble each other in the shape of the body, the shape of the nose, the color of their eyes, the color of hair, or even the way they walk.
FOURTH WEEK: Introduce genetic diseases. During this time the students will learn that when genes or chromosomes are altered or changed, they produce what is known as mutation or new characters.
FIFTH WEEK: Introduce tinkering with genes. During this time the students will become aware of some of the research being done in the field of genetic engineering.
SIXTH WEEK: Introduce improving on nature. During this time the students will discuss the advantages and disadvantages of genes from the results of crossbreeding of varied ethnic groups.

SEVENTH WEEK: Field Trips and Culminating Activities. During this time the students will take planned field trips which would reinforce any or all of the lessons taught during the previous six weeks. Throughout the development of this unit, it is my intention to create an atmosphere in which the students and the teachers will be motivated and/or inspired to increase their knowledge about the factors involved in the normal development of human beings. When this unit is completed, the teacher and students will be able to:

1. discuss how both heredity and environment affect the development of living things.

2. discover that a complex molecule in the nuclei of cells carries a code that determines the traits of organisms.
3. observe that plants and animals with the same heredity will not be identical if their environments are different.

4. discover that although some straits are dominant, other traits can act together. Much of the information presented in this unit will be closely tied to the objectives which are expected to be mastered to successfully pass the Connecticut Mastery Test as well as the Metropolitan Achievement Test.

The students will be able to:

1. recognize facts and/or opinions about things occurring in the present, past and future as they are related to genetic engineering. 2. interpret information using charts, diagrams, timelines, and other hands on materials to clarify a given concept. As you have seen, this unit is designed to be completed in seven weeks. However, you, the teacher, have the option to teach this unit using the suggested sequence or use it as a supplement to the science curriculum provided by the school system.

At the end of this unit, a variety of activities will be provided which will meet some of the needs of the

students who are functioning at the levels of grades 5-8. Each activity will show how it can be adapted to other disciplines of the curriculum.

A Startling Experiment *Gregor Mendel*

An inquisitive mind almost always spells success. For hundreds of years, people have been breeding animals and plants. Selected individuals with valuable traits were chosen for the purpose of improving those traits or to pass their fine qualities on to future generations. During those early times, society relied upon common sense to make the right decision for a favorable outcome. It's only natural that the end product became better and better.

The modern age of genetics did not begin until the mid 1800's. Gregor Mendel often wondered why in some plants and animals, all their offspring looked just like their parents for generation after generation. It was also puzzling to note that some offspring of plants and animals looked like their parents, but also had some triats that were unlike their parents. These questions became more pronounced to Gregor Mendel as he tended his peas growing in the monastery garden where he was an Austrian monk. He noted that tall pea plants produced tall plants and short pea plants produced short pea plants. However, sometimes there were mixed patches of plants too. He also noticed other traits among his patch of peas. These traits were recorded as: 1) the color of the flowers found on the plants; 2) the smoothness of the seeds from the plants; and 3) the color of the seeds produced by the plants.

It was in 1857 when Mendel began his long study and recording the results of his experiments. He was very careful when planting his seeds the first year. He wanted to make sure that there were no mixup in the tall seeds and short seeds. When the seeds from tall plants produced tall plants and the seeds from short plants produced short plants, he referred to them as the purebred generation of plants. The next spring he decided to crossbreed the plants. He took pollen from tall plants and fertilized short plants. After these seeds were planted, he was surprised to note all of the seeds produced tall plants. This raised his curiosity even more and naturally he felt that the trait for short plants was somewhere even though it was not visible. He referred to this group of plants as hybrids.

The following spring Mendel carefully planted the seeds from those hybrids. To his amazement, he found an interesting pattern. Out of the 1,064 plants produced, Mendel found that 787 were tall plants and 277 were short plants. That, of course, calculated to a ratio of 3 to 1 for the tall plants.

Although Gregor Mendel knew nothing about chromosomes or genes, his knowledge of biology told him that male and female carried messages. It is obvious today that some of those messages were more powerful than others. As he continued to record findings from his experiments, he referred to the powerful messages as dominant and the less powerful messages as recessive. His experiments concluded that characteristics or traits do not blend into some middle group, but kept their own identity. Although pairs of characteristics might combine, they sorted themselves out according to a fixed or predictable set of rules. Regardless of the experiment, when looking for traits the rules always stayed the same—dominant traits and recessive traits. (See Diagram Below)

Red Flower
(figure available in print form)
Different combinations of genes produce different traits in living things.
PARENTS
(figure available in print form)

Mendel crossed tall and short pea plants. He discovered that the offspring in the first generation were all tall. The second generation produced 75% tall plants.

(figure available in print form)

The chart above shows the seven characteristics that Mendel studied in pea plants. Each characteristic has a dominant and a recessive gene.

Mendel applied all of the results of his experiments with sweet peas to the laws of mathematics and probability. He came up with the theory which is applied to the science of inheritance.

There were other scientists who had dome similar experiments many years later. Farmers were also aware of the changes in their plants and animals. They did not have a scientific explanation for the changes, but they called theses changes “sports”. Of course, they took advantage of sports when the change was for the better. One good example was the sheep born with short legs. Farmers found that short-legged sheep could not jump over fences; therefore, they bred that sheep until they had a generation of many short-legged sheep. A farmer who discovered that a strain of wheat with a good yield or one which survived well in spite of drought or disease, planted that seed until he had developed a whole new field of better wheat.

Mendel tried to convince the most famous scientists during his days to accept his theory. His ideas were dismissed as being amateur. Mendel even gave talks about his experiments and theories at the local natural history society in Brunn. His audiences were not interested in his discoveries. It was not until the turn of the century that three different scientists, working separately discovered the basic principals of heredity. These scientists, Hugo de Vries in the Netherlands, Karl Correns in Germany, and Erich von Tschermak in Austria made a careful search of the scientific literature before publishing their own findings. All three of these scientists discovered Mendel’s papers and realized that their own discovery was actually a rediscovery. Although each scientist wanted to be recognized for his discovery, they reported their findings only as evidence to support Mendel’s work about thirty years earlier. Mendel was given full credit as the true pioneer in genetics. Today we refer to him as the “Father of Genetics”.

Thomas Hunt Morgan, a geneticist, conducted similar experiments to Mendel’s. He chose the fruit fly to get his results. His task was more difficult because it was hard to catch a fruit fly. Morgan was able to conduct his experiments using bottles and placing them on a laboratory shelf. Fruit flies show a great deal of natural variation due to crossbreeding. Most have a gray body, but some have a body that is black or some other color. Their usual red eyes vary from shades of brown, amber, or white. Some fruit flies are born with tiny wings, which cannot be used for flight. Morgan studied his fruit flies in the same manner that Mendel studied his peas. Morgan discovered that some traits of the fruit flies seemed to be linked with the fruit flies’ sex, especially the eye color. (See Diagram Below)

PARENTS
(figure available in print form)
FIRST GENERATION
(figure available in print form)
SECOND GENERATION
(figure available in print form)

One of Morgan’s experiments:Some traits, such as body color and wing shape in the fruit fly are not inherited separately,but seem to be linked together.

(figure available in print form)

Body Cells

Before we are able to fully understand our beginning from a scientific point of view, we must have clear definitions of certain terms. The human body is one of the most fascinating units found in the world. There are 1001 unsolved mysteries of the human body. You might wonder what is the contributing factor to these mysteries. We can honestly state that there is no one factor, but several factors combined. This section of the unit will discuss cells, chromosomes, genes, and traits. We know that the basic unit of structure of all living things is the cell. It is the simplest, smallest unit which can carry on all life functions. Although cells are capable of carrying on all life functions, it takes many specialized cells to perform certain activities. Just to give you some general idea, there are brain cells, blood cells, muscle cells, skin cells, and nerve cells. These cells and others work independently and together in order for the human body to function properly.

Each single cell found in our bodies is capable of reproducing itself by dividing in half. When a cell divides, this process is called mitosis. In this process every part of the cell doubles. The cell, including all its parts, splits in half. Each new cell is exactly like the original or parent cell only smaller. (See Diagram Below)

Each new cell has a center which is called the nucleus. The nucleus is the part of the cell that controls all the activities of the cell. If we were to take a look at a cell under a microscope, we will see that in the nucleus there are tiny threadlike parts which are called chromosomes. Chromosomes are formed in pairs. All human beings have 24 pairs of chromosomes.

MITOSIS
(figure available in print form)

The sex cells found in the body go one step further. In order for sex cells to develop, they must divide twice. When they divide twice, the end result is four new cells. This division process is referred to as meiosis. When sex cells divide, however, there is no doubling of chromosomes and genes before the second division; therefore, each new sex cell has only half the number of genes and chromosomes as the original parent cell. We find that the chromosome pairs split in the meiosis process. One Chromosome of each pair goes into one new cell and the other chromosome of that pair goes into the other new cell. We can see how sperm cells and egg cell differ from other cells because they contain only 23 chromosomes instead of 23 pairs of chromosomes. (See Diagram Below)

MEIOSIS
(figure available in print form)

The polar bodies disintegrate, leaving only one egg cell.

The complexity of the human body does not end with the chromosomes. As we take a closer look at the chromosomes, we will find that our genes are located there. It is the genes that determine every trait or characteristic within the cells as well as the entire human body.

Genes occur in pairs too. There are two genes for each trait that you have. For example, there are two genes that determine hair color, two that determine eye color, and two that determine the height of the offspring. Sex determination depend on an X and Y chromosome, but may be more than two genes.

Are you beginning to see and understand how complexed the human body is? You will never be confused as long as you thoroughly investigate each part and understand its function before showing its relationship to the other parts of the human body.

At this point, we can see that everything which has been addressed in this unit so far comes in pairs. As we look at the appearance of the human body, we find that we conveniently have two of most things. We have two hands, two feet, two eyes, two ears, two legs, and so on. We become handicapped if we were to lose one of them. We are limited to performing certain tasks when we have only one of these body parts. Scientists and technology have been able to help us overcome the losses of some of these body parts, however, there is too much unknown to replace damaged or lost cells, chromosomes, and genes. Laboratories are full of cells being studied for the purpose of trying to find answers to those unsolved mysteries of the human body.

Genes

When we see or hear the term heredity, it is only natural that we immediately think of our ancestors. Heredity is defined as the passing of traits from parents to offspring. Those traits that are inherited have the ability to be passed from one generation to the next in a predictable manner. Earlier we learned that our genes determine our traits. As we look at ourselves and others we can honestly say, “What you see is not always what you get”. The characteristics of a human being which are visible or have measurable properties or qualities are called phenotype. The genetic factors that we must infer to be responsible for creating the phenotype are called genotype.

The gene is the basic unit of inheritance. Although a gene is a stable entity, it is subject to an occasional change in sequence. We now know that genes are found in the nucleus of a cell. It is amazing to us how genes are able to control what goes on in the cell outside of the nucleus. In order for a cell to function, it needs proteins. Some proteins taken into the body help the cell get the energy it needs while other proteins help break down complex compounds found in the body. Proteins are also used to make new compounds for the body.

Numerous experiments have been done by scientists and they have found that basically each protein found in a cell is controlled by one gene. Some proteins have more than one component. Each component is controlled by one gene. An example of such a protein is collagen. The DNA code makes sure the right organic compounds come together in the right order to make the right protein in order for the body to function properly.

DNA is short for deoxyribonucleic (day-OX-ee-rye-bownew-CLAY-ic) acid. The chromosomes carrying genes that are made up or DNA are passed from one generation to another. DNA is made up or six parts: a sugar, a mineral or phosphate, and four special chemical bases known as adenine (A), thymine (T), guanine (G), and cytosine (C). It was the discovery of Francis Crick and James Watson who figured out how the six parts fit together. This discovery helped to explain how heredity occurs. Crick and Watson created a model of DNA which resembles a spiral staircase. The sugar and phosphate form the sides of the staircase while the special chemicals form the steps. These chemicals or steps are always paired in the same way. The adenine (A) base always pairs or attracts the thymine (T) base while the guanine (G) base pairs or attracts the cytosine (C) base. The shapes of these special chemicals make it almost impossible for them to be attracted to the wrong chemical. (See Diagram Below)

The rungs of the DNA staircase always combine in a specific way.
(figure available in print form)

The body needs to keep in balance, thus makes it necessary to produce more DNA which is needed in the formation of new cells. In order to do this, the staircase splits or separates and two new DNA are replicated. The new DNA is identical to the original one. This process can be viewed during the mitosis or cell division. The replication of DNA is the key to heredity. DNA replication not only results in the formation of new

reproductive cells, but also results in the formation of new body cells. please bear in mind that DNA replication only occurs during the first division of the meiosis process and not the second division. (See Diagram Below)

The Structure of DNA

(figure available in print form)

Spiral staircase structure of a DNA molecule, with steps made of protein bases.

DNAReplication

(figure available in print form)

DNA molecule duplicates itself

Traits

As we have already learned, traits are determined by the genes found in the chromosomes. This section of the unit takes a closer look at dominant and recessive genes. The more we examine and learn about the genes, their codes, and the messages that they send out, the more we can compare them against a giant computer. The coded messages make everything in the body run smoothly, however, nothing is said to be perfect. Genes can sometimes malfunction or break down; thus, produce the wrong code. If and when this happens, it causes changes in the organism. If the gene breaks down in the sex cells, the changes can be passed on to the offspring. This change,which is lasting, is called nutation. Most of the changes in genes are recessive and do not show up for generations. However, sometimes a change is dominant and can be noticed right away.

Mutations are usually not harmful and they do not happen that often. In actuality, one mutation occurs about every 10,000 genes. This can be interpreted as one mutation per person in each generation. Of the millions of genes found in an individual, there may be one gene that is different from one that an individual received from a parent. That one gene will probably not be that noticeable.

Mutations can be caused by a number of ways. Cosmic rays and natural radiation are always present in the environment; therefore, are two contributing factors of mutations. Although industrial activities of nuclear energy may appear to be harmless at times; there is a great risk of these activities being a contributing factor. X-rays are considered contributing factors too. That’s why it is recommended that we don’t have several x-rays over a short period of time. All of the activities mentioned are a major concern to scientists, environmentalist, as well as the general public.

Our society has made some remarkable changes through the years. One of these changes, interracial marriages or sexual activities of different ethnic groups, is creating blended traits. This type of blending could be to an advantage for individuals as well as a disadvantage for all individuals involved. These blended traits have had a definite affect on the appearance of offspring, especially skin color, hair color, and hair texture. Over a long period of time, inherited diseases could be affected from the results of blended traits. There is the great possibility that a dominant gene of a family could become a recessive one in generations to come or vice-versa. This would work and have the same results as the breeding of short-legged sheep and the productive strain of wheat which were described at the beginning of this unit. We will hear and read more of blended traits as scientists produce more findings as they strive toward developing a theory based on their experiments which are sure to be forthcoming in the future. I’m sure that fifty years from now we will have the answers to the 1001 questions of the unsolved mysteries of the human body. Of course, we can’t abandon the fact that there will be just as many or more unanswered questions. We can surmise that unsolved mysteries is a cycle that goes on infinitely.

Conclusion

This unit has only touched the surface of your possible connection to the past. We know that heredity lets us know what we may become and what small affect we as individuals have on this vast society. It is remarkable to note that the cell, a small microscopic structure, can be so powerful. It is in the nucleus of the cell where we find DNA, the substance that controls our heredity. Although the life cycle of man began millions of years ago, we know the role that the environment plays on the development of the human being. Isn't it wonderful how we have changed? Aren't we optimistic of what lies ahead for us? There are many wonders ahead, but there's no doubt that "Our ancestors hold the key(s) to our unsolved mysteries!"

VOCABULARY LIST

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breeding—the producing of animals or new types of plants, especially to get improved kinds.
cells—the basic units of structure and function of all living things.
chromosomes—short, thick threadlike units which contain the determiners of heredity or genes.
component—the necessary or essential part of a unit.
dominant—the most powerful or influential part of a unit.
egg—female gamete.
evolution—changes in living things in which simple forms become more complex.
fact—a piece of information that has been proven to be true.
fertilization—a sexual form of reproduction in which unlike gametes, such as sperms and eggs, unite to form a new unit.
gametes—the producing of animals or new types of plants, especially to get improved kinds.
genes—determiners of heredity which contain DNA molecules.
hybrid—offspring of two animals or plants of different species.
molecules—the smallest particle into which an element can be divided without changing its chemical properties.
mutation—appearance of a sudden change in a gene. The organism with the mutation is a mutant.
nucleus—a mass of specialized protoplasm found in most plant and animal cells. Without a nucleus a cell cannot grow and divide.
protein—a group of energy producing nutrients composed of the elements carbon, hydrogen, oxygen, and nitrogen. proteins are essential for building up protoplasm and growth, and repair of worn-out or damaged cells.
protoplasm—the mixture of proteins, fats, and many other complex substances suspended in water which forms the living matter of all plant and animal cells.
recessive—a character hidden by the dominant character.
theory—an explanation based on observation and reasoning, especially one that has been tested and confirmed as a general principle explaining a large number of related facts or occurrences over a long period of time.
traits—a quality or characteristic which an organism inherits from its parent.

Sample Lesson

The Cell

Objectives The students will be able to:

1. differentiate plant cells and animal cells.
2. identify and describe two types of protoplasm.
3. identify and discuss the function of the nucleus.

Vocabulary cell, protoplasm, nucleus, meiosis, mitosis

Material Needed paper, pencil, microscope, wall posters of animal and plant cells

Brainstorming Questions

1. How many cells do you think you have in your body?
2. How does life begin in living organisms?
3. Are cells replaced in plants and animals? Why do you think they do or do not?
4. Can you see cells on your body?

Procedures Discuss the vocabulary words with emphasis placed on the nucleus of the cell because it controls most of the cell activity. Make sure that the students are aware that there are several kinds of cells found in the body, such as bone, nerve, blood, skin, etc. Point out that animal cells have no rigid cell was as found in plant cells. Make sure that the students are aware that the nucleus has a major role with the cells' reproductive process. Using the diagrams in the unit point out the mitosis and meiosis process of cell division. Point out how they are alike as well as how they are different. There are over 10,000,000,000 cells in the human body.

Related Activities

1. Have the students to write 10,000,000,000 using exponents. 10^{13}
2. Have the students to find pictures of at least three kinds of cells found in the body and make sketches of them. Make sure they identify the parts of their drawings.
3. If slides are available, have the students to observe cells under a microscope. Discuss what

they see.

Sample Lesson

Genes

Objectives The students will be able to:.

1. distinguish between dominant genes and recessive genes.
2. determine some of the genes that they inherited from their parents.
3. determine some of the genes that they inherited from an ancestor such as grandparents and/or great grandparents.

Vocabulary dominant genes, recessive genes, ancestors, inherit, phenotype, genotype

Materials Needed Charts illustrating dominant and recessive genes, paper, pencil, blank chart of 'Tracing Inherited Genes'

1. Are you more like your father's family or your mother's family?
2. Do you ever wonder why you don't look exactly like your brother(s) and sister(s)?
3. What traits can sisters and brothers have which are nearly the same?
4. What traits can sisters and brothers have which are totally different from yours?

Procedures Introduce the vocabulary. Using the chart illustrating the several traits that Mendel observed with his peas, discuss how traits can be passed on to an offspring. Discuss dominant and recessive genes. Allow the students to discover at least one trait which is dominant and can be seen (phenotype) in their parents, grandparents, and great grandparents such as hair color, eye color, height, and skin color.

Related Activities

1. Reproduce the chart titled ‘Tracing Inherited Genes’. Have the students to choose a specific phenotype (visible) trait and trace it for at least four generations. Record heights, length, or colors on the lines provided. (This would be a good time to introduce and discuss a family tree.

TRACING INHERITED GENES
(figure available in print form)

Sample Lesson

DNA: Factors of Inheritance

Objectives The students will be able to:

1. describe the process of meiosis.
2. identify and describe the structure of DNA and how it replicates.
3. discuss how sex traits are inherited.

Vocabulary DNA, minerals, proteins, genes, chromosomes, inherited, replicate, meisos, mitosis, traits, cells

Materials Needed paper, colored pencils, chart of a DNA structure

Brainstorming Questions

1. If cells did not reproduce themselves how long do you think you would live?
2. What makes you look the way you do?
3. What ways can people change their appearance?

Procedures Review cells with emphases on the nucleus. Introduce DNA. Using the diagram, point out the structure of this unit of the body and them importance of the six parts of which it is made. Make sure the students are aware of the manner that the four basic chemicals which form the protein needed in order for the body to function properly. Tell the students that because cells die they must constantly replace themselves in order for the body to remain in balance. Due to the fact that DNA is a part of the cell structure, it too must replicate itself. Make sure that the students understand that the four basic chemicals used to form the protein of the body must be

attached in a certain way or there could be problem which could be passed on to offspring.

Related Activities

1. Have the students colored paper and cut the six parts of the DNA structure. (Sugars and minerals could be 2”x5” and the chemicals can be 2”x6”) Distribute the pieces among the students, making sure that each student gets two or three different pieces. Using a flat surface, have the students attach the sides together in the proper order. Once that is done, have the students to attach the protein steps. (Like a jigsaw puzzle, the students should get the feel of how this structure works in the body.)

Teachers’ Bibliography

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This book is a summary of current knowledge in molecular biology. Genes reflect a rethinking of the way we view genetics as a whole in light of recent discoveries and techniques.

Bodmer, W. F. and L. L. Canalli-Sforza. *Genetics* , *Evaluation, and Man* . W. H. Freeman & Company. San Francisco. 1976.

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In this book Dr. Carter explains is simple terms what is known about heredity with particular reference to man.

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DNA research and test-tube babies.

Frankel, Edward. *DNA: The Ladder of Life* . McGraw-Hill. New York. 1979.

This book gives a clear and concise way of how we arrived at the DNA revolution.

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This book gives a description of some of the results of past genetic research. It also takes a look at what may be possible in the future.

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This book explains the biological factors of heredity that make each person found in the universe unique.

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This book introduces fundamental concepts of genetics, the branch of science which studies inherited characteristics.

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This book discusses genetics and genetic diseases. It also explores the controversy over genetic engineering along with its potential health hazards.