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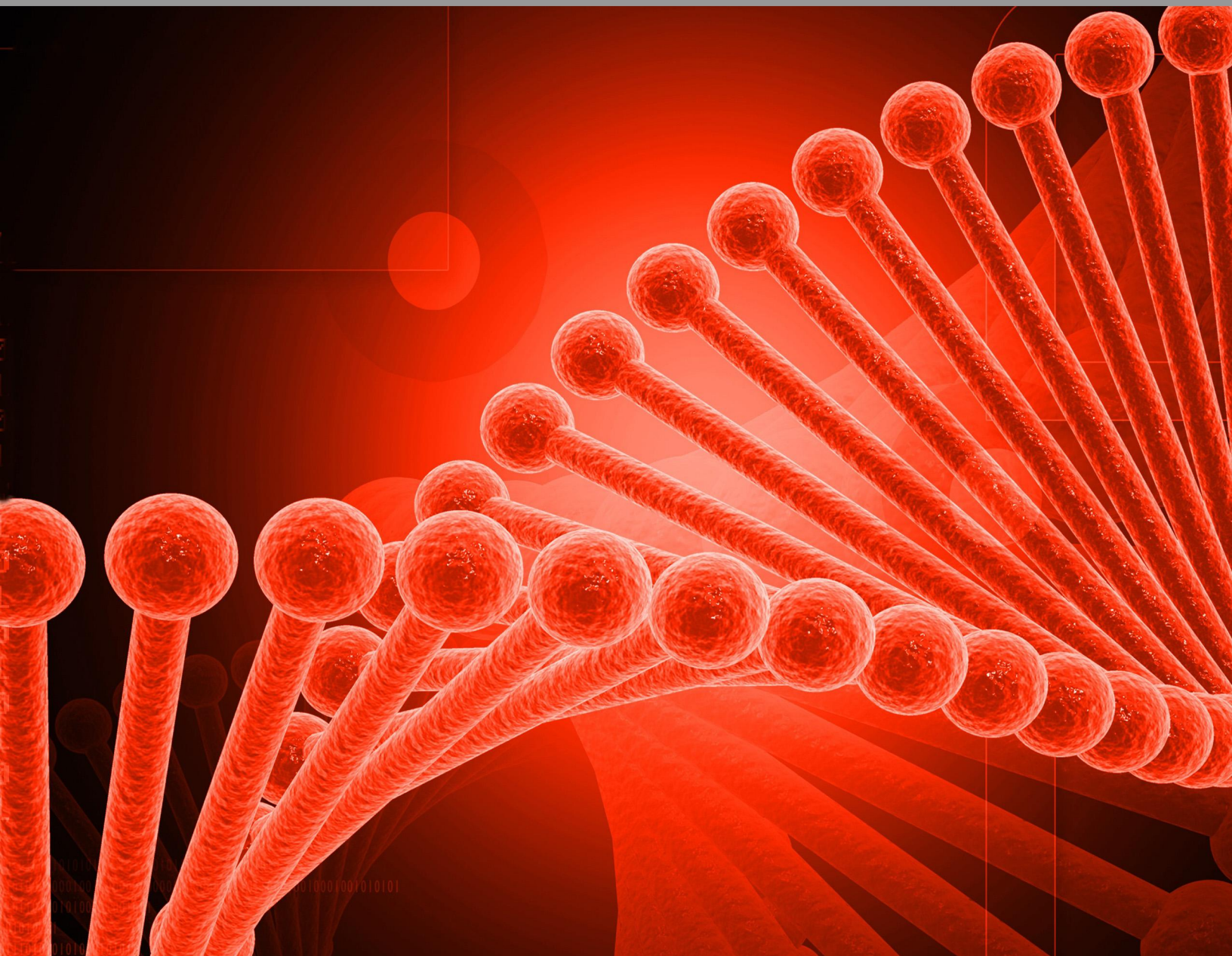
Human Biology - Genetics

Teacher's Guide



Human Biology Genetics Teacher's Guide

The Program in Human Biology,
Stanford University, (HumBio)

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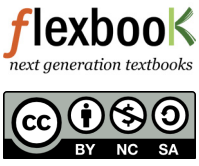

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CHAPTER 1 Introduction to Genetics - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

1.1 Human Biology

An inquiry-based guide for the middle school student.

Developed by the Program in Human Biology at Stanford University

EVERYDAY LEARNING®

1.2 Introduction to Genetics

Contents

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Dedication

The faculty, staff, and teachers of Stanford University's Human Biology Middle Grades Life Science Curriculum Project dedicate the publication of the HumBio Curriculum in memory of our colleagues and friends, Mrs. Donna Harrison and Dr. Mary Budd Rowe. Donna was the lead science teacher at Dozier Middle School, the project test site school in Newport News, Virginia. She was an outstanding teacher, a community leader, a devoted wife and mother, and a wonderful human being. Her involvement in the HumBio Project enriched the curriculum materials and brought great joy to our lives. Although her life ended suddenly and tragically, the inspiration she gave to all who knew her will live on in what we do to improve the education of children and youth. Mary Budd Rowe was our most distinguished science education colleague and our dear friend. She guided the early organizational stages of the project as a group of university scientists attempted to address issues of middle level science education. Her unbridled enthusiasm for the education of children always reminded us of the important purpose of our work. Mary continued her unwavering support of the HumBio curriculum until her passing in June of 1996.

1.4 Preface

Stanford University's Middle Grades Life Science Project began in 1986 with the vision of David A. Hamburg, M.D., then President of Carnegie Corporation of New York. A new wave of science education reform was gathering momentum following the release of *A Nation at Risk* by the United States Department of Education and *Educating Americans for the Twenty-First Century* by the National Science Board. Dr. Hamburg brought together the concerns of scientists and science educators over the watered down, vocabulary laden life science curricula that were typical of middle level science courses at that time, with broader public concern over large and increasing numbers of young adolescents who engaged in high risk behaviors leading to school failure, teen pregnancy and other health problems. Because of his leadership in developing Stanford's undergraduate Program in Human Biology and his interests as a physician and scientist in the major physiological and behavioral transitions in the lives of children, Dr. Hamburg believed that a rigorous middle grades life science curriculum focused on human biology, and where possible on the adolescent, would not only greatly improve the science taught at this level, but through its relevance would capture the interest of this age group.

Initial work on the Human Biology (HumBio) Middle Grades Life Science Curriculum brought together faculty, staff and students from Stanford's Program in Human Biology and its School of Education, with local middle and high school teachers. The curriculum development team was enriched in 1991 by twelve interdisciplinary teams of middle level teachers from diverse test site schools across the country. These teams became our most valued collaborators. The teachers attended annual two week summer institutes at Stanford between 1991 and 1994, and used the draft curriculum units in their classes between 1991 and 1995. The teachers and their students provided extensive formative evaluation data on the field test materials, which has shaped the final student and teacher versions of the units that comprise the HumBio Curriculum. Using HumBio units as a starting point, many teams also created their own innovative, interdisciplinary materials, which they taught across the middle level curriculum in their schools.

The Project's Advisory Board provided insightful advice on the development of the curriculum from the unique perspectives of the professional associations, institutions, and the fields its members represented. We are grateful to all of those who served for periods of time during the past seven years. We also would like to express our appreciation to the education consultants from universities, the National Middle School Association, and the California State Department of Education who made presentations and worked with the teacher teams during the summer institutes at Stanford. C. Stuart Brewster served with great distinction as our advisor on publication. We are indebted to him for his keen insights and good advice.

The Project faculty, the staff, and the teachers contributed more to the development of the HumBio Curriculum than anyone could have imagined before this work began. Their expertise, determination and dedication to improving the education of young adolescents were inspirational. Supporting the curriculum development team and the test site teachers were wonderful groups of Stanford undergraduates from the Program in Human Biology. They helped to ensure a productive and pleasurable working environment, which was an essential part of the success of the summer institutes.

To be sure, none of this work would have been possible without funding from Carnegie Corporation of New York, the National Science Foundation and most recently The David and Lucile Packard Foundation. On behalf of the entire Project team we would like to thank these foundations and the Program Officers who have worked with us over the years for their support. As always, the final content of this curriculum is the sole responsibility of the Stanford University Middle Grades Life Science Project and does not necessarily reflect the views of Carnegie Corporation of New York, the National Science Foundation, or The David and Lucile Packard Foundation.

H. Craig Heller, *Principal Investigator*

Mary L. Kiely, *Project Director*

January, 1998. Stanford, California

1.5 Letter to the Teacher

Dear Teacher:

You and your students are about to embark on the study of genetics. Can you remember your first exposure to genetics? It was probably like mine, in 10th grade, and consisted of going through the crosses and back crosses that the Austrian monk, Gregor Mendel, carried out with garden peas. You may remember using Punnett squares to figure out the famous ratios of Mendelian genetics. You and I can appreciate these experiments as being some of the most beautiful in the history of biology. However, that does not mean that today's middle grade students will be fascinated by the genetics of pea plants. We introduce students to genetics by having them observe and measure human traits. They study themselves to learn about constancy and variation. Then we introduce them to examples of dog breeding to figure out the rules governing the inheritance of a trait.

The next step is still not Mendel's peas, but aspects of genetics that were unknown to Mendel. Cellular and molecular details of genetics are in the news every day and are the subjects of popular movies and TV programs. Chromosomes, DNA, genes, cloning, and mutations are common concepts, but not necessarily well understood. Therefore, we explore the cellular and molecular biology underlying inheritance-mitosis, meiosis, fertilization, chromosome replication, and the genetic code. With that background, students can see the pea plant experiments as great examples of how genetics works, rather than as the focal point of their study of genetics.

The relevance of genetics becomes obvious with consideration of human genetic disorders and the issue of genetic counseling. The unit concludes with a discussion of genetic engineering and the Human Genome Project-subjects that are in the news practically every day, subjects that will continue to touch your students whether or not they continue to study science. Your students will end this unit with knowledge of genetics that will enable them to form their own opinions on such issues as genetically engineered crops, environmental mutagens, genetic testing, and the use of DNA as forensic evidence.

As with all the HumBio curricular units, this unit is intended to promote interdisciplinary study and team teaching. There are many opportunities for you to relate this unit to other subjects. The measurements that students make open up opportunities to discuss the mathematical concepts of variation, normal distributions, and significant differences. The genetic code is a wonderful way to introduce permutations and more simply deal with very large numbers. Of course, Mendelian genetics revolves around ratios. Language arts and social studies can be emphasized in writing and discussing controversial issues such as genetic cloning, genetic testing, and environmental mutagens. Health can be emphasized in discussions of genetic disorders and genetic counseling.

The genetics unit is inquiry based and provides abundant hands-on activities. The learning gains and the retention by the students are much greater than is accomplished with a traditional text approach. The activities in this unit are especially important to help students conceptualize the cellular and molecular mechanisms of genetics. After all, making a molecular model of DNA similar to the ones your students will make resulted in Nobel Prizes for James Watson and Francis Crick! The activities also are helpful in presenting the quantitative aspects of genetics. The activities in this unit offer opportunities for creativity. They are not difficult, and the materials required are common items.

We are confident that you and your students will enjoy this unit and that your students will learn more about genetics than you or I did when we were in high school.

Best wishes,

H. Craig Heller

Chair, Department of Biological Sciences, Stanford University

1.6 Unit Planning

Content Overview

Genetics: Who are our ancestors? Whose nose do you have? From what side of the family does your artistic ability come?

This unit invites students to learn about the genetic mechanisms that make each individual uniquely different. For adolescents, learning why people are the way they are can be an important process. Adolescents need to realize that they are not alone-that they are part of the continuity of a species and a family, and that they carry in them a genetic history of their ancestors. Over the course of the unit, students can begin to address some of the personal and societal bio-ethical decisions that arise from our continuing exploration and knowledge of human genetics.

The structure of this unit moves from the fundamentals of continuity and diversity through the structure and function of DNA and the process of protein synthesis, to a discussion of genetic engineering and genetic disorders, such as cystic fibrosis, sickle-cell disease, and color blindness. Students explore variations in eye width, wrist circumference, and make a personal set of fingerprints. They apply their knowledge of chromosomes to construct and interpret human karyotypes. Students conduct two laboratory activities that enable them to see purified DNA and DNA that they remove from thymus tissue. They extend their knowledge of chromosomes and heredity by using pipe cleaners to simulate meiosis. Students investigate the Human Genome Project and study a trait found on one of the chromosomes. They conclude their studies of human genetics and apply what they have learned by participating in a mock senate hearing on genetic engineering. This unit places the student in the context of making decisions for the future-for their genes will be passed on to future generations. Learning about genetic inheritance sets up an opportunity to talk about decision-making, risk, and control.

Summary Questions to Consider throughout the Unit

- If you could predict your future, what would you want to know?
- If you could control genetic expression, what would you control for?
- How far should genetic engineering go?
- Who should set policy regarding genetic research and the many business opportunities that arise from each new discovery?

How Is This Unit Structured?

The unit begins with a discussion of continuity and diversity and how the study of genetics is relevant to our lives.

Section 2 reviews some cell biology and introduces chromosomes.

Sections 3, 4, and 5 focus on DNA, cell division, and protein synthesis.

Section 6 discusses the concepts of dominant and recessive genes.

Sections 7, 8, and 9 look at genetic disorders, genetic engineering, and the Human Genome project.

Why Teach This Unit?

Connections to the Real World

"For the first time in history, it is within our power to design life by deliberate human intervention. The possibilities and implications are awesome, but we lack the historical, social and cultural guidelines that can lead us through this uncharted territory."

-David Suzuki and Peter Knudson, *Genetics*, Cambridge, Mass.: Harvard University Press, 1989.

"Every human gene must have an ancestor."

As you read this unit, geneticists are hard at work trying to identify human genes, read DNA, and produce proteins in a laboratory. Their work could have tremendous implications for the future of the human race. Will we have a disease-free society? Will couples "design" their children? If you had something about you that you didn't like, would you fix it?

Adolescents are fascinated with human disorders and human appearance. The study of genetics helps them to learn about the how's and why's of appearances and how a person may have a inherited a disorder or disfigurement-in the hope that through this knowledge, adolescents will show more compassion towards individuals with these physical challenges.

Adolescents often feel isolated and unsure of their identity. Genetics offers students the opportunity to think about themselves in a different context-in one of continuity and diversity. Students learn that each adolescent carries a genetic family history that offers a strong connection with the past and with distant relatives. It also places students in the context of making decisions for the future-for their genes will be passed on to future generations. Learning about genetic inheritance sets up an opportunity to talk about decision-making, risk, and control.

TABLE 1.1: Unit Activities and Key Ideas

Section	Key Ideas	Activity
1. Continuity and Diversity What makes one species different from another?	• Members of an animal or plant species have distinctive characteristics, or traits, in common. • Within a species, individuals have variations which are examples of diversity. • Members of a species produce offspring that have characteristics similar to the parents. • Geneticists study the biological causes of continuity and diversity among living things.	**Mini Activity:** Peanut Sort **Mini Activity:** Eye Variation **Activity 1-1:** Fingerprinting **Mini Activity:** Continuity and Diversity in Art **Mini Activity:** Wrist Variation **Mini Activity:** Human Variations

TABLE 1.1: (continued)

Section	Key Ideas	Activity
2. Cells and Chromosomes How does an individual develop certain characteristics?	• Chromosomes in the nucleus carry the genes responsible for human traits and variations. • Chromosomes occur in pairs, with exception of the sex chromosomes which may not be the same. • Individuals of the same species have the same number of chromosomes. • A karyotype is a "portrait of the chromosomes in a cell" and is useful in helping diagnose, learn about, and explain many genetic diseases.	**Mini Activity:** Genetics in the news **Activity 2-1:** Karyotyping-A Chromosome Portrait
3. Chromosomes and DNA What is the composition of a chromosome?	• Chromosomes are made of two chemical substances, deoxyribonucleic acid (DNA) and protein. • A gene is a segment of the DNA of a chromosome that can be copied (replicated) and that codes for a specific protein. • DNA is composed of four different nucleotides: adenine, thymine, guanine, and cytosine. • Each nucleotide is composed of a sugar molecule (deoxyribose), a phosphate molecule, and one of four nitrogen bases. • Nucleotides are arranged in pairs, guanine with cytosine, and adenine with thymine, to form DNA.	**Activity 3-1:** Precipitation and Spooling of DNA **Activity 3-2:** Removing DNA from Thymus Cells **Activity 3-3:** Building and Using a DNA Model

TABLE 1.1: (continued)

Section	Key Ideas	Activity
4. Cell Division How are traits passed from one generation to the next generation?	• Mitosis is the division of replicated chromosomes which is necessary for making new cells having the same number of chromosomes and the same traits as the parent cells. • Meiosis is the division process that reduces the chromosome number, producing gametes (sperm and ova) in preparation for fertilization. • Fertilization, or union of sperm and ovum, yields a zygote (fertilized ovum) and restores the normal number of chromosomes in somatic cells of that new organism. • Models are important tools that help geneticists explain biological processes.	**Activity 4-1:** Cell Division-Double or Nothing **Activity 4-2:** Meiosis and Fertilization
5. Gene Expression-DNA Codes of specific proteins How is information contained in DNA expressed?	• DNA contains the coded information for the synthesis of specific proteins, which is the result of gene expression. • Protein are large molecules composed of amino acids that perform essential functions in the body. • The DNA code, or gene, for a protein resides in the nucleus and is taken by messenger RNA (rnRNA) to the ribosome in the cytoplasm for synthesis. • Transfer RNA (tRNA) transports each amino acid to the ribosome to take its place in the newly forming protein molecule according to the instructions encoded in the mRNA.	**Mini Activity:** Run to the Ribosome **Activity 5-1:** Making Protein

TABLE 1.1: (continued)

Section	Key Ideas	Activity
6. Expressing Dominant and Recessice Genes Why are offspring from the same parents different? how can offspring show traits not seen in either of their parents	• Pedigrees are important tools for geneticists to use in Mini Activity: Family Dominant and tracing traits and variations from one generation to the Pedigree One Recessive Genes next. • Genes have different forms, called alleles. Two alleles Pedigree Two the same parents make up a gene pair for a specific trait • A dominant allele expresses its trait whenever it is present in a gene pair. Two recessive alleles must be present in order to express that trait • Gregor Mendel's work studying inheritance in garden peas in the 1860s laid the foundation for the modern science of genetics.	**Mini Activity:** Family Pedigree one **Mini Activity:** Family Pedigree two **Activity 6-1:** Expression:Dominant and Recessive
7. Single Gene Disorders What are some genetic conditions that research might be able to help treat or cure?	• Single gene disorders are classified by geneticists into Activity 7-1: Exploring a Disorders dominant, recessive and sex-linked, depending upon Single Gene Disorder their pattern of inheritance. • Dominant patterns of inheritance occur when the genetic defect is a dominant allele. • Recessive patterns of inheritance occur when the Inheritance Pattern-Color genetic defect is a recessive allele. • Sex-linked patterns of inheritance occur when the genetic defect is located on the X or Y chromosome.	**Activity 7-1:** Exploring a single gene disorder **Mini Activity:** Hemophilia **Mini Activity:** X-linked Inheritance Pattern-Color Blindness

TABLE 1.1: (continued)

Section	Key Ideas	Activity
8. Other Genetic Conditions and Genetic Counseling How do chromosomes and the environment contribute to human variation?	• Some genetic conditions are caused by the interaction of several genes. The interaction makes predicting the condition of the offspring more difficult. • Chromosomal disorders leading to other genetic are caused by errors that occur during the process of meiosis. Sometimes a piece of a chromosome is missing, an entire chromosome is missing, or an extra chromosome is present in the offspring. • Non genetic birth defects are caused by factors that affect the maternal environment in which the fetus grows and develops. • Genetic counselors can help couples and families learn more about their risks for genetic diseases and help families living with a genetic disease find good medical treatments. • Population geneticists are concerned with variations in gene frequencies in different populations of people around the world.	**Activity 8-1:** Investigating the human genome project

TABLE 1.1: (continued)

Section	Key Ideas	Activity
9. Genetic Engineering How can learning about DNA solve new problems?	• Genetic engineering is the process by which genes are made to produce proteins in the laboratory by using recombinant DNA procedures • Recombinant DNA technology places a desired gene into a bacterial plasmid, which then expresses the protein for which it codes. • Recombinant DNA technology is used to produce many proteins, some of which safely and effectively treat human genetic diseases. • The goals of the Human Genome Project are to map all human genes and determine the DNA sequence of all of the chromosomes of the human genome. • The new genetic technologies have created the need for each person to learn about genetics in order to make responsible and informed decisions on how these technologies should be used by our society.	**Mini Activity:** Role-Play Issues in Genetic Engineering **Mini Activity:** Gene Information **Mini Activity:** Explaining Genetics **Mini Activity:** Concept Map **Activity 9-1** Biotechnology in the U.S senate

Teacher's Guide Overview

This *Genetics* unit is built around a set of student activities. Text material can be used to introduce, reinforce, and extend the concepts developed in the activities. The activities are the foundation of this unit, so the unit's success depends on student involvement in the activities. Embedded activities are interrelated, since the concepts developed in one may be applied in another.

Section Planning For each section, you'll find extensive advance planning for the student activities and the section topic. Key ideas, section objectives, background information, suggestions for introducing activities, and the materials needed for each activity are listed on the Section Planning page. Review this information ahead of time to ensure that materials for each activity are available when you need them.

Support for Embedded Activities

Embedded activities are those activities contained or "embedded" in the student edition. Procedures for each embed-

ded activity are contained in the student edition. In the Teacher's Guide, you'll find activity planning information, activity assessment, and student reproducible pages for each embedded activity.

Enrichment Activities Enrichment activities are activities found in the Teacher's Guide. These activities are designed to extend and enrich students' learning experiences. Enrichment activities, including student procedures and reproducible pages, are located at the end of each appropriate section of the Teacher's Guide.

Group Work Activities Learning science is a process that is both individual and social. Students in science classrooms often need to interact with their peers to develop a knowledge of scientific concepts and ideas, just as researchers, engineers, mathematicians, and physicians do who are working in teams to answer questions and to solve problems. The GroupWork activities in the HumBio Curriculum have been developed to foster a collaborative environment for groups of students. Group Work activities provide an environment in which students are "doing science" as a team.

For more information, refer to "Using Group Work Activities" on page 110. The specific GroupWork activities for this unit can be found beginning on TE page 114.

Projects The research and action projects in HumBio are varied and provide students with time to explore a particular topic in depth. With projects, students have the opportunity to take a position based on knowledge gained through research, debate an issue, and devise a plan of action. In this way, students can apply what they are learning to larger issues in the world around them.

Projects for this unit include

- Research Questions
- Investigating Careers in Genetics
- Developing a Lesson in Genetics

Assessment Overview

Within each section of the unit there are suggestions for assessment that can be used individually or in combination to develop a complete assessment package. The list below describes the variety of assessment tools provided.

Apply Your Knowledge questions appear throughout each section. They can be used as homework assignments and as ways to initiate a class discussion. These questions are designed to assess

- communication skills
- depth of thought and preparation
- problem-solving skills
- ability to apply concepts to related or big ideas
- how well students relate their new knowledge to different problems

What Do You Think?.

These questions appear in each section. They provide students with opportunities to think and write about the concepts they are learning in a larger context. You can use these questions to assess

- writing skills
- problem-solving abilities

- creativity and depth of thought
- the ability to analyze and summarize

Journal Writing

Journal Writing prompts are suggested throughout the unit. These prompts provide opportunities for students to write critically and creatively about concepts and issues. The writing products can be used to assess

- writing skills
- depth of thought
- and the ability to explain and expand concepts

Review Questions

Review Questions are located at the end of each section. These questions can be used for written responses or as the basis for class discussion. These questions are designed to assess content knowledge and whether students can explain the concepts explored in the section.

Activity-Based Assessment

Inquiry-base student-centered activities are the foundation of the *Human Biology* Program. The unit is rich with relevant a exciting activities that introduce support, or reinforce concepts students are exploring. Within the Teacher's Guide, you'll find extensive teacher information, including assessment strategies, for each type of activity:

- Embedded Activities
- Enrichment Activities
- Mini Activities
- Group Work
- Projects

You can use students' products to assess their progress. These products includes models, simulations observations and reports of laboratory investigations, role-plays, written responses to questions and written observations, student-designed explorations and procedures, poster presentations, and classroom presentations.

PORTFOLIO ASSESSMENT You may want to have your students develop a portfolio for the unit. Portfolio assessment is an excellent way to assess the whole student as he or she progresses throughout the unit. Although there are many opportunities to select a variety of the student's products, the following list shows one possible assessment portfolio for this unit:

- Written responses to three *What Do You Think?* questions.
- Written responses to one *Apply Your Knowledge* question from each section.
- An analysis of their two favorite activities and how those activities helped them learn an important concept.
- Reports from three laboratory investigations such as:

  Activity 1-1: Fingerprinting Activity 2-1: Karyotyping-A Chromosome Portrait Activity 3-2: Removing DNA from Thymus Cells

- A model from *Activity 3-3: Building and Using a DNA Model*
- An example of calculation from *Activity 6-1: Expression: Dominant and Recessive*

Getting Started

Keep Students Interested. Encourage students to read the text: It is the story line that ties all of the content together. Every effort has been made to make the text interesting to students and appropriate to their reading level. Text material can be used to introduce, reinforce, and extend the concepts addressed within the activities.

The success of the unit depends on the completion of at least the Embedded activities. And keep in mind that some activities are related, since the data obtained in one may be used in another.

Plan Ahead. The unit is activity-based, and you can select the activities that will best meet your class needs. The activities are listed in the Unit Matrix on page xiii and in the Activity Index on page 152. Mini Activities are shorter and can be done with minimal teacher input; they are located in the margin of the student edition. The Embedded activities in the student text are investigations that require some planning and setup time; these are the essential activities within the unit. Other investigations called Enrichment activities are located at the end of each section in the Teacher's Guide. Enrichment activities expand student knowledge of the concepts explored in the given section.

A variety of projects were designed to extend the content of the unit. These include ongoing class projects, school projects, and/or community projects. Projects are located at the end of the Teacher's Guide, beginning on page 145.

Customize the Unit. Each section of this unit builds upon knowledge gained in the previous sections. Teaching timelines are provided on TE pages xii-xiii. The first timeline on TE page xii demonstrates how to complete this unit within a three week schedule. The timeline on TE page xxiii demonstrates how to complete this unit within a five-week schedule. Both of these timelines highlight the essential activities. If your class has time to study the unit over a longer period of time, many additional activities are available.

Allow Time for Projects. Consider having students start projects at the beginning of the unit and then prepare those projects for presentation as a culminating event.

Use Current Events. Ask students to bring in newspaper and magazine articles that relate to what they are studying each week. Relating the unit content to current events helps students see that what they are doing in class is, in fact, relevant to their lives outside of school. Students can use current events to make group scrapbooks, bulletin boards, and posters or to develop class presentations.

Make a "Question Box" Available. Have students write down questions they have about what they are investigating and put them in the box. At appropriate times select questions and read them to the class to generate discussion. These questions can also be used to initiate class research projects.

Use a Variety of Resources. We encourage you and your students to use a wide variety of sources for information. The activities provide rich opportunities for students to explore a variety of concepts. The more students incorporate information from resources outside the classroom, the richer their learning experiences will be. Use computer services for gathering student and teacher information, for networking with students in different schools and with community resources, and for contacting experts in the field under study. A list of resources can be found on page 150 of this Teacher's Guide.

Make Career Connections. Encourage students to investigate careers related to the content of the unit. Invite scientists, physicians, and technologists working in the field to come to your classroom to discuss career opportunities, their research, and specific topics of interest.

Plan for Field Trips. Field trips to local hospitals, industrial sites, or universities need, of course, to be arranged well in advance. Contact the public affairs offices of these institutions for assistance.

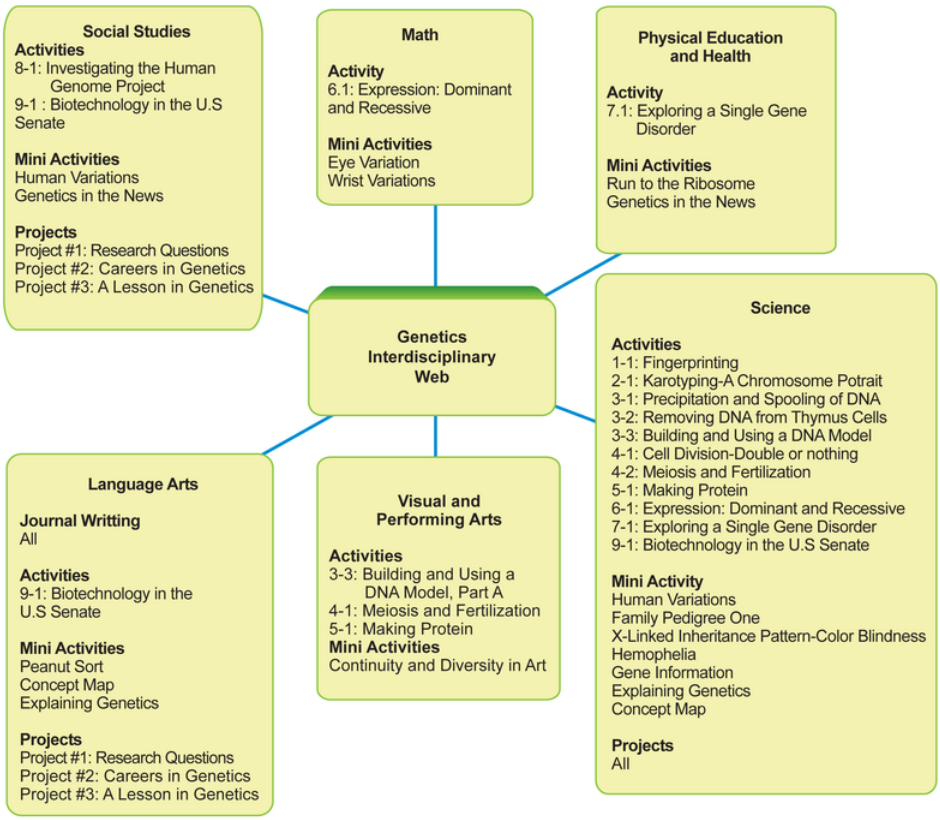
Address Health Concerns. Be aware of any special health problems your students may have. Some students may have health conditions that would make it uncomfortable for them to participate in certain activities, such as those that require exercise or that relate directly to their particular health problems. For students unable to participate fully in these activities you may wish to create an alternative assignment or have them use data from another group. If the class is appropriately prepared, the affected students may want to share information about their special circumstances

with the class in order to increase empathy and knowledge of all students.

Connect with Other HumBio Units. The units covering human physiological systems, cell biology, and genetics are related. There are many opportunities to make connections among the concepts taught in these units. Similarly, the three units covering the biological, behavioral, and social aspects of adolescent development can be taught in sequence.

Connect with Other Disciplines. The interdisciplinary web provided is a guide for planning if your school uses an interdisciplinary team approach. The web classifies the unit's activities and projects by related discipline-language arts, math, social studies, physical education, health/nutrition, and visual/performing arts, and science. For interdisciplinary planning, schedule meetings with your team early. You are encouraged to tap the talents and interests of your team members as well as of your unique school and community resources in developing other suitable activities for this unit.

Connect with the Home. Give special attention to the unit activities as a means of involving family and community members. Also, encourage your students to take selected Apply Your Knowledge questions and Mini Activities home for further exploration.



Teaching Time lines

You can use these time1ines as a place to start in designing your own timelines, or you can use them as they are laid out. If you're planning your own timeline, consider the inclusion of the Embedded activities first. The "Embedded activities" are included in the student edition. The Enrichment activities, GroupWork activities, and Projects can then be included, depending on your time restrictions. The timelines are guides, which can vary depending on activities assigned as homework and those conducted in other classes.

We realize it may not be possible to do all the activities shown on these timelines. If you need to remove activities, be careful not to remove any activities critical to the content of the unit. You may want to divide the activities among interdisciplinary members of your teaching team.

Page references in this chart refer to the student edition, except when Enrichments are suggested. The page references for Enrichments are to this Teacher's Guide.

TABLE 1.2: Option 1: Three Week Timeline

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Week 1	Introduce the unit Introduce Section 1 **Mini Activities:** Peanut Sort Human Variations Eye Variation	**Activity 1-1:** Fingerprinting **Mini Activities:** Continuity and Diversity in Art as homework Wrist Variation	Introduce Section 2 **Activity 2-1:** Karyotyping-A Chromosome Portrait Begin and complete for homework	Introduce Section 3 Demonstrate **Activity 3-1:** Precipitation and Spooling of DNA **Activity 3-2:** Removing DNA from Thymus Cells	**Activity 3-3:** Part A Building and Using a DNA Model using preassembled nucleotides Part B Replication
Week 2	Review Section 3 Introduce Section 4 and begin **Activity 4-1:** Cell Division-Double or Nothing	Demonstrate **Activity 4-2:** Meiosis and Fertilization	Introduce Section 5 **Mini Activity:** Run to the Ribosome	Assess Sections 4 and 5	Introduce Section 6 **Mini Activities:** Family Pedigree One or Family Pedigree Two
Week 3	**Activity 6-1:** Expression: Dominant and Recessive Assign Punnett Square Practice homework	Introduce Section 7 **Activity 7-1:** Exploring a Single Gene Disorder **Mini Activities:** Hemophilia X-linked Inheritance Pattern-Color Blindness	**Activity 8-1:** Investigating the Human Genome Project Assign roles for **Activity 9-1:** Biotechnology in the U.S. Senate	**Activity 9-1:** Biotechnology in the U.S. Senate	**Activity 9-1:** Biotechnology in the U.S. Senate Unit review and assessment (next week)

TABLE 1.3: Option 2: Five Week Timeline

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 1	Introduce the unit Introduce Section 1 **Mini Activities:** Peanut Sort Human Variations Eye Variation	**Activity 1-1:** Fingerprinting **Mini Activities:** Continuity and Diversity in Art as homework Wrist Variation	Introduce Section 2 **Activity 2-1:** Karyotyping-A Chromosome Portrait Assign the Journal Writing activity that deals with genetics in the news.	Complete **Activity 2-1:** Karyotyping-A Chromosome Portrait Review Sections 1 and 2	Introduce Section 3 **Activity 3-1:** Precipitation and Spooling of DNA
Week 2'	**Activity 3-2:** Removing DNA from Thymus Cells	**Activity 3-3:** Building and Using a DNA Model Part A	**Activity 3-3:** Building and Using a DNA Model Part B Review Section 3	Introduce Section 4 **Activity 4-1:** Cell Division-Double or Nothing	**Activity 4-2:** Meiosis and Fertilization Part A
Week 3	Complete **Activity 4-2:** Meiosis and Fertilization Part B	Introduce Section 5 **Mini Activities:** Run to the Ribosome **Activity 5-1:** Making Protein	Complete **Activity 5-1:** Making Protein	Assess Sections 4 and 5	Introduce Section 6 **Mini Activities:** Family Pedigree One or Family Pedigree Two
Week 4	**Activity 6-1:** Expression: Dominant and Recessive Punnett Square Practice	Introduce Section 7 **Activity 7-1:** Exploring and Single Gene Disorder	**Mini Activities:** Hemophilia X-linked Inheritance Pattern-Color Blindness	Review Sections 6 and 7	Assess Sections 6 and 7 Introduce Section 8 Assign and discuss **Activity 8-1:** Investigating the Human Genome Project Assign roles for **Activity 9-1:** Biotechnology in the U.S. Senate

TABLE 1.3: (continued)

	Monday	Tuesday	Wednesday	Thursday	Friday
Week 5	Introduce Section 9 **Mini Activities:** Gene Information Explaining Genetics Concept Map Prepare for role-play for Activity	**Activity 9-1:** Biotechnology in the U.S. Senate	**Activity 9-1:** Biotechnology in the U.S. Senate	Review Unit	Assess Unit

Safety for Teachers

- Always perform an experiment or demonstration on your own before allowing students to perform the activity. Look for possible hazards. Alert students to possible dangers. Safety instructions should be given each time an experiment is begun.
- Wear glasses and not contact lenses. Make sure you and your students wear safety goggles in the lab when performing any experiments.
- Do not tolerate horseplay or practical jokes of any kind.
- Do not allow students to perform any unauthorized experiments.
- Never use mouth suction in filling pipettes with chemical reagents.
- Never "force" glass tubing into rubber stoppers.
- Use equipment that is heat resistant.
- Set good safety examples when conducting demonstrations and experiments.
- Turn off all hot plates and open burners when they are not in use and when leaving the lab.
- When students are working with open flames, remind them to tie back long hair and to be aware of loose clothing in order to avoid contact with flames.
- Make sure you and your students know the location of and how to use fire extinguishers, eyewash fountains, safety showers, fire blankets, and first-aid kits.
- Students and student aides should be fully aware of potential hazards and know how to deal with accidents. Establish and educate students on first-aid procedures.
- Teach students the safety precautions regarding the use of electricity in everyday situations. Make sure students understand that the human body is a conductor of electricity. Never handle electrical equipment with wet hands or when standing in damp areas. Never overload electrical circuits. Use 3-prong service outlets.
- Make sure that electrical equipment is properly grounded. A ground-fault circuit breaker is desirable for all laboratory AC circuits. A master switch to cut off electricity to all stations is desirable for all laboratory AC circuits.
- Make sure you and your students are familiar with how to leave the lab safely in an emergency. Be sure you know a safe exit route in the event of a fire or an explosion.

For Student Safety Safety in the Classroom

- Wear safety goggles in the lab when performing any experiments. Tie back long hair and tuck in loose clothing while performing experiments, especially when working near or with an open flame.
- Never eat or drink anything while working in the science classroom. Only lab manuals, notebooks, and writing instruments should be in the work area.

- Do not taste any chemicals for any reason, including identification.
- Carefully dispose of waste materials as instructed by your teacher. Wash your hands thoroughly.
- Do not use cracked, chipped, or deeply scratched glassware, and never handle broken glass with your bare hands.
- Lubricate glass tubing and thermometers with water or glycerin before inserting them into a rubber stopper. Do not apply force when inserting or removing a stopper from glassware while using a twisting motion.
- Allow hot glass to cool before touching it. Hot glass shows no visible signs of its temperature and can cause painful burns. Do not allow the open end of a heated test tube to be pointed toward another person.
- Do not use reflected sunlight for illuminating microscopes. Reflected sunlight can damage your eyes.
- Tell your teacher if you have any medical problems that may affect your safety in doing lab work. These problems may include allergies, asthma, sensitivity to certain chemicals, epilepsy, or any heart condition.
- Report all accidents and problems to your teacher immediately.

HANDLING DISSECTING INSTRUMENTS and PRESERVED SPECIMENS

- Preserved specimens showing signs of decay should not be used for lab observation or dissection. Alert your teacher to any problem with the specimen.
- Dissecting instruments, such as scissors and scalpels, are sharp. Use a cutting motion directed away from yourself and your lab partner.
- Be sure the specimen is pinned down firmly in a dissecting tray before starting a dissection.
- In most cases very little force is necessary for making incisions. Excess force can damage delicate, preserved tissues.
- Do not touch your eyes while handling preserved specimens. First wash your hands thoroughly with warm water and soap. Also wash your hands thoroughly with warm water and soap when you are finished with the dissection.

CHAPTER 2 Continuity and Diversity - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

2.1 Planning

Key Ideas

- Members of an animal or plant species have distinctive characteristics, or traits, in common.
- Within a species, individuals have variations that are examples of diversity.
- Members of a species produce offspring that have characteristics similar to the parents.
- Geneticists study the biological causes of continuity and diversity among living things.

Overview

Students are asked to observe their classmates and identify characteristics, or traits, common to all humans and variations of these traits that are examples of diversity among humans. Students explore variation in eye width and wrist circumference. They make a personal set of fingerprints in order to compare and contrast variations among individuals. They reflect on and discuss genetics as the study of continuity and diversity among living things and propose reasons for the importance of learning about genetics.

Objectives

Students:

✓ identify characteristics, or traits, common to humans.

✓ distinguish among variations as examples of human diversity.

✓ explain what genetics is and why it is important to learn about human genetics.

Vocabulary

characteristics, continuity, diversity, genetics, species, trait, variation

Student Materials

Activity 1-1: Fingerprinting

- Activity Report
- Stamp pad; Magnifying glass; Metric ruler; Clear tape; Paper towels and soap, or packaged hand wipes

Teacher Materials

Activity 1-1: Fingerprinting

- Activity Report Answer Key
- Calculator; Graph paper; White paper for students to make extra fingerprints for story (Language Arts); Extra student materials, especially ink for pads

Advance Preparation

See Activity 1-1 in the student edition

Gather one set of student materials for each group of students.

Advise students to wear old clothes in case they get ink on their clothes. Also have large, old shirts available if students wish to put them on over their regular clothing.

Coordinate interdisciplinary activities with other teachers.

Interdisciplinary Connections

Social Studies Cultural, ethnic, and religious diversity can be investigated and discussed.

Math Use graphing activities, particularly pie graphs and bar graphs to present data illustrating variations and similarities among individuals of a species. Calculate the frequency of each fingerprint pattern and create a graph to depict this information.

Language Arts Write a story describing personal traits and unique interests. Illustrate this story using a "fingerprint character" designed from the students' own fingerprints to which arm, legs and other human traits have been added.

2.2 Using Continuity and Diversity – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Introduce this topic with the *Mini Activity: Human Variations.*

Assign *Mini Activities: Eye Variation* and *Wrist Variation* as a prelude to a discussion of diversity.

Point out the role of the environment in influencing variations in humans.

Complete *Activity 1-1: Fingerprinting,*

Discuss the *Mini Activity: Peanut Sort.*

Review the big ideas of this section by discussing student answers to the *Review Questions.*

Consider beginning *Activity 8-1: Investigating the Human Genome Project,* so students can share their information throughout this unit.

Select appropriate Projects if time permits.

At the end of the section refocus students' attention on the key ideas.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Identify each of the following as a trait or a variation.

1. Parrot has feathers.
2. Cat has a striped coat.
3. Geranium plant has flowers.
4. Chris has two arms.
5. Dog has droopy ears.
6. Rosebush has thorns.
7. Jamie has freckles.

Peanut Sort Students select a peanut (with shell) and describe its shape, weight, or any other distinguishing characteristics. They mix their peanut with five others and then with an entire bowl of peanuts and attempt to distinguish their peanut from the rest.

Human Variations Students observe their classmates and answer several questions related to their observations.

Eye Variation Students measure the width from the outside corner of one eye to the outside corner of the other eye and include this measurement on a class chart. As an extension they may also graph the eye width measurements for the entire class to display the variations.

2.3 Activities and Answer Keys

Activity 1-1: Fingerprinting

PLAN

Summary Students make a set of their own fingerprints and classify each print into one of four different groups. Students calculate the frequency for each pattern that occurs in the class. They learn that fingerprints are unique to each individual and can provide a valuable means of identification.

Objectives

Students:

✓ make a set of their own fingerprints.

✓ classify each print into one of the four fingerprint patterns.

✓ calculate the frequency for each pattern occurring in the class.

✓ recognize that fingerprint patterns are unique to each individual and are an example of human genetic variation.

Student Materials

- Activity Report
- Stamp pad
- Magnifying glass
- Metric ruler
- Clear tape
- Paper towels and soap; or packaged hand wipes

Teacher Materials

- Activity Report Answer Key
- Calculator
- Graph paper
- White paper for students to make extra fingerprints for story (Language Arts)
- Extra student materials, especially ink for pads

Estimated Time One class period

Interdisciplinary Connections

Math Calculate the frequency of each fingerprint pattern and graph this information.

Art Draw posters for each of the four fingerprint patterns for use as class references.

Social Studies Research the history and use of fingerprints.

Language Arts Write a story describing personal traits and unique interests. Illustrate this story using a "fingerprint character" designed from the student's own fingerprint to which some arms, legs, and other personal traits have been added.

Prerequisites and Background

Students need to know how to calculate frequency.

A frequency, in this context, is the number of times a particular variation occurs in the total population or total number of observations. Frequency can be calculated by dividing the total number of occurrences by the number of observations. For example, for each fingerprint pattern, the frequency is determined by dividing the number of students with fingerprint pattern by the total number of fingerprints observed in the class.

Advance Preparation

Gather one set of student materials for each group of students.

Advise students to wear old clothes in case they get ink on their clothes. Also have large, old shirts available if students wish to put them on over their regular clothing.

Coordinate interdisciplinary activities with other teachers.

IMPLEMENT

Divide students into groups of 2 or 4, depending on the availability of student supplies.

Step 1 Discuss the four basic fingerprint patterns shown in Figure 1.3.

Steps 2-4 Demonstrate how to obtain a clear fingerprint using your own hand or that of a student. (See Step 4 of student procedures.)

Step 5 Caution students to clean hands immediately after obtaining their fingerprints.

Steps 6-9 Explain to students how to calculate frequency. You may want to share class totals with each of your classes, especially noting fingerprint patterns from identical twins.

> **Helpful Hints**
> Arrange a display area for student work (fingerprints, graphs, and fingerprint stories).

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ make a set of their own fingerprints.

✓ classify each print into one of the four fingerprint patterns.

✓ calculate the class frequency for each fingerprint pattern.

✓ explain how fingerprint patterns are unique to each individual and are an example of human genetic variation.

Activity 1-1: Fingerprinting Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Record your fingerprints in the table below.
2. Which one of the four patterns is represented by your fingerprints?
3. What is the most common fingerprint pattern in your class?
4. It is said that no two people, even identical twins, have the same fingerprints. Do you agree or disagree? Explain.

5. Calculate the frequencies for each fingerprint pattern found in your class. List them in order from most common to least common.

Mini-Activity

Continuity and Diversity in Art Students demonstrate their knowledge of continuity, diversity, trait, and variation in a drawing, cartoon, or painting.

Wrist Variation Students measure the circumference of their wrists and then graph the results for the entire class.

Journal Writing

Describe what everyday life would be like if there were less variety among living things. How would your life be different? What would be the drawbacks to having less diversity, and what are the benefits to having more diversity?

You may observe some of the following in students' writing. Everyday life might be different if there were less diversity because there would be the same plants and animals everywhere we went. We might only have lawns and gardens instead of forests, grasslands, wetlands, scrub lands, etc. Instead of lots of different kinds of animals (like many breeds of dogs), there would only be one of a few kinds. Life would be boring. More diversity means a variety of things to choose from in terms of plants we eat, animals we interact with, and natural places we can visit. It also means that organisms in ecosystems can change and adapt to a changing environment.

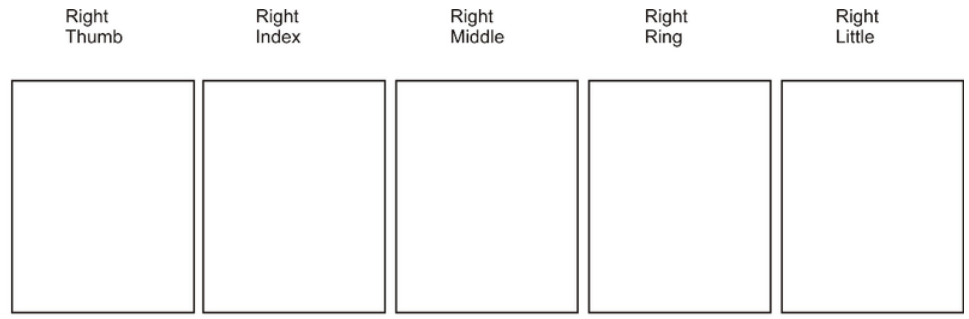
Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

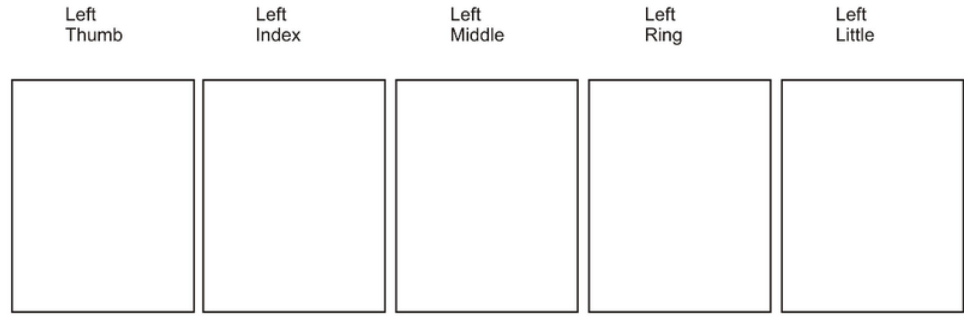
1. What is unique about a species?
   (a) What term refers to the phenomenon of living organisms producing offspring with similar characteristics?
   (b) What term refers to the phenomenon that all living organisms, even those from the same species, are different from each other?
2. What is the difference between traits and variations?
3. What is genetics? What are geneticists most interested in? Why wouldn't a geneticist be interested in hair length in humans?

Activity 1-1: Report Fingerprinting (Student Reproducible)

1. Record your fingerprints in the table below.



Pattern:



Pattern:

2. Which one of the four patterns is represented by your fingerprints?

3. What is the most common fingerprint pattern in your class?

4. It is said that no two people, even identical twins, have the same fingerprints. Do you agree or disagree? Explain.

5. Calculate the frequencies for each fingerprint pattern found in your class. List them in order from most common to least common.

CHAPTER 3 Cells and Chromosomes - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

3.1 Planning

Key Ideas

- Chromosomes in the nucleus carry the genes responsible for human traits and variations.
- Chromosomes occur in pairs, with exception of the sex chromosomes that may not be the same.
- Individuals of the same species have the same number of chromosomes.
- A karyotype is a "portrait of the chromosomes in a cell." A karyotype is useful in helping diagnose, learn about, and explain many genetic diseases.

Overview

Students describe how geneticists solve problems that help them explain and predict the inheritance of human traits and variations. They review cell structures and identify the nucleus as the location for chromosomes that carry genes as the units of heredity. Students use their knowledge of chromosomes to explain similarities within a species and differences among species. Students apply their knowledge of chromosomes to construct, analyze, and interpret human karyotypes.

Objectives

Students:

- identify the location of chromosomes.
- explain that genes are responsible for human traits and variations.
- explain why chromosomes usually occur in pairs.
- determine the reason for continuity and diversity within a species.
- construct, analyze, and interpret a human karyotype.

Vocabulary

cells, chromosomes, karyotype, nucleus

Student Materials

Activity 2-1: Karyotyping - A Chromosome Portrait

- Resources 1 or 2, and 3
- Activity Report
- Scissors; Metric ruler; Glue or tape

Teacher Materials

Activity 2-1: Karyotyping - A Chromosome Portrait

- Activity Report Answer Key
- Extra student materials
- Resource 4 and Map of the Human Genome (Optional)

Human Genome Project addresses:

DOE sites

http://www.er.doe.gov/production/ober/hug_top.html

http://www.ornl.gov/TechResources/Human_Genome/home.html

http://www.ornl.gov/hgmis/links.html

NIH site: National Human Genome Research Institute

http://www.nhgri.nih.gov/

Advance Preparation

See Activity 2-1 in the student edition

Activity 2-1: Karyotyping - A Chromosome Portrait

- Copy Resources 1-3 and the Activity Report.
- Optional: Review Resource 4, Down syndrome karyotype, to decide whether or not to assign this optional activity. You can copy Resource 4 for students and/or make a transparency of this karyotype.
- Optional: Arrange for guest speaker (see Helpful Hints).

Interdisciplinary Connections

Health Education Discuss the ethical dilemmas presented when karyotypes are used to get chromosomal information on genetic disorders.

Art Make posters of the karyotypes or collages of chromosomes for display.

Background Information

Karyotyping can be used to diagnose more than 100 genetic diseases during fetal development by a procedure known as amniocentesis. This procedure is usually performed between 16 and 18 weeks of pregnancy. A thin hypodermic needle inserted through the mother's abdomen removes amniotic fluid from the amniotic sac surrounding the developing fetus. The fluid contains fetal cells and other materials shed from the amniotic sac.

The fluid is centrifuged to compact the cells, which are then placed in a growth medium for nourishment. After several days of incubation the dividing cells are removed from the incubator and prepared for a study of the chromosomes. A photograph of the chromosomes is taken and then the magnified chromosomes are paired. The resulting karyotype can be used to identify extra, defective, or missing chromosomes.

The cut and paste procedure that students use in Activity 2-1 has been used to make karyotypes for many years. Today, high-powered microscopes are connected to computers that digitize and print out a karyotype.

3.2 Using Cells and Chromosomes – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Begin this section by discussing the first paragraph to see if students know the meaning of these six words: *geneticist, explain, predict, inheritance, traits,* and *variations.*

Review the parts of a cell as a way of introducing the term chromosome.

Introduce *Activity 2-1: Karyotyping-i-A Chromosome Portrait* by discussing the meaning of the term karyotype.

Assign *journal Writing* that deals with karyotype.

Review the big ideas of this section by discussing student answers to the *Review Questions.*

Select appropriate Projects if time permits.

At the end of the section refocus students' attention on the key ideas.

Mini-Activity

Genetics in the News Students collect current articles relating to genetics. This is an ongoing activity throughout the unit.

3.3 Activities and Answer Keys

Activity 2-1: Karyotyping - A Chromosome Portrait

PLAN

Summary Students construct a karyotype by arranging chromosomes in pairs according to size, shape, and position of the centromere. Students analyze the karyotypes to distinguish differences among the chromosomes, including the sex (X and Y) chromosomes.

Objectives

Students:

✓ arrange paper chromosomes in pairs according to chromosome size, shape, and position of the centromere.

✓ identify distinctive characteristics of each chromosome.

✓ explain how karyotypes are used to detect genetic disorders.

Student Materials

- Resources 1 or 2, and 3
- Activity Report
- Scissors
- Metric ruler
- Glue or tape

Teacher Materials

- Activity Report Answer Key
- Extra student materials
- Resource 4 and Map of the Human Genome (Optional)

Human Genome Project addresses:

DOE sites

http://www.er.doe.gov/production/ober/hug_top.html

http://www.ornl.gov/TechResources/Human_Genome/home.html

http://www.ornl.gov/hgmis/links.html

NIH site: National Human Genome Research Institute

http://www.nhgri.nih.gov/

Helpful Hints

- Provide an envelope for cutout chromosomes in case some students do not finish in one class period.

- Resources 1, 2, and 4 should each be printed on different colored paper. If possible, use card stock.
- Check that students record the letter of the "squash" sheet on their human karyotype form sheet.
- For additional research, students can use the Human Genome Project Website to explore its progress and find out how many human genes have been identified and their location.

Advance Preparation

Copy Resources 1-3 and the Activity Report.

Refer to *Enrichment 4-1: Chromosome Cards* to see the actual ordering of chromosomes 1-22 and the sex chromosomes. You might have these pages available in the classroom, so students can check their completed karyotypes against them.

Optional: Review Resource 4, Down syndrome karyotype, to decide whether or not to assign this optional activity. You can copy Resource 4 for students and/or make a transparency of this karyotype.

Optional: Arrange for guest speaker such as a genetic counselor.

Estimated Time One class period

Interdisciplinary Connections

Art Make posters of the karyotypes or collages of chromosomes for display.

'Prerequisites and Background for the Teacher'

Down syndrome is a genetic condition that affects 1 out of 800 live births. People with Down syndrome have an extra portion of chromosome 21 in some or all of their cells. The extra copy of some or all of chromosome 21 results in over-expression of those genes and increased production of certain gene products. Down syndrome is usually caused by non disjunction, a failure of sister chromatids to separate during meiosis. In this case, during anaphase I both members of the pair of chromosome 21 migrate to the same side of the cell resulting in either a gamete with no copies of chromosome 21 or a gamete with two copies of chromosome 21. If the gamete with two copies of chromosome 21 is fertilized (or fertilizes) then the resulting zygote will have three copies of chromosome 21, a condition known as Trisomy 21.

Down syndrome also can be caused by translocation, where a piece of a chromosome breaks away and attaches to another chromosome. In Down syndrome, translocation usually occurs between chromosomes 14 and 21. These individuals have two normal chromosomes 21 plus an extra piece of chromosome 21.

Finally, in a small percentage of cases, Down syndrome can be caused by a mosaic chromosomal makeup where some of the cells contain the normal number of chromosomes and some cells contain 47 chromosomes.

The extra genetic material that results in Down syndrome can come from either parent, but in 95% of the cases it comes from the mother. Although a Down Syndrome child can be born to a mother of any age, the risk greatly increases over 35 years of age.

Children with Down syndrome often have low muscle tone, increased incidence of congenital heart defects and leukemia, respiratory problems, some degree of impaired intelligence, and abnormalities of the hands, eyes, ears, and tongue.

IMPLEMENT

Introduce Activity 2-1 by reading the introduction and discussing the information about karyotyping in the student edition.

Step 1 Remind students to keep track of their chromosome pieces.

Step 2 Have students finish Resources 1 and 2 and fill out Resource 3. Then make sure they complete the Activity Report.

Extend Activity 2-1 by showing students a karyotype of Down syndrome (Resource 4). This is optional. Ask students to identify any difference between Resource 4 and the karyotypes from Activity 2-1. Students should recognize that the Down syndrome karyotype contains three copies of chromosome 21.

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ arrange paper chromosomes in pairs according to chromosome size, shape, and position of the centromere.

✓ distinguish distinctive characteristics of each chromosome.

✓ explain how karyotypes are used to identify genetic disorders.

Activity 2-1: Karyotyping - A Chromosome Portrait Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Name three ways human chromosome pairs are different from one another.
2. Describe the difference between a normal male and a normal female karyotype.
3. What reasons might a health professional have for wanting a karyotype of a person's chromosomes?

Journal Writing

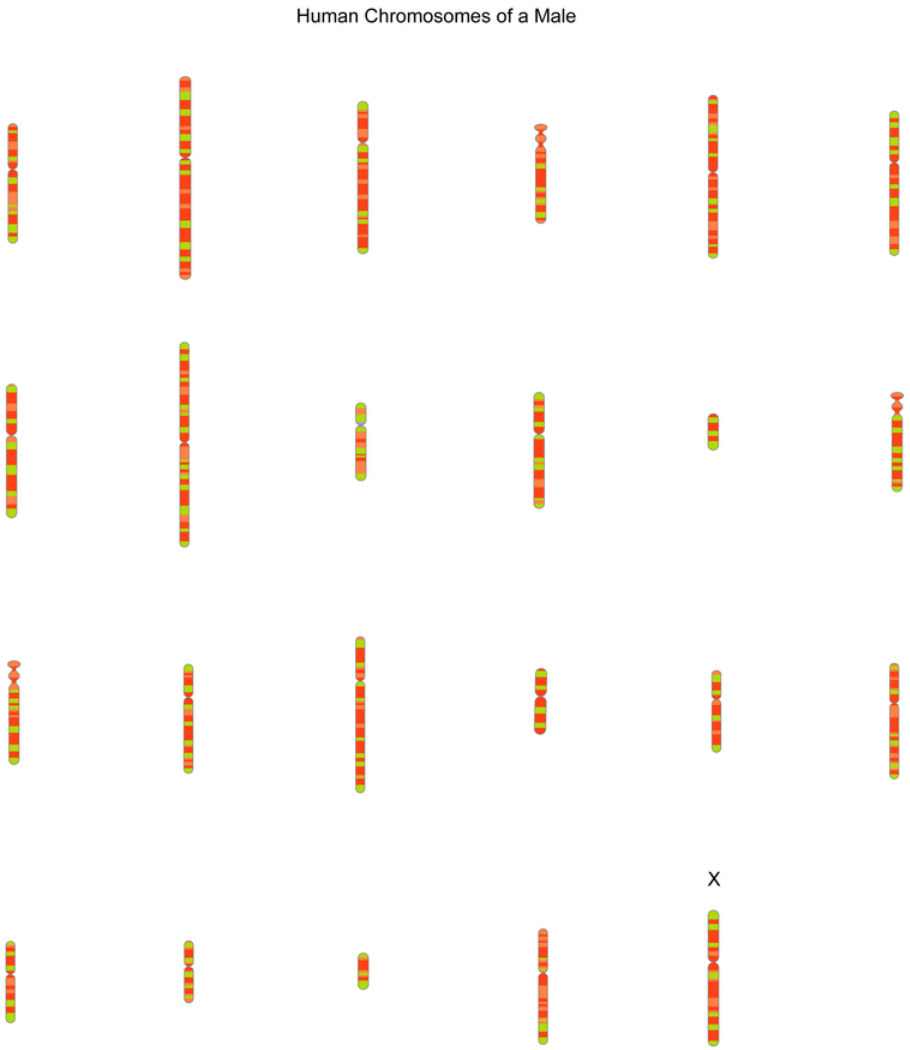
The person who makes karyotypes is called a cytotechnologist. (Cyto is the Greek word for cell; technologist comes from the Greek word meaning art.) In Activity 2-I you did some of the things a cytotechnologist does. Find out what some of the jobs of a cytotechnologist are. Do you think you would want to be a cytotechnologist? If not, why do you think someone else might want to be a cytotechnologist? In a paragraph, explain why you would or would not want to be a cytotechnologist.

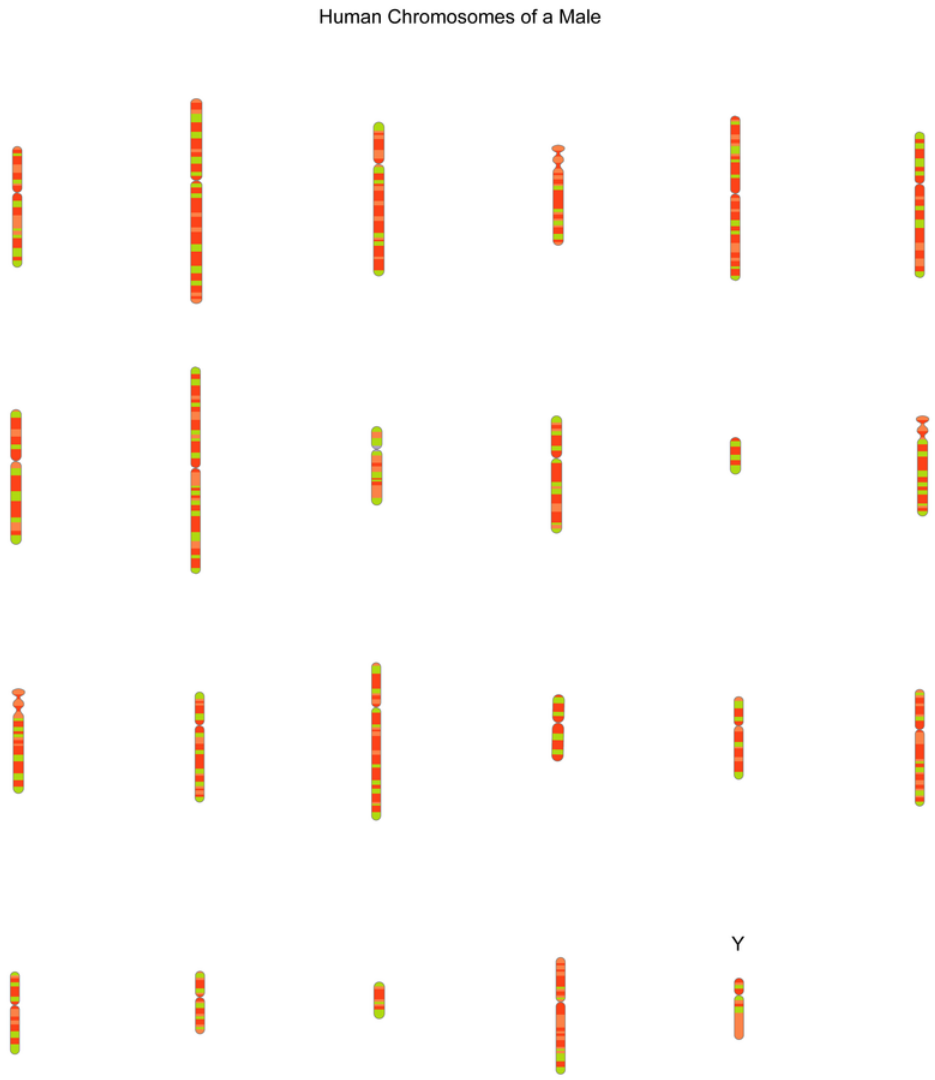
Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

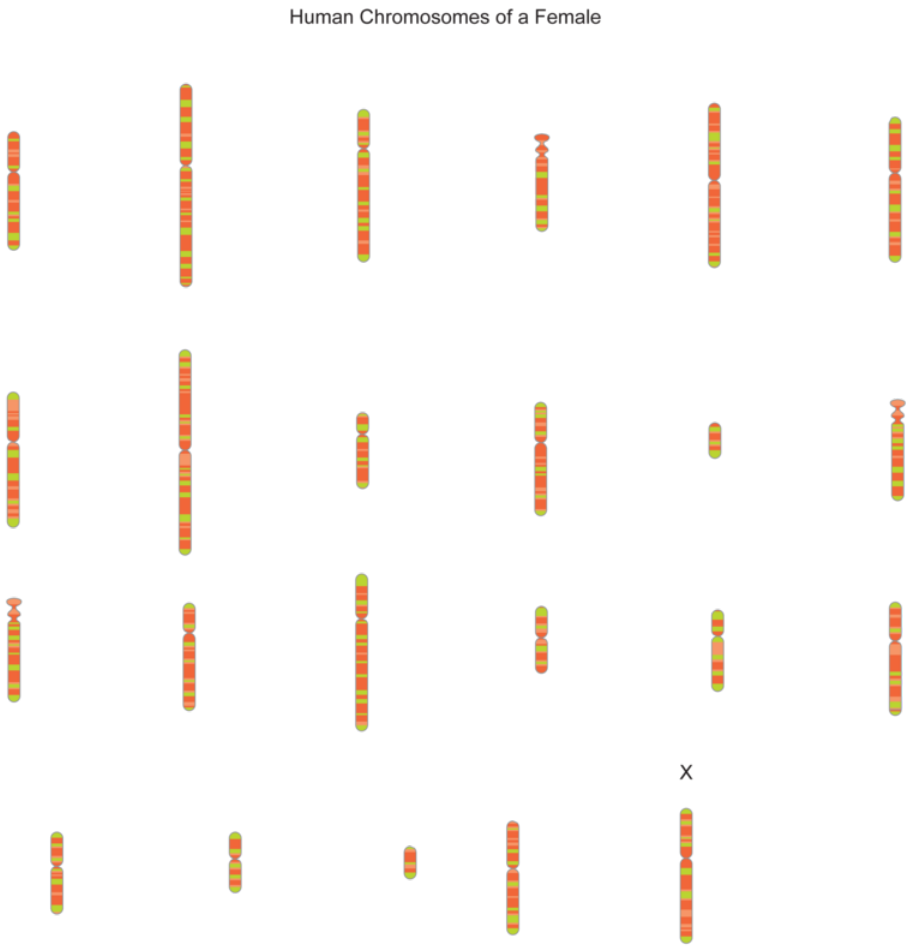
1. Explain three facts that scientists know about chromosomes.
2. Chromosomes exist in pairs with one exception. Describe that exception.
3. What is a karyotype? How is it made? How is a karyotype useful in the study of genetics?

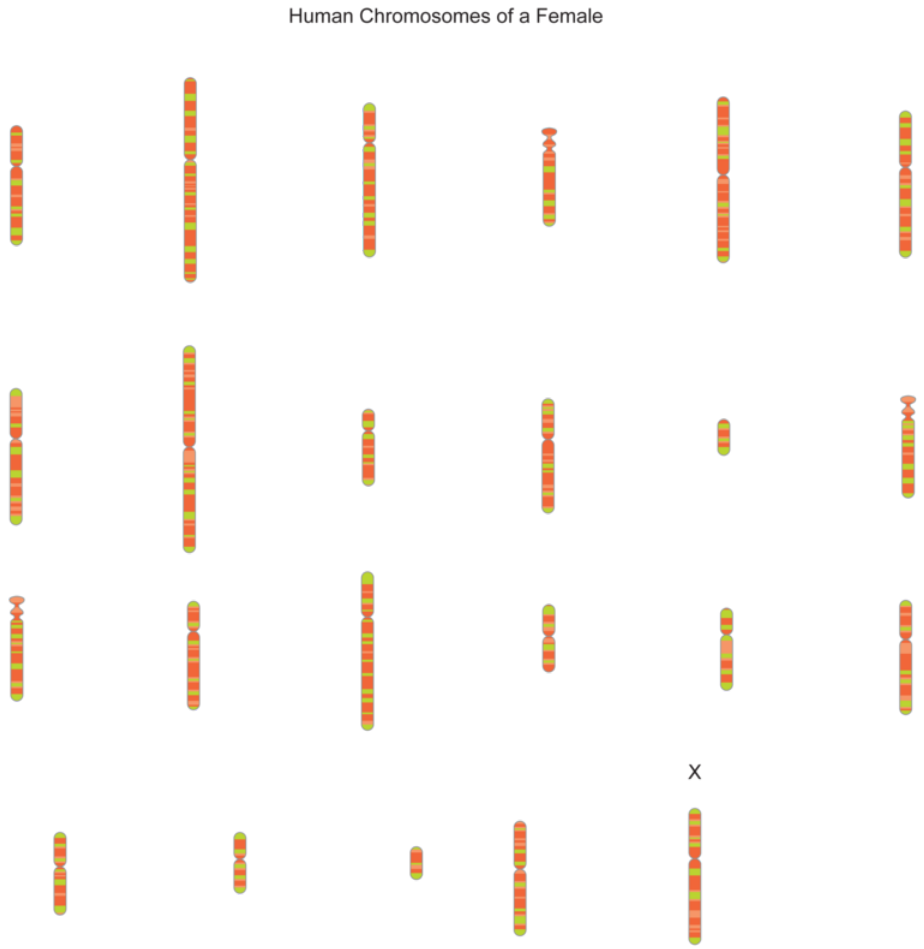
Activity 2-1 Resource 1: Karyotyping - A Chromosome Portrait (Student Reproducible)



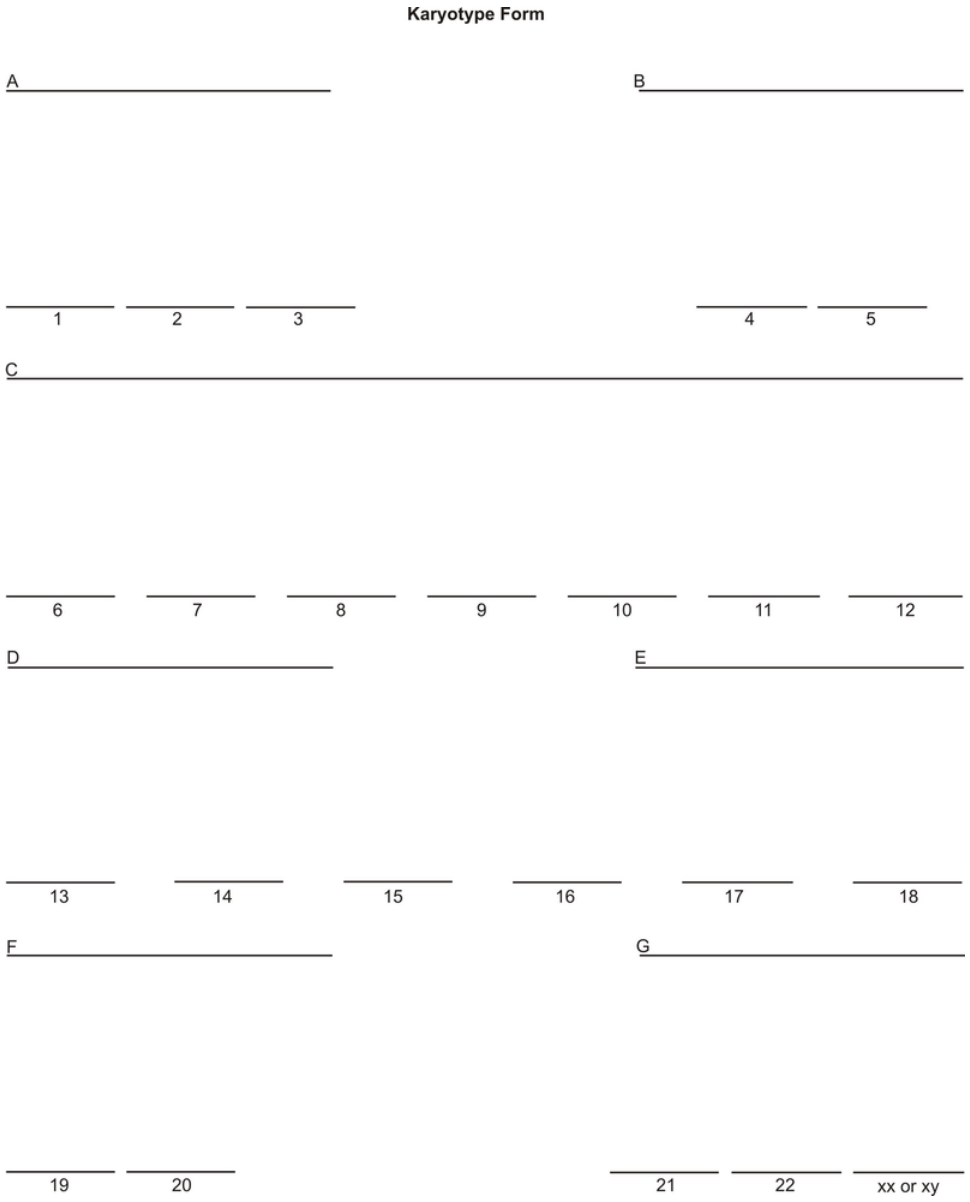

Human Chromosomes of a Male
Y

Activity 2-1 Resource 2: Karyotyping - A Chromosome Portrait (Student Reproducible)

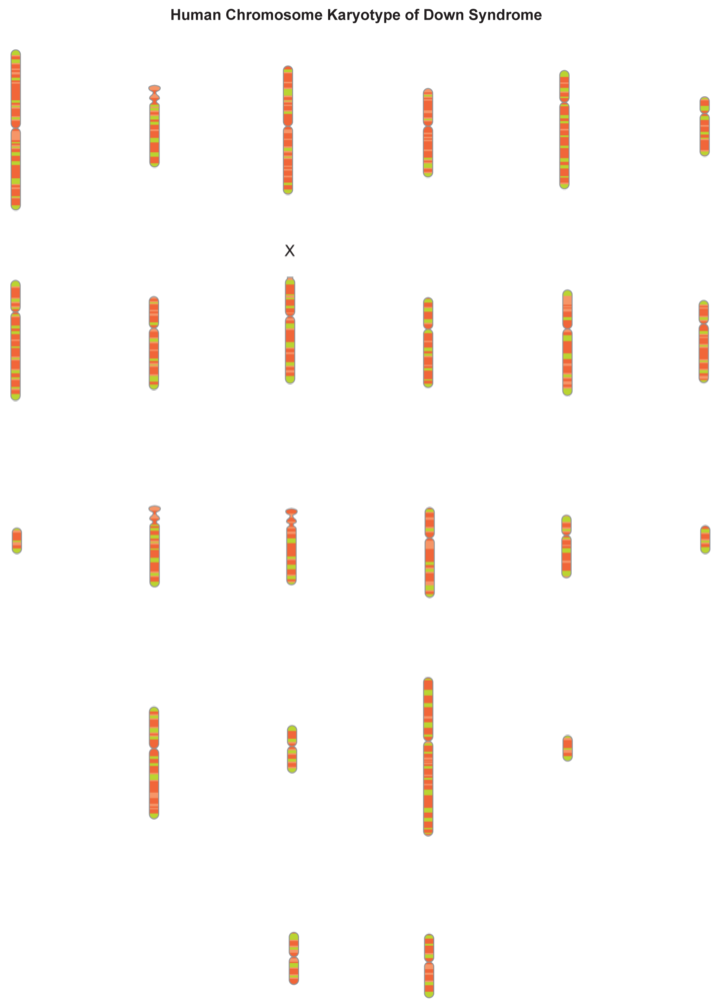


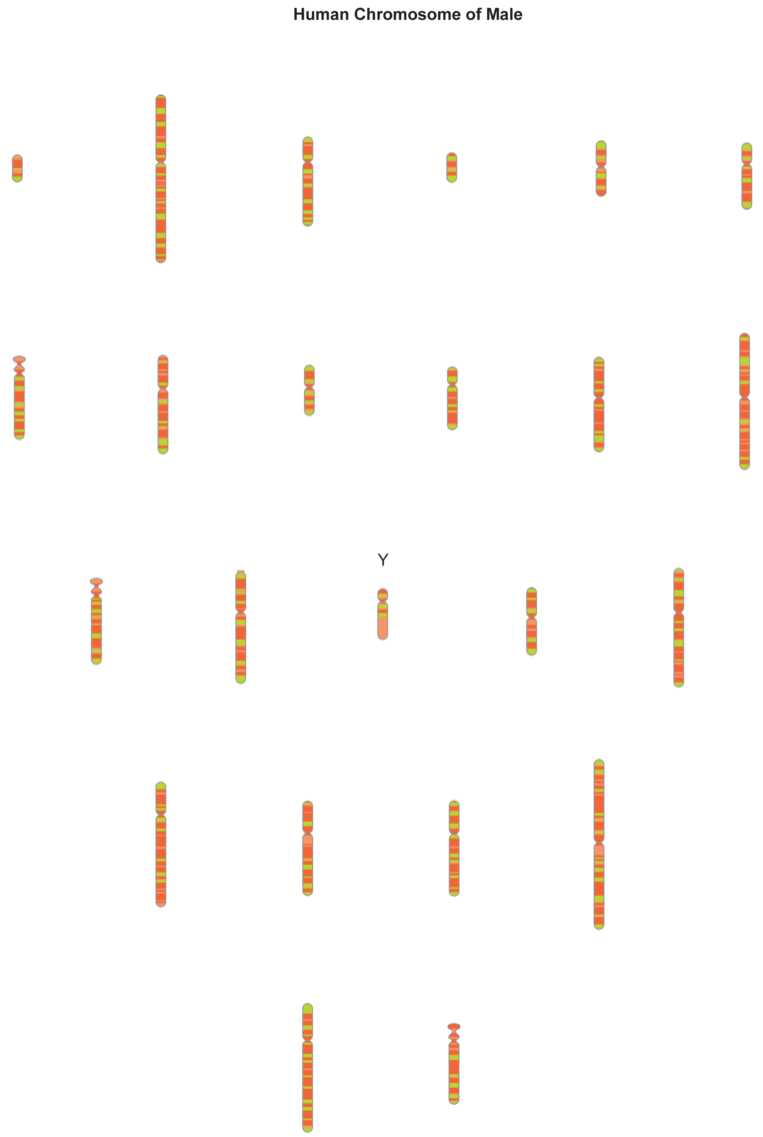

Human Chromosomes of a Female
X

Activity 2-1 Resource 3: Karyotyping - A Chromosome Portrait (Student Reproducible)



Activity 2-1 Resource 4: Karyotyping - A Chromosome Portrait (Student Reproducible)





Activity 2-1 Report: Karyotyping - A Chromosome Portrait (Student Reproducible)

1. Name three ways human chromosome pairs are different from one another.

a.

b.

c.

2. Describe the difference between a normal male and a normal female karyotype.

3. What reasons might a health professional have for wanting a karyotype of a person's chromosomes?

CHAPTER 4 Chromosomes and DNA - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

4.1 Planning

Key Ideas

- Chromosomes are made of two chemical substances, deoxyribonucleic acid (DNA) and protein.
- A gene is a region of the DNA of a chromosome that can be copied (replicated) and that codes for a specific protein.
- DNA is composed of four different nucleotides-adenine, thymine, guanine, and cytosine.
- Each nucleotide is composed of a sugar molecule (deoxyribose), a phosphate molecule, and one of four nitrogen bases.
- Nucleotides are arranged in pairs, guanine with cytosine, and adenine with thymine, to form DNA.

Overview

Building on their knowledge of the structure and function of chromosomes from Section 2, students learn about the scientific discoveries leading to the Watson and Crick model of the DNA double helix. They perform two laboratory experiments with DNA. They first remove and spool purified DNA from solution to examine and record its physical properties. Students then isolate DNA from the nuclei of mammalian thymus cells to observe its appearance, and then they design an alternative procedure for isolating DNA from these cells. Students construct a paper model of DNA to examine the structure of the double helix and then they use the model to simulate the replication of DNA in preparation for cell division.

Objectives

Students:

✓ describe the scientific discoveries leading to the model of the structure of DNA.

✓ identify the scientific contributions of Franklin, Watson, and Crick.

✓ precipitate, spool, and observe purified DNA.

✓ isolate and examine mammalian DNA.

✓ construct a model of the DNA double helix.

✓ simulate the replication of DNA.

Vocabulary

deoxyribonucleic acid, (DNA), double helix, gene, nucleotide, replication

Students Materials

Activity 3-1: Precipitation and Spooling of DNA

- Activity Report

Per team of 2-4 students

- Test tube containing 2 ml DNA in solution
- Test tube containing 4 ml alcohol
- 50 ml beaker containing strong salt (NaCl) solution and an eye dropper
- Wooden skewer

Activity 3-2: Removing DNA from Thymus Cells

- Activity Report
- Safety goggles
- Sample of fresh thymus cells in a beaker; Sand; Liquid soap, clear; Alcohol; Cheesecloth square (several layers, 15×15 cm); Mortar and pestle; Test tube; Small funnel; Test tube rack; Wooden skewer; Forceps; Eyedropper; Permanent marking pen; Paper towels; Black construction paper, 4×4 cm ; Transparent tape; Microscope, slides, and cover slips; Tap water in beaker

Activity 3-3: Building and Using a DNA Model

- Resource
- Activity Report
- Scissors; Paper; 6 sets of different colored paper; Tape

Teacher Materials

Activity 3-1: Precipitation and Spooling of DNA

- Teacher Resource
- Optional: DNA visuals, including models and/or posters, lab materials

Note: You can substitute glass for the stirring rod.

Activity 3-2: Removing DNA from Thymus Cells

- Activity Report Answer Key
- Serrated knife for cutting the thymus tissue
- Extra student materials, especially cheesecloth, skewers, test tubes, and fresh thymus cells Note: You can substitute glass for the stirring rod.
- Methylene blue stain can be used to stain the thymus nuclei in Step 5
- Optional: DNA visuals, including models and/or posters
- Model of a cell with a large, distinct nucleus
- Picture of a human torso to show the location of the thymus gland

Activity 3-3: Building and Using a DNA Model

- Activity Report Answer Key
- Models and diagrams of DNA molecules and nucleotides
- Extra supply of colored paper (6 different colors)

Advance Preparation

See Activities 3-1, 3-2 and 3-3 in the student edition.

Activity 3-1: Precipitation and Spooling of DNA

- Order DNA for delivery at least a week before use. Dissolve DNA in buffer or distilled water and store several days in refrigerator.
- If you are going to do the DNase extension (Resource) you will need additional materials indicated in Resource.

Activity 3-2: Removing DNA from Thymus Cells

- Purchase fresh thymus tissue, also called sweet-breads from your local butcher. You can freeze the thymus tissue if you do not plan to use it right away.
- Cut the thymus tissue into 2 – cm cubes using a clean knife.
- Keep all solutions cold prior to activity.

Activity 3-3: Building and Using a DNA Model

- You can have students color the sugars, phosphates, and nitrogen bases as follows, or you can copy them on me indicated colors of paper.
- 60 deoxyribose sugars (white)
- 60 phosphates (orange)
- 15 of each of the four nitrogenous bases: adenine (red), thymine (blue), cytosine (yellow), and guanine (green)
- Allow ample time to precut the template pieces.

Interdisciplinary Connections

Art Make a drawing or 3-D model of a DNA molecule.

Math Research how many base pairs make up a typical chromosome or a DNA molecule. Discuss how it is possible to have so many traits and variations considering that there are only 4 nucleotides which make up DNA.

Language Arts Assign the book *The Double Helix* by James Watson.

Social Studies Research and write about the history and the awarding of the Nobel Prize for medicine.

4.2 Using Chromosomes and DNA – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Begin this section with a review of DNA and protein that make up chromosomes.

Introduce DNA by having the students do *Activity 3-1: Precipitation and Spooling of DNA*. Follow this Activity with *Activity 3 -2: Removing DNA from Thymus Cells.*

Complete *Activity 3-3: Building and Using a DNA Model.*

Have the students use their completed DNA model to explain replication.

Review the big ideas of this section by discussing student answers to the *Review Questions.*

Select appropriate Projects if time permits.

At the end of the section refocus students' attention on the key ideas.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Why do we use models of structures, such as a model of DNA, in science?

4.3 Activities and Answer Keys

Activity 3-1: Precipitation and Spooling of DNA

PLAN

Summary Students precipitate, spool, and observe the physical properties of purified DNA. They record observations, determine the importance of studying DNA, and propose a follow-up activity using the isolated DNA.

Objectives

Students:

✓ precipitate, spool, and observe purified DNA.

✓ record observed results using words and diagrams.

✓ explain the importance of DNA in genetic studies.

✓ propose a follow-up activity using the isolated DNA.

Students Materials

- Activity Report

Per team of 2-4 students

- Test tube containing 2 ml DNA in solution
- Test tube containing 4 ml alcohol
- 50 ml beaker containing strong salt (NaCl) solution and an eye dropper
- Wooden skewer

Teacher Materials

- Teacher Resource
- Optional: DNA visuals, including models and/or posters Note: You can substitute glass for the stirring rod.

Estimated Time One class period

Interdisciplinary Connection

Art Make drawing of 3-D model of DNA.

Prerequisites and Background

Students should be familiar with metric units of volume.

This activity is a great way to introduce and motivate students to learn more about deoxyribonucleic acid (DNA). In this activity the DNA has been isolated from the nuclei of herring sperm cells. Isolated and purified DNA can be obtained from Sigma Company (1-800-325-3010). The catalog number for herring sperm DNA is D 6898. Salmon sperm DNA (catalog number D 1626) also works well and is less expensive. A buffer identified on the container of DNA you receive will be required to dissolve the DNA.

Herring are fish that belong to the family Clupeirdae; a commercially important food fish *Clupea harengus* is found in the Atlantic and Pacific oceans.

The DNA requires several days to dissolve in the buffer or water. It is important that the DNA solution be kept refrigerated until use.

When students observe the DNA in solution, they will notice that it appears colorless and viscous. This appearance is due to the phosphate on the DNA, which is negatively charged. The viscosity will be reduced with the addition of sodium chloride (NaCl) , enhancing the precipitation. In addition, DNA is not very soluble in 95-100% ethyl alcohol. Therefore, at the interface-where the DNA layer comes in contact with the alcohol layer-the DNA precipitates out of solution and can be spooled onto a *clean* wooden skewer.

Advance Preparation

Order DNA for delivery at least a week before use. Dissolve DNA in buffer or distilled water, and store several days in refrigerator.

Aliquot DNA and alcohol into test tubes. If alcohol is aliquotted in advance, the test tubes need to be sealed or capped to prevent evaporation.

Keep all solutions cold prior to activity.

If you are going to do the DNase extension (Resource) you will need additional materials indicated in Resource.

IMPLEMENT

This activity precedes *Activity 3 -2: Removing DNA from Thymus Cells.* Though it is possible to do these activities in either order, it is recommended that the purified DNA spooling be done first so students first see purified DNA, which helps them to correctly identify the impure DNA extracted from the thymus cells.

Steps 1-2 Have students begin recording their observations on the Activity Report. You might want to demonstrate how to mix by tapping the test tube gently.

Step 3 Demonstrate how to trickle the alcohol down the inside of the test tube. Remind students to wash their hands thoroughly at the end of the activity.

Steps 4-7 Make sure students are recording their observations on the Activity Report. Make sure students wash their hands at the end of this activity.

Step 8 Consider the following method for having students save their DNA samples:

Using a clean dry forceps, carefully remove the DNA from the skewer and place it on a small piece of black construction paper. Use clear tape to cover the specimen, to keep it from drying out, and fasten in onto the paper.

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ precipitate and spool isolated DNA.

✓ describe the physical properties of the spooled DNA.

✓ explain the importance of DNA in genetic studies.

✓ propose a follow-up activity using the isolated DNA.

Helpful Hints

If students have difficulty proposing a follow-up activity using their spooled DNA, provide some guidance using the following examples:

- Observe DNA under a microscope.

- Redissolve DNA with DNase (Genentech: Pulmozyme) and discuss applications in treating cystic fibrosis (see Resource).

Have students bring in, discuss, and summarize news articles about DNA. Display articles on a "DNA Bulletin Board" for all to see.

Activity 3-I: Precipitation and Spooling of DNA Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Write a paragraph describing your observations of the DNA during the procedure. Include drawings as necessary.
2. Describe in words and a drawing the appearance of your isolated DNA.
3. Why is it important to study and learn about the structure and function of DNA?
4. Describe a follow-up activity using your isolated DNA.

Journal Writing

DNA is frequently the subject of scientific study and sometimes a point of controversy. Watch your local newspapers and select articles about chromosomes and DNA. Write a one-paragraph summary and another paragraph about your opinion and thoughts.

What Do You Think?

Science is partly a process of answering questions that then produce more questions. What questions come to your mind from the discovery of DNA and its structure?

Activity 3-2: Removing DNA from Thymus Cells

PLAN

Summary Students treat fresh thymus tissue, sweetbreads, to remove its DNA. They precipitate, spool, and observe the DNA in a test tube. Students design an alternative procedure to isolate thymus DNA. They also consider different tissue sources for obtaining DNA.

Objectives

Students:

✓ extract the DNA from the nuclei of thymus cells.

✓ describe the physical properties of DNA.

✓ design an alternative procedure to isolate thymus DNA.

Student Materials

- Safety goggles; Activity Report Sample of fresh thymus cells in a beaker; Sand; Liquid soap, clear; Alcohol; Cheesecloth square (several layers, 15 × 15 cm); Mortar and pestle; Test tube; Small funnel; Test tube rack; Wooden skewer; Forceps; Eyedropper; Permanent marking pen; Paper towels; Black construction paper, 4 × 4 cm ; Transparent tape; Microscope, slides, and cover slips

Teacher Materials

- Activity Report Answer Key
- Serrated knife for cutting the thymus tissue
- Extra student materials, especially cheesecloth, skewers, test tubes, and fresh thymus cells (You can substitute glass for the stirring rod.)
- Methylene blue stain can be used to stain the thymus nuclei in Step 5
- Optional: DNA visuals, including models and/or posters
- Model of a cell with a large , distinct nucleus
- Picture of a human torso to show the location of the thymus gland

Advance Preparation

Purchase fresh thymus tissue, also called sweetbreads, from your local butcher. You can freeze the thymus tissue if you do not plan to use it right away.

Cut the thymus tissue into 2 – cm cubes using a clean knife.

Keep all solutions cold prior to beginning the activity.

Estimated Time One to two class periods

Interdisciplinary Connection

Art Students make a 3-D model of DNA.

Prerequisites and Background

Students should have good microscope skills. If the microscopes use mirrors and natural light, remind students not to point the mirror directly at the sun.

This activity is a great way to introduce and motivate the student to learn more about deoxyribonucleic acid (DNA).

DNA is not very soluble in 95- 100% ethyl alcohol. It is at the interface where the DNA layer comes in contact with the alcohol layer that the DNA precipitates out of solution and can be spooled onto a clean, wooden skewer, glass rod, or pipette.

IMPLEMENT

Introduce Activity 3-2 by reminding students of safety procedures in the lab, such as safety when using microscopes and wearing goggles when working with alcohol.

Point out the location of the thymus gland on a picture of a human torso.

Set up a slide to show intact thymus cells .

Steps 1-13 Be sure students are using their Activity Report as they progress through the Procedure.

Step 4 Monitor disposal of thymus tissue and cleanup.

Step 5 This step can be done as a demonstration.

Steps 6-7 Make sure students tap only gently.

Step 8 Demonstrate how to trickle the alcohol down the inside of the test tube.

Steps 9-12 Monitor the disposal of materials and the general cleanup process. Again, make sure students are recording responses on their Activity Reports.

Step 13 Include a discussion of controls and variables.

Step 14 Remind students to wash their hands thoroughly at the end of the activity.

Helpful Hints

- Use a clear detergent.
- Any alcohol such as ethanol, isoproponol, or rubbing alcohol can be used.
- Have students evaluate how they liked designing their own experiments and if it helped them learn more about DNA.

ASSESS

Use the completion of the activity and written responses on the Activity Report to assess if students can

✓ identify the location of DNA in thymus cells.

✓ describe the physical properties of DNA.

✓ design an alternative procedure to isolate thymus DNA.

✓ identify different tissue sources for obtaining DNA.

Activity 3-2: Removing DNA from Thymus Cells Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the purpose of the thymus tissue?
2. Make a drawing of your observations. You should be able to see the nuclei from the thymus cells. Be sure to label a few nuclei.
3. Which part of the cell was broken by the sand and grinding? Which part was broken by the soap?
4. Draw a labeled diagram and explain in words what happened when the alcohol was added to the test tube.
5. What is the purpose of twirling the wooden skewer?
6. Describe the appearance and texture of the DNA. In the space below, attach the paper containing your specimen. Label the DNA.
7. Describe your alternative procedure for removing thymus DNA. Include labeled diagrams as needed.
8. Explain how you would modify your original experimental design using different sources of DNA.

Activity 3-3: Building and Using a DNA Model

PLAN

Summary Students make paper models of DNA nucleotides and use them to construct a DNA molecule consisting of 12 nucleotide pairs. They then use this DNA model to simulate the process of DNA replication.

Objectives

Students:

✓ build models of DNA nucleotides.

✓ construct a model of a DNA double helix.

✓ simulate the replication of DNA.

Student Materials

- Resource
- Activity Report
- Scissors
- 6 sets of different colored paper
- Tape

Teacher Materials

- Activity Report Answer Key
- Models and diagrams of DNA molecules and nucleotides
- Extra supply of colored paper (6 different colors)

Advance Preparation

If you are unable to get different colors of paper, you can have students color the sugars, phosphates, and nitrogen bases as follows. Or you can copy them on the indicated colors of paper.

60 deoxyribose sugars (white)

60 phosphates (orange)

15 of each of the four nitrogenous bases: adenine (red), thymine (blue), cytosine (yellow), and guanine (green)

Allow ample time to precut the template pieces.

Estimated Time One to two class periods, if template pieces have been precut

Interdisciplinary Connections

Math Relate the repeating patterns of nucleotides in DNA to other patterns in math.

Prerequisites and Background

Students should read and/or discuss the text material on DNA and replication before beginning this activity.

IMPLEMENT

Students can work in lab teams of 2-4. As indicated in the Advance Preparation, you can have students color the sugars, phosphates, and nitrogen bases as follows.

60 deoxyribose sugars (white)

60 phosphates (orange)

15 of each of the four nitrogenous bases: adenine (red), thymine (blue), cytosine (yellow), and guanine (green).

It takes about one class period to color and cut out the templates. This can be done at home. It is important that the same color code is used for the different parts of the DNA nucleotides, or you can copy them on paper of the colors indicated above.

> **Helpful Hints**
>
> Instead of using the colored paper for the copies of the templates, students can color both sides of the templates with pens or crayons. It takes about one class period to color and cut out the templates. This can be done at home. It is important that the same color code is used for the different parts of the DNA nucleotides.

Introduce Activity 3-3 by demonstrating how to put together a nucleotide, and then how to combine the nucleotides into a DNA molecule.

Steps 1-3 Remind students that they can sequence the nucleotides in any way they choose, but they should use no more than seven of each nucleotide. Remind students to save extra nucleotides for simulating replication.

Step 4 Remind students to complete items 1 to 5 on their Activity Reports.

Step 5 Confirm that students can explain replication.

Step 6 Remind students to complete their Activity Reports and tell them where to store their completed model.

ASSESS

Use the construction of the nucleotides and DNA double helix, the simulation of DNA replication, and the written answers on the Activity Report to assess if students can

✓ build accurate models of nucleotides.

✓ construct an accurate model of a DNA double helix.

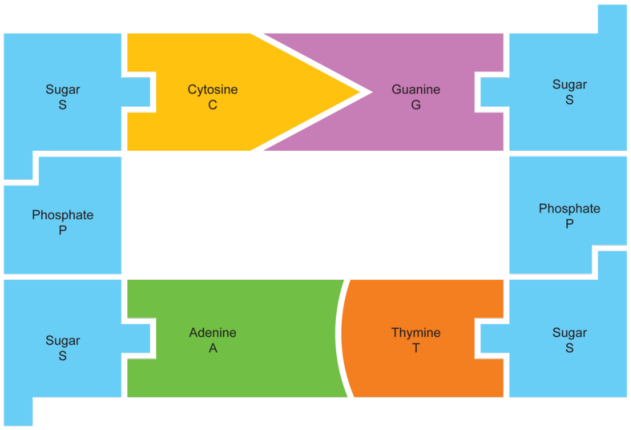
✓ explain the structure of DNA.

✓ simulate the replication of DNA.

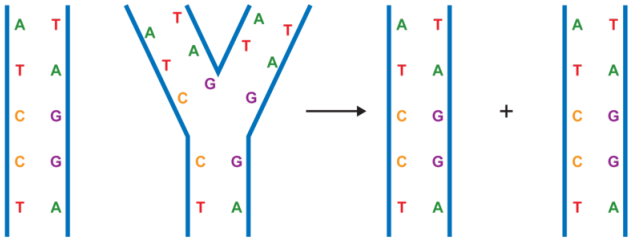
Activity 3-3: Building and Using a DNA Model Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What are the three components of a nucleotide molecule?
2. What makes up the "rungs" of the DNA ladder?
3. What makes up the sides (uprights) of the DNA ladder?
4. What are the possible combinations of nitrogen bases?
5. Make a drawing of your completed DNA model. Be sure to include labels.



6. Make a drawing of the process of replication (Steps 8 and 9).



7. How do the replicated DNA molecules compare with the original DNA molecule?

Journal Writing

Many people have said that the discovery of DNA is the most important discovery of the 20th century. Do you agree? Why or why not? Find articles from newspapers or magazines about DNA. Use the articles to write your own article that might appear 10 years from now.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is a chromosome made of?
2. What is DNA made of?
3. What is a nucleotide?
4. What is a double helix? What is its structure?
5. Which nucleotide molecules pair together?
6. What happens to DNA during cell replication?

Activity 3-1: Teacher Resource Precipitation and Spooling of DNA

One of the major symptoms of a patient with cystic fibrosis is the thick, sticky mucus that causes recurrent lung infection. The thick mucus also blocks the airways interfering with normal breathing and blocks the secretion of digestive enzymes needed to digest food. The main cause of the mucus being thick and sticky is the presence of DNA. A new treatment for cystic fibrosis is to give patients DNAase. DNAase is an enzyme that dissolves the DNA, making the mucus less sticky and thick.

I. Demonstration

A. Place 1 ml of 10 mg/ml DNA in test tube B. Add 50 ¯l of 1 M Tris pH 7.5 C. Add 10 ¯l of 1 M $MnCl_2$ D. Flick to mix Sample should be very viscous (may not slide along tube when slightly inverted, bubbles trapped in solution barely move). E. Add 2 ¯l DNAse I F. Flick to mix. Continue to flick and/or slightly invert tube to notice change in viscosity. You will note definite change at -20 sec.; very fluidy 2 minutes.

II. Students' own spooled DNA.

A. Students will have spooled DNA. B. Have students place their DNA into a sterile 15 – ml tube containing 1 ml of TE buffer (10mM Tris, 1 mM EDTA @ pH 8) or water. Let sit overnight or until it dissolves. The solution should be quite viscous. C. Proceed as in B-F above.

Activity 3-1 Report: Precipitation and Spooling of DNA (Student Reproducible)

1. Write a paragraph describing your observations of the DNA during the procedure. Include drawings as necessary.
2. Describe in words and a drawing the appearance of your isolated DNA.
3. Why is it important to study and learn about the structure and function of DNA?
4. Describe a follow-up activity using your isolated DNA.

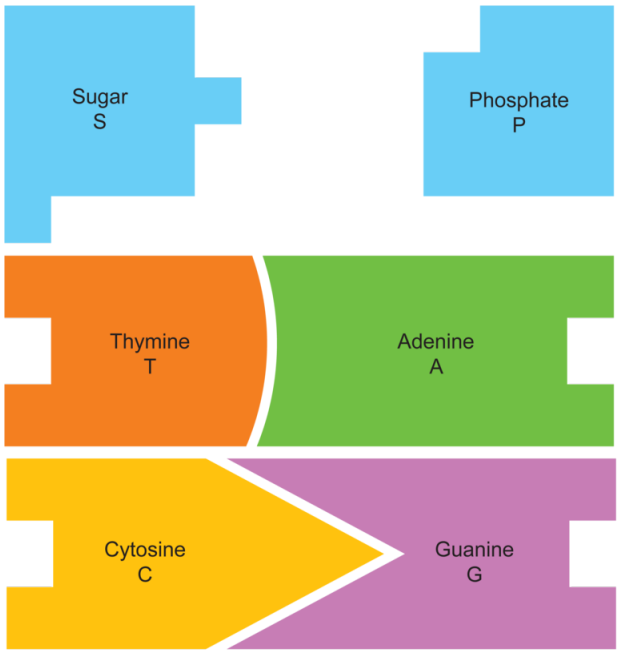
Activity 3-2 Report: Removing DNA from Thymus Cells (Student Reproducible)

1. What is the purpose of the thymus tissue?
2. Make a drawing of your observations. You should be able to see the nuclei from the thymus cells. Be sure to label a few nuclei.
3. Which part of the cell was broken by the sand and grinding? Which part was broken by the soap?
4. Draw a labeled diagram and explain in words what happened when the alcohol was added to the test tube.
5. What is the purpose of twirling the wooden skewer?
6. Describe the appearance and texture of the DNA.

In the space below, attach the paper containing your specimen. Label the DNA.

7. Describe your alternative procedure for removing thymus DNA. Include labeled diagrams as needed.
8. Explain how you would modify your original experimental design using different sources of DNA.

Activity 3-3 Resource: Building and Using a DNA Model (Student Reproducible)



Activity 3-3 Report: Building and Using a DNA Model (Student Reproducible)

1. What are the three components of a nucleotide molecule?
2. What makes up the “rungs” of the DNA ladder?
3. What makes up the sides (uprights) of the DNA ladder?
4. What are the possible combinations of nitrogen bases?
5. Make a drawing of your completed DNA model. Be sure to include labels.
6. Make a drawing of the process of replication (Steps 8 and 9).
7. How do the replicated DNA molecules compare with the original DNA molecule?

CHAPTER 5 Cell Division - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

5.1 Planning

Key Ideas

- Mitosis is the division of replicated chromosomes which is necessary for making new cells having the same number of chromosomes and the same traits as the parent cells.
- Meiosis is the division process that reduces the chromosome number, producing gametes (sperm and ova) in preparation for fertilization.
- Fertilization, or union of sperm and ovum, yields a zygote (fertilized ovum) and restores the normal number of chromosomes in somatic cells of that new organism.
- Models are important tools that help geneticists explain biological processes.

Overview

Applying and extending their knowledge of chromosomes and heredity, students learn about the differences between mitosis and meiosis. They identify mitosis as a process necessary for cell division of somatic cells to produce exact copies of parent cells for growth, replacement, and repair. Through a simulation, students demonstrate and explain that meiosis is a unique type of cell division to produce gametes (sperm and ova) that have half the number of chromosomes, in preparation for fertilization. At fertilization, the union of sperm and egg restores the normal number of chromosomes for that organism, ensuring continuity of genetic information from one generation to another.

Objectives

Students:

✓ distinguish the differences between mitosis and meiosis.

✓ demonstrate and explain the process of meiosis.

✓ simulate and explain the transfer of chromosomes during fertilization.

✓ explain the importance of DNA replication and meiosis to the continuity of a species.

✓ propose reasons why models are important tools to help geneticists learn more about important processes like DNA replication, mitosis, and fertilization.

Vocabulary

fertilization, gamete cells, meiosis, mitosis, ova, ovum, sperm, zygote

Student Materials

Activity 4-1: Cell Division - Double or Nothing

- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible); 2 large paper plates; 8 pipe cleaners (2 long of color A, 2 long of color B, 2 short of color A, and 2 short of color B)

Activity 4-2: Meiosis and Fertilization

- Data Sheets 1 and 2
- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible)
- 4 large paper plates
- Pipe cleaner set (4 double pairs) 2 long pairs (Each member of the pairs is made up of 2 long pipe cleaners for a total of 4 pipe cleaners per pair. 1 pair, color A. 1 pair, color B.) 2 short pairs (Each member of the pairs is made up of 2 pipe cleaners for a total of 4 pipe cleaners per pair. 1 pair, color A. 1 pair, color B.)

Teacher Materials

Activity 4-1: Cell Division - Double or Nothing

- Activity Report Answer Key
- Additional student supplies

Activity 4-2: Meiosis and Fertilization

- Activity Report Answer Key
- Extra pipe cleaners

Advance Preparation

See Activities 4-1 and 4-2 in the student edition.

Activity 4-1: Cell Division - Double or Nothing

- Collect student materials.
- You may want to extend students' experiences with Activity 4-1 by using *Enrichment 4-1: Chromosome Cards.*

Activity 4-2: Meiosis and Fertilization

- Arrange for video equipment if you plan to tape the activity.

- Obtain pipe cleaner sets for each team.
- You may want to extend students' experiences with Activity 4-2 by using *Enrichment 4-2: Crossing Over in Meiosis.*

Interdisciplinary Connection

Art Compare and contrast mitosis and meiosis by using models, drawings, etc.

Enrichment Activities

Enrichment 4-1: Chromosome Cards

This Enrichment activity extends students' experiences with Activity 4-1. Because this is an extension of Activity 4-1, there are no Teacher Activity Notes or Activity Report, There is a Student Activity Guide on TE page 58. Students should complete Activity 4-1 before they complete Enrichment 4-1.

If you choose to do this optional activity, consider the following:

1. Laminate the chromosome cards before students use them.
2. Encourage students to enhance their demonstrations of chromosome card movements with verbal and/or written explanations.
3. Students can summarize what they learned by completing one of the following additional creative activities to share with classmates.

They can create a

- poster.
- book, with illustrations.
- poem.
- computer simulation.

Enrichment 4-2: Crossing Over in Meiosis

This Enrichment activity extends students' experiences with Activity 4-2. Because this is an extension of Activity 4-2, there are no Teacher Activity Notes. There is a Student Activity Guide on TE page 63. The Teacher Resource for Enrichment 4-2 provides background information on meiosis. Students should complete Activity 4-2 before they complete Enrichment 4-2.

This activity illustrates genetic variation in gametes.

Encourage students to investigate nondisjunction of chromosomes and the results in humans. For example, Down syndrome results from nondisjunction of chromosome pair 21.

5.2 Using Cell Division – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Review mitosis and, if necessary, complete *Activity 4-1: Cell-Division Double or Nothing.*

Discuss mitosis and introduce meiosis before beginning *Activity 4-2: Meiosis and Fertilization.*

Review the role of models in science as they are used to help learn about and explain important biological life processes such as cell division.

Discuss the *Apply Your Knowledge* question dealing with the relationship between DNA replication and chromosomes.

Select appropriate Projects if time permits.

Review the big ideas of this section by discussing student answers to the *Review Questions.*

At the end of the section refocus students' attention on the key ideas.

5.3 Activities and Answer Keys

Activity 4-1: Cell Division - Double or Nothing

PLAN

Summary Students simulate the process of mitosis using pipe cleaners to represent chromosomes. They compare the cell before and after division to learn that no genetic information is lost during cell division, and that each new cell has the same number of chromosomes.

Objectives

Students:

✓ simulate each stage of mitosis using pipe cleaners to represent chromosomes.

✓ identify and explain the sequence of events in mitosis.

✓ determine that no genetic information is lost during cell division and each new cell has the same number of chromosomes.

Student Materials

- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible)
- 2 large paper plates
- 8 pipe cleaners (2 long of color A, 2 long of color B, 2 short of color A, and 2 short of color B)

Teacher Materials

- Activity Report Answer Key
- Additional student supplies

Advance Preparation

Collect student materials. Prepare Enrichment 4-1 materials if you plan on extending this activity.

Estimated Time One class period

Interdisciplinary Connection

Art Students can illustrate the processes of mitosis on a poster or in a collage.

Prerequisites and Background

Students need to be familiar with the parts of the cell and the process of mitotic cell division.

Helpful Hints

- Check student knowledge after each simulated stage of mitosis.
- The first teams to demonstrate the correct sequence of mitotic stages can act as "Teacher Assistants" to help other teams.

IMPLEMENT

Steps 1-8 Have students work in pairs. Give one set of student materials to each pair. However, each student should complete his or her own Activity Report.

Monitor student progress to check students' knowledge after each simulated stage of mitosis.

ASSESS

Use the completion of the activity and written responses on the Activity Report to assess if students can

✓ simulate each stage of mitosis.

✓ identify the sequence of events in mitosis.

✓ determine that no genetic information is lost during cell division and each new cell has the same number of chromosomes.

Activity 4-1: Cell Division - Double or Nothing Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Compare the chromosome number of the parent cell with that of each of the two daughter cells.
2. Compare the genetic information of the parent cell with that of each of the two daughter cells with single chromosomes.
3. What is the importance of mitosis to the organism?
4. You have 46 chromosomes in each of your somatic cells. If you cut your arm, how many chromosomes would be in each newly formed skin cell?
5. Pretend that you are a double chromosome in the nucleus of a finger cell. Describe in a paragraph your experience going through cell division to become a new finger cell. Draw diagrams as you did on your Activity Report.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Which parent determines the sex of the child?

Activity 4-2: Meiosis and Fertilization

PLAN

Summary Students model each stage of meiosis using pipe cleaners to represent chromosomes. They compare the chromosomes of the parent cell with gametes to learn that the number of chromosomes is reduced by half. They use their chromosome models to simulate fertilization.

Objectives

Students:

✓ simulate the process of meiosis using pipe cleaners to represent chromosomes.

✓ observe and record the movements and positions of chromosomes during meiosis.

✓ recognize that the number of chromosomes is reduced by half.

✓ compare and contrast the process of mitosis with the process of meiosis.

Student Materials

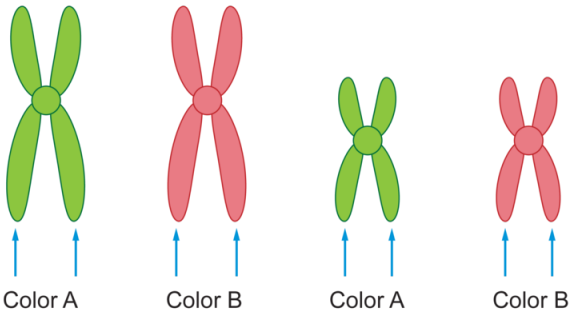
- Data Sheet
- Activity Report
- Crayons or colored pens or pencils (same colors as pipe cleaners if possible)
- 4 large paper plates
- Pipe cleaner set (4 double pairs) 2 long pairs (Each member of the pairs is made up of 2 long pipe cleaners for a total of 4 pipe cleaners per pair.) 1 pair, color A. 1 pair, color B. 2 short pairs (Each member of the pairs is made up of 2 pipe cleaners for a total of 4 pipe cleaners per pair. 1 pair, color A. 1 pair, color B.)

Teacher Materials

- Activity Report Answer Key
- Extra pipe cleaners

Advanced Preparation

Gather student materials. Arrange for video equipment if you plan to tape the activity. Prepare the pipe cleaner sets for each team.



Estimated Time One class period

Interdisciplinary Connection

Art Summarize the process of meiosis on a poster or a collage.

Prerequisites and Background Information

Students should have knowledge of the parts of the cell, especially the nucleus. Knowledge of mitotic and meiotic cell division is necessary.

Nondisjunction results when members of a chromosome pair fail to separate in normal meiosis and move into the same cell. Nondisjunction is more common in the production of gametes in females than in males.

The process of crossing-over is addressed in Enrichment 4-2

IMPLEMENT

Have students work in pairs. Give one set of student materials to each pair.

Step 1 Demonstrate the first step of procedure before students continue with Step 2. Students will discuss the questions from the Activity Report in pairs, but each student should turn in his/her own Activity Report.

Steps 2-11 Consider videotaping student simulations of the process of meiosis. Show these videotapes to the class at a later time, to other classes, at back-to-school nights, or to students who missed the class.

ASSESS

Use the completion of the activity and the written answers on the Activity Report to assess if students can

✓ simulate and describe the movements and positions of chromosomes during meiosis.

✓ recognize that the number of chromosomes is reduced by half during meiosis.

✓ explain the significance of producing haploid gamete cells.

✓ compare and contrast the process of meiosis with the process of mitosis.

Helpful Hints

- Check student knowledge of meiosis, especially after completing Steps 5 and 7.
- You may want to do procedure B (Fertilization) the following day.

Activity 4-2: Meiosis and Fertilization Activity Report Answer Key

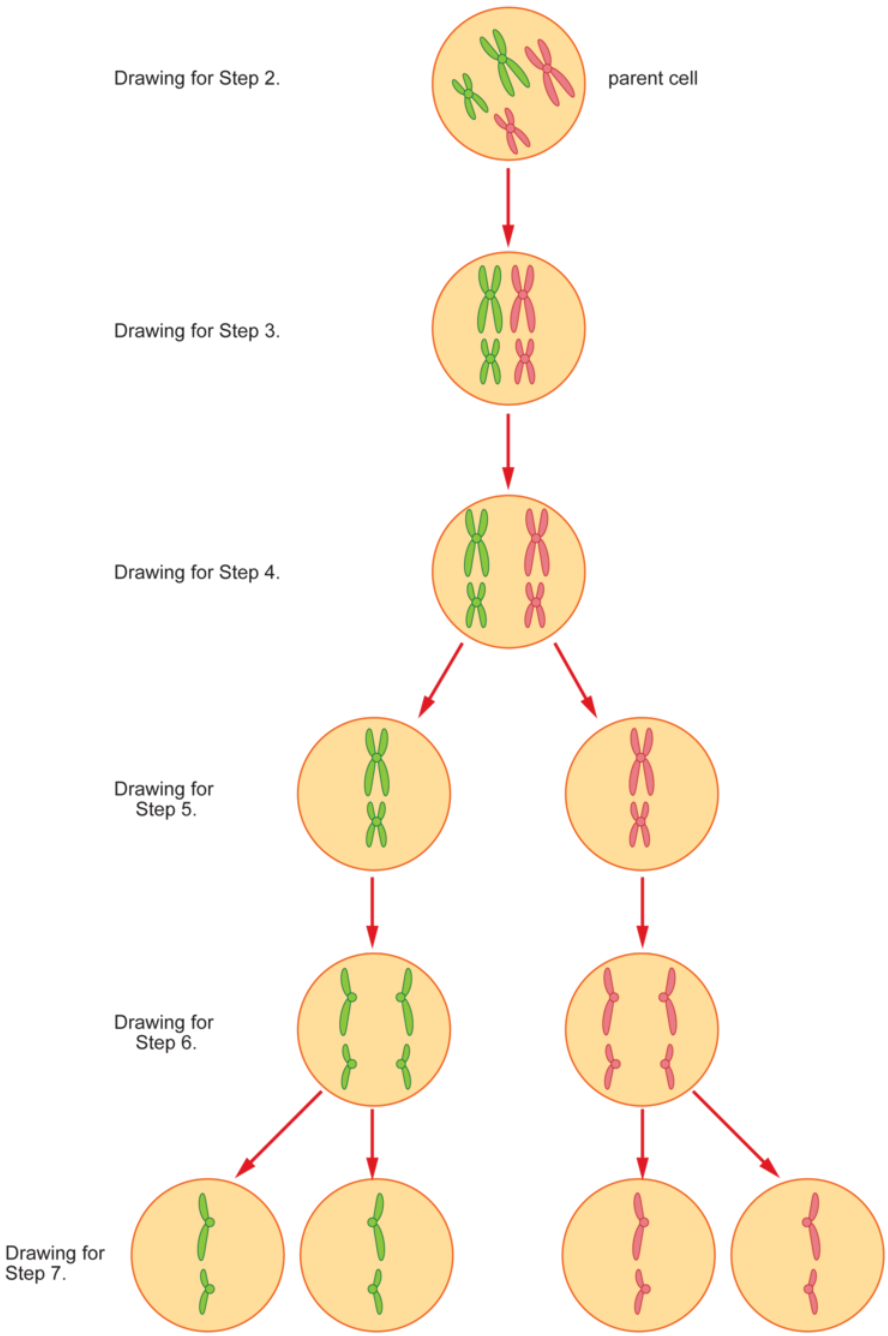
- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Compare the chromosome number of the parent cell with that of each of the four gamete cells.
2. Compare the genetic information of the parent cell with that of each of the four gamete cells.
3. How are the chromosomes of the offspring (Data Sheet #2) similar to the chromosomes of the parents (Data Sheet #1)?
4. Given your response to the question above, do you think the offspring looks different from its parents? Explain.
5. What is the importance of meiosis and fertilization in sexual reproduction?
6. You have 46 chromosomes in each of your body cells. How many chromosomes are in each gamete cell? Are the gamete cells produced by mitosis or meiosis?
7. Compare and contrast the process of mitosis with the process of meiosis including a) chromosome number, b) degree of genetic variation, c) purpose, and d) where it occurs.

TABLE 5.1:

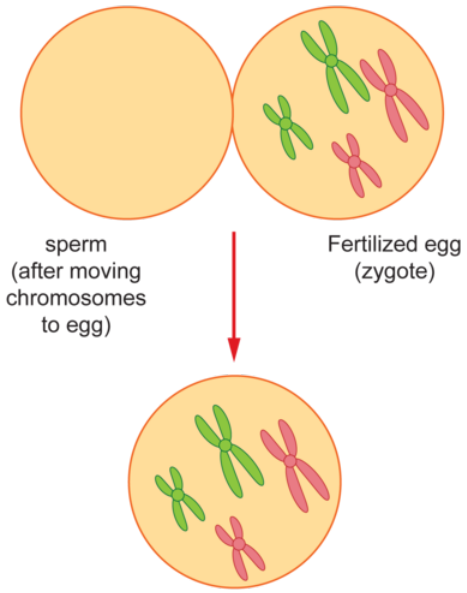
	mitosis	meiosis
a. chromosome number		
b. degree of genetic variation		
c. purpose		
d. where it occurs		

Activity 4-2: Data Sheets 1 and 2 Answer Key Meiosis and Fertilization



Drawing for Step 9.

Drawing for Step 10.



Fertilized egg (zygote)

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

What is the relationship between DNA replication and the fact that chromosomes are doubled when they begin meiosis?

What Do You Think?

In the models you made of the processes of meiosis and fertilization, you used pipe cleaners in place of chromosomes. You followed only two chromosomes, but imagine how the chromosomes in humans sort and recombine when there are 46 chromosomes. In what other ways were your models of meiosis and fertilization different from the real thing?

Journal Writing

Make a list of the characteristics that make you, you. They can be both characteristics you see and characteristics in personality or choice of activities. Now separate those characteristics into two groups: those you think you cannot control and are part of your genetic self (nature), and those characteristics you have developed and you think you can change (nurture). How much of who you are is truly genetic, and how much of who you are is a product of how you were raised?

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the difference between mitosis and meiosis?
2. Describe the process of meiosis.
3. Why is meiosis important to the continuity of a species?
4. Why are models important tools for geneticists?

Enrichment 4-2: Crossing Over in Meiosis Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Why is modeling clay better than pipe cleaners for illustrating crossing over? What other materials can you suggest?
2. What is crossing over?
3. What is the value of crossing over to the long-term survival of a species?

Activity 4-1: Report Cell Division - Double or Nothing (Student Reproducible)

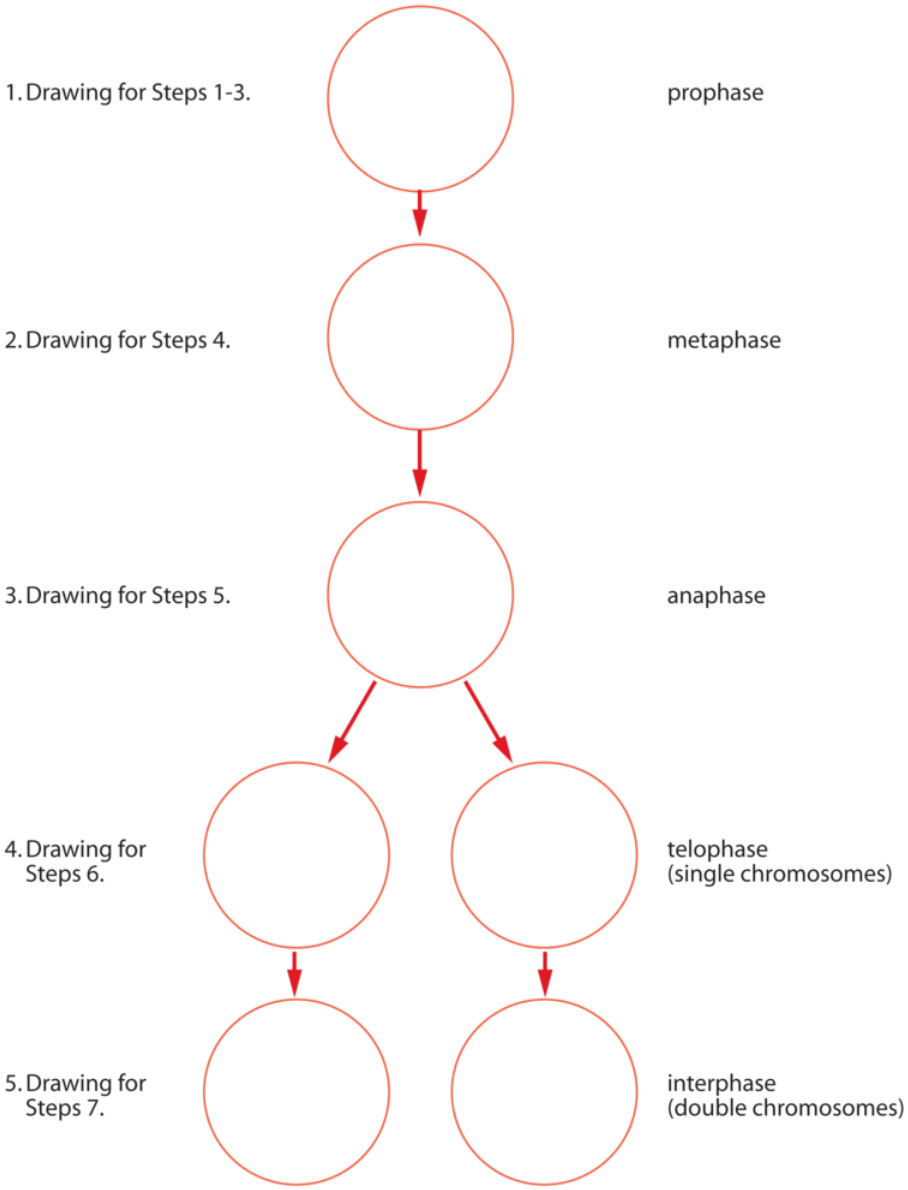
1. Compare the chromosome number of the parent cell with that of each of the two daughter cells.

2. Compare the genetic information of the parent cell with that of each of the two daughter cells with single chromosomes.

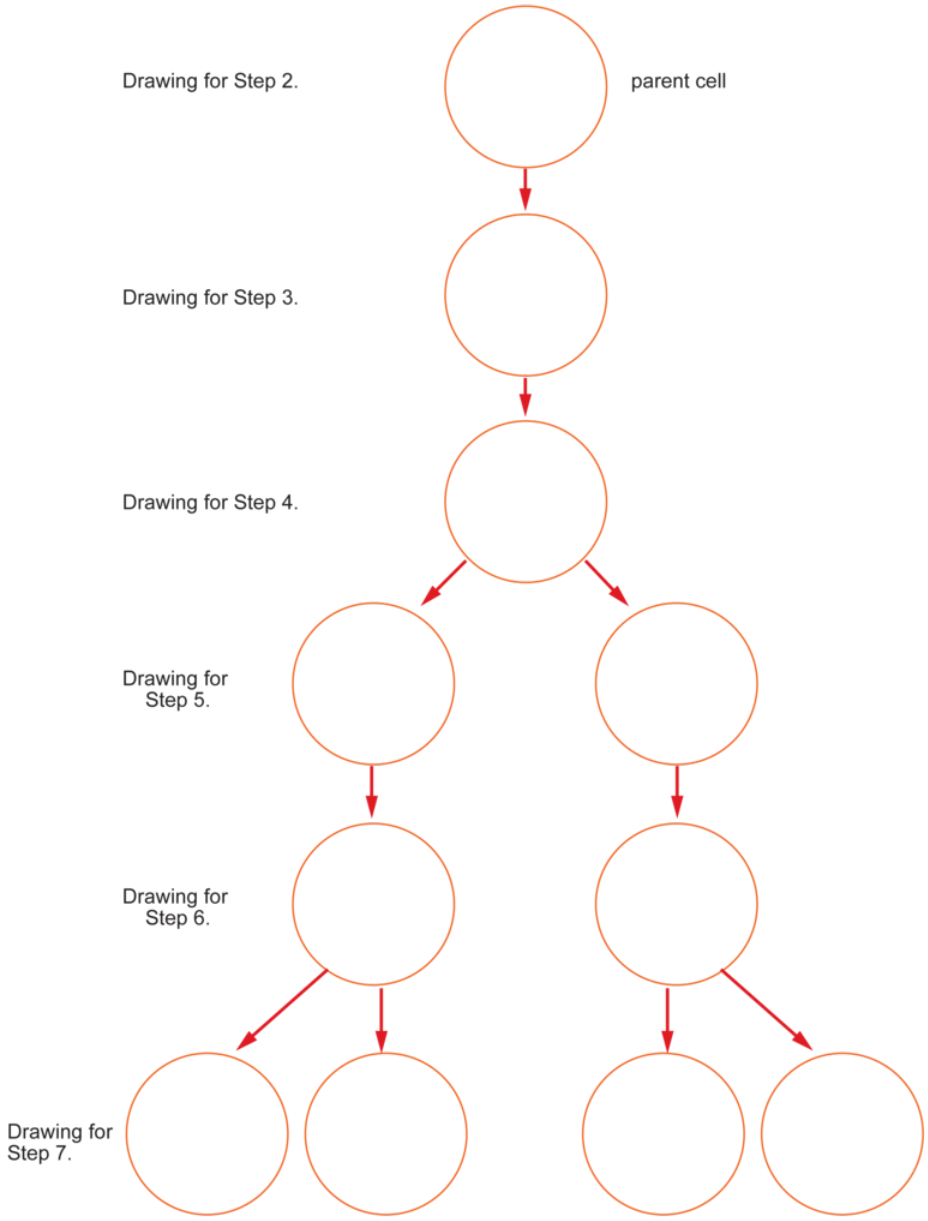
3. What is the importance of mitosis to the organism?

4. You have 46 chromosomes in each of your somatic cells. If you cut your arm, how many chromosomes would be in each newly formed skin cell?

5. Pretend that you are a double chromosome in the nucleus of a finger cell. Describe in a paragraph your experience going through cell division to become a new finger cell. Create diagrams as you did on your Activity Report.


1. Drawing for Steps 1-3.
prophase
2. Drawing for Steps 4.
metaphase
3. Drawing for Steps 5.
anaphase
4. Drawing for Steps 6.
telophase (single chromosomes)
5. Drawing for Steps 7.
interphase (double chromosomes)

Activity 4-2: Data Sheet 1 Meiosis and Fertilization (Student Reproducible)



Activity 4-2: Data Sheet 2 Meiosis and Fertilization (Student Reproducible)

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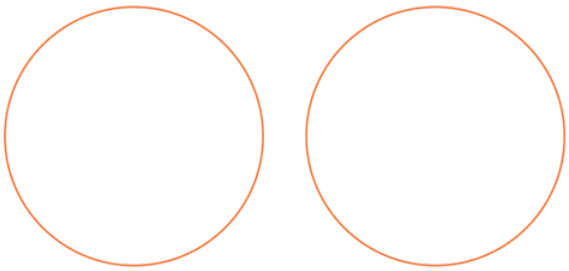
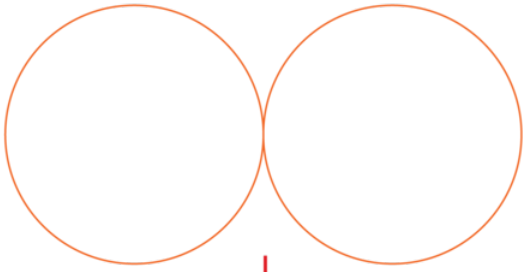
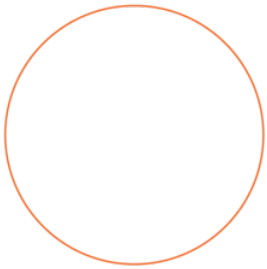


sperm egg

Drawing for Step 10.



Fertilized egg (zygote)



Activity 4-2 Report: Meiosis and Fertilization (Student Reproducible)

1. Compare the chromosome number of the parent cell with that of each of the four gamete cells.

2. Compare the genetic information of the parent cell with that of each of the four gamete cells.

3. How are the chromosomes of the offspring (Data Sheet #2) similar to the chromosomes of the parents (Data Sheet #1)?

4. Given your response to the question above, do you think the offspring looks different from its parents? Explain.

5. What is the importance of meiosis and fertilization in sexual reproduction?

6. You have 46 chromosomes in each of your body cells. How many chromosomes are in each gamete cell? Are the gamete cells produced by mitosis or meiosis?

7. Compare and contrast the process of mitosis with the process of meiosis including a) chromosome number, b) degree of genetic variation, c) purpose, and d) where it occurs.

TABLE 5.2:

	mitosis	meiosis
a. chromosome number		
b. degree of genetic variation		
c. purpose		
d. where it occurs		

Enrichment 4-1 Activity Guide: Chromosome Cards (Student Reproducible)

Introduction

How much do you know about mitosis? Can you demonstrate your knowledge of mitosis to a friend? Using the instructions below and the chromosome cards, work with a partner to simulate the sequence of events that occur during mitosis. Be sure that you demonstrate events before and after replication of DNA, the sorting of chromosomes, and the cell division resulting in two daughter cells.

Materials

- Resource (chromosome cards)
- Scissors
- Tape
- Large piece of butcher paper to represent the cell

Procedure

Step 1 Put your initials on the back of each card in your deck of 46 cards. This deck represents the diploid number of chromosomes.

Step 2 Place your chromosomes in numerical sequence from autosomal chromosome #1 through #22 and then the sex chromosomes. Note the characteristic differences in size and position of the centromere and banding patterns among the chromosomes. This double set represents the number of chromosomes you have in each of your body (somatic) cells.

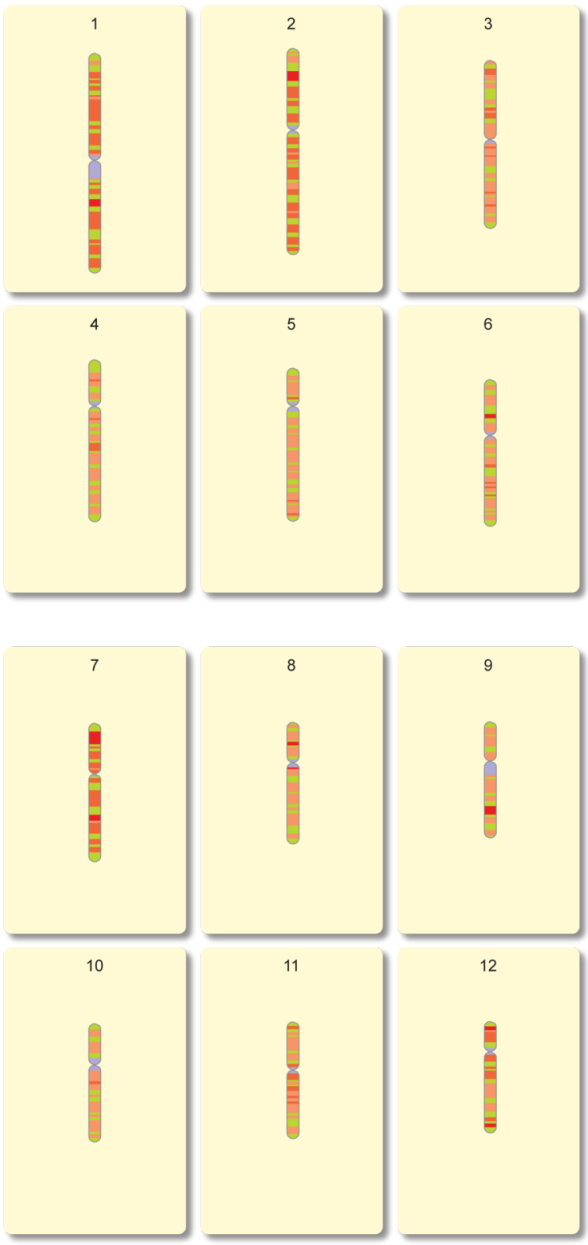
Step 3 Work with a partner who has a different colored set of cards.

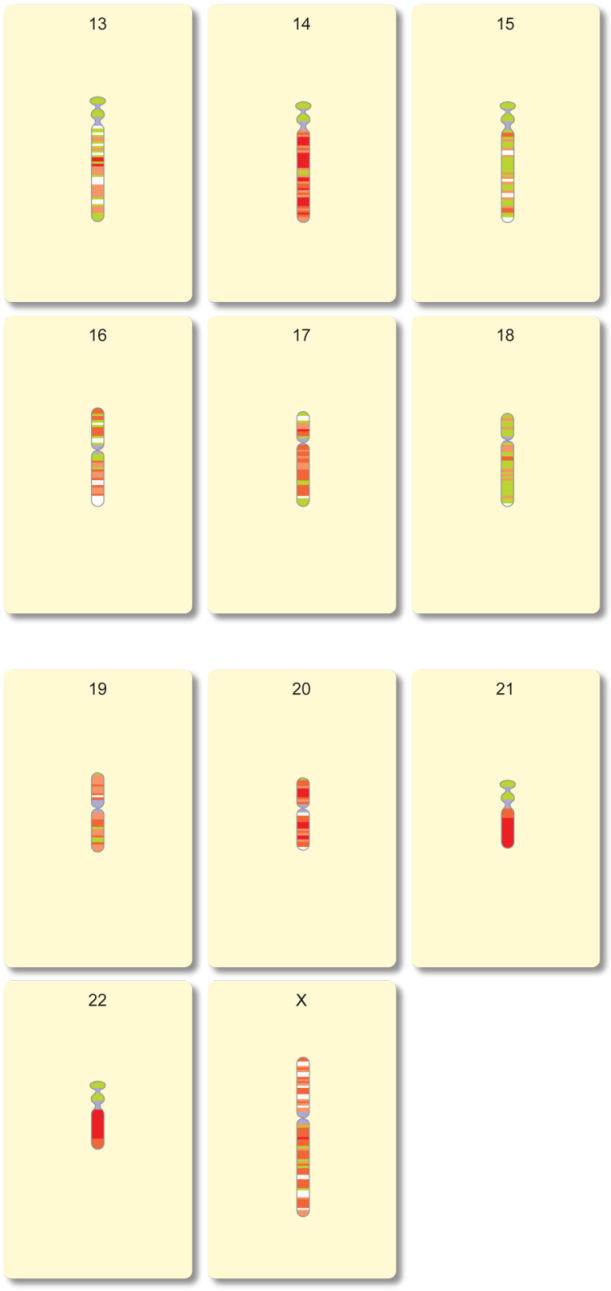
Step 4 To represent DNA replication, take sticky tape and place your partner's set of chromosomes onto each of your chromosomes, pairing each homologous pair. For example, you will have green chromosome #1 linked to yellow chromosome #1. The tape represents the centromere. That is the amount of genetic material that you have in a somatic cell just after DNA replication, but before cell division. The difference is that each chromosome is joined at the centromere so that you have two sister chromatids linked together.

Step 5 Line up your chromosomes in the center of the large sheet of construction paper along the same plane (in single file order). Separate each of the sister chromatids that are taped together. Send one of each pair to each end of the large piece of construction paper. You can see that each half of the construction paper has a complete set of chromosomes.

Step 6 Cut the butcher paper in the middle. Now you have two cells, each with a complete set of 46 single chromosomes. What do you conclude about the overall outcome of mitosis in terms of chromosome content? Is each daughter cell the same?

Enrichment 4-1 Resource: Chromosome Cards (Student Reproducible)

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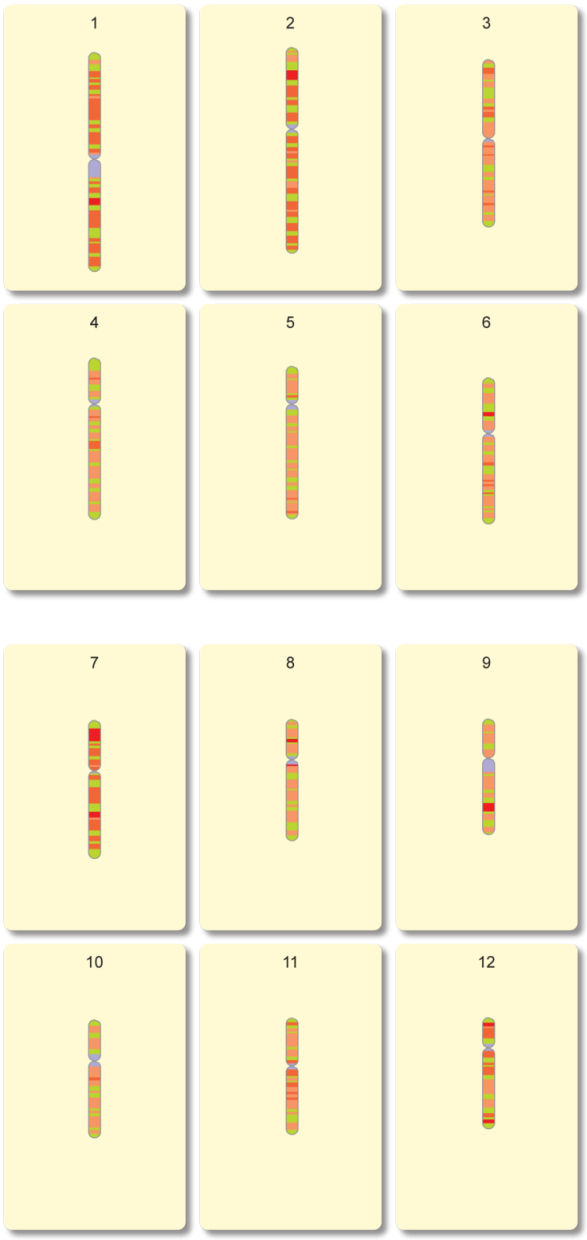
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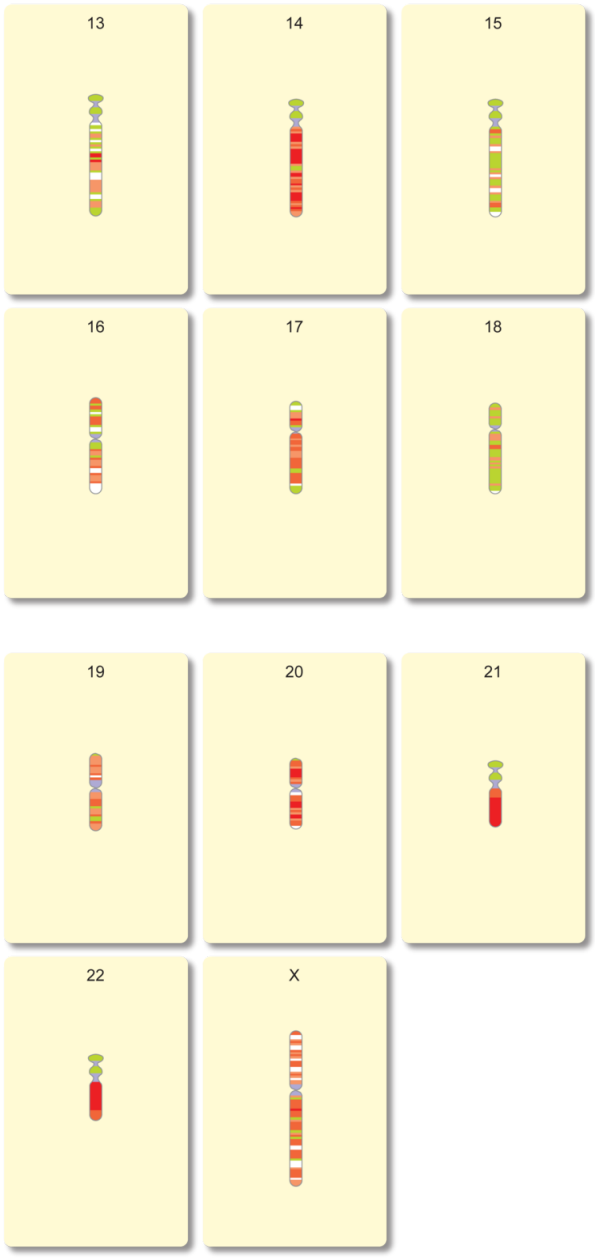


Enrichment 4-2 Activity Guide: Crossing Over in Meiosis (Student Reproducible)

In this activity, you use modeling clay to simulate an event that occurs during meiosis and increases the possibilities for genetic variation in offspring.

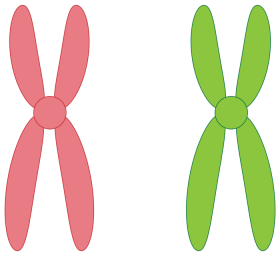
As you complete this activity, think about why it is important for a species to produce a lot of offspring having many genetic variations.

Materials

- Modeling clay (two different colors)
- Activity Report

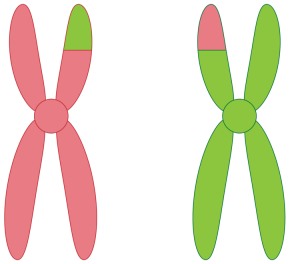
Procedure

Step 1 Use one color of modeling clay to make one double chromosome. Use the other color of modeling clay to make a second double chromosome. Each double chromosome should be the same length, but a different color.



Step 2 Place the two double chromosomes side-by-side. Remember that this pairing up of duplicated chromosomes is unique to meiosis and occurs early during the process. This process can occur with all of the double chromosome pairs at the beginning of meiosis. You will use only one pair of double chromosomes to represent the many found in the cell.

Step 3 Use your fingers to grasp the inner half of each double chromosome and twist until the chromosome ends break off. Next, take each broken end and join it onto the chromosome of the opposite color, as shown in the diagram below.



This process that you have just simulated, occurs during meiosis, and is called crossing over.

Enrichment 4-2 Resource: Crossing Over in Meiosis (Student Reproducible)

Meiosis is a special type of cell division that results in sperm and egg cells having half the normal number of chromosomes. In humans, each gamete cell (sperm and egg) contains only 23 chromosomes.

The chromosomes of the sperm and egg combine through fertilization to create offspring that are different from the parents.

An important difference between meiotic and mitotic cell divisions is the difference in the resulting cells. In mitosis the new cells have identical DNA with that of the parent cell. Cells produced by meiosis have half the amount of parental DNA and recombine through fertilization to produce genetic combinations of greater variety than that of the parents. However, how can two parents have several biological children, each of whom looks quite different from each other? If the children only received genes from each parent, what happens genetically to make each child a unique individual?

One way each child is unique is by the pattern of dominant and recessive genes he or she receives from each parent. Let's use eye color as an example. Although several genes are thought to be involved, we will ignore the complications and note that the allele for brown eyes is dominant over the allele for blue eyes. If both parents are heterozygous for brown eyes, that is Bb, then we know that there is a one and four chance that they could produce an

offspring with blue eyes. Do the cross to see. We know that every time these parents produce gamete cells there are three gamete cells with the dominant brown gene (B) for eye color and one gamete cell with the recessive blue gene (b) for eye color on the chromosome that carries the trait for eye color. The expressed eye color (phenotype) and the genetic makeup for eye color of that child depend on which gamete cell from the mother combines with which gamete cell from the father. Children of these parents genetically could be BB, Bb, or bb, but only the child that is genetically bb will have blue eyes.

Beyond one single trait, think for a moment and imagine how chromosomes could arrange themselves to create many more different combinations of genes than are possible by the simple reassortment of whole chromosomes. Crossing over is a process in which genetic information is exchanged between the two members of a chromosome pair. When the chromosomes separate and are divided into two separate cells, the resulting gamete cell contains a unique combination of genes, different from the parent cell. Normally genes are not lost, but are switched between similar chromosomes. The new combination of genes gives rise to new variations of traits, different from those in the parents, which over long periods of time may allow the species to survive and reproduce more effectively.

Enrichment 4-2 Activity Report: Crossing Over in Meiosis (Student Reproducible)

1. Why is modeling clay better than pipe cleaners to illustrate crossing over? What other materials can you suggest?
2. What is crossing over?
3. What is the value of crossing over to the long-term survival of a species?

CHAPTER 6 Gene Expression - DNA Codes for Proteins - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

6.1 Planning

Key Ideas

- DNA contains the coded information for the synthesis of specific proteins, which is the result of gene expression.
- Proteins are large molecules composed of amino acids that perform essential functions in the body.
- The DNA code, or gene, for a protein resides in the nucleus and is taken by messenger RNA (mRNA) to the ribosome in the cytoplasm for synthesis.
- Transfer RNA (tRNA) transports each amino acid to the ribosome to take its place in the newly forming protein molecule according to the instructions encoded in the mRNA.

Overview

In the previous sections, students learned about DNA replication and its role in mitosis and meiosis. In this section, they study the other function of DNA, the expression of genes to produce specific proteins. Students consider the different functions of proteins in the body and the physical properties that enable them to so many different things. They learn how information for the synthesis of a particular protein is coded for in the DNA molecule. They discuss the problem of how this information is transported from the nucleus to the cytoplasm, where protein synthesis occurs. Students learn how the DNA code is transcribed into a messenger RNA (mRNA) molecule, and how the mRNA message is translated at the ribosome to produce a protein. They study the function of tRNA in decoding the mRNA message and bringing the correct sequence of amino acids to the ribosome to form the growing protein molecule. Students simulate the entire process of protein synthesis through a role-play.

Objectives

Students:

✓ explain how DNA codes for specific proteins.

✓ describe several different functions of proteins in the body.

✓ identify the chemical composition of proteins.

✓ simulate and explain the process of gene expression and protein synthesis in a cell.

Vocabulary

amino acids, mRNA, protein synthesis, ribosomes, RNA, tRNA

Student Materials

Activity 5-1: Making Protein

- Activity Report
- Signs

DNA (GGT-CTC-CTC)

Make Protein

Messenger RNA (mRNA)

Transfer RNA (tRNA)/Proline

Transfer RNA (tRNA)/Glutamic Acid 1

Transfer RNA (tRNA)/Glutamic Acid 2

Amino Acid Proline (reverse side: The)

Amino Acid Glutamic Acid 1 (reverse side: Protein)

Amino Acid Glutamic Acid 2 (reverse side: Hemoglobin)

Ribosome (3)

- String or rope
- Resource (Optional)

Teacher Materials

Activity 5-1: Making Protein

- Resource (Optional)
- Activity Report Answer Key

Advance Preparation

See Activity 5-1 in the student edition

Activity 5-1: Making Protein

1. Make signs for each of the roles. If the signs are to be computer-generated, print the roles on 8.5 [U+0080] [U+009D] × 11 [U+0080] [U+009D] sheets of paper. Staple or glue the sheets onto a piece of construction paper. Color code for roles requiring more than one player, such as tRNA and its corresponding amino acid. An alternative is to print the role names onto the color-coded construction paper.
2. Punch two holes in each sign and attach a piece of string so that the sign can be worn around the player's neck.
3. Prepare a copy of the selected script for each player (10 copies). Highlight each player's part throughout the script. It might be helpful to provide scripts for all members of the class. As an option use Resource 1 as the script.

4. Arrange the string/rope in a large circle to represent the cell membrane. You could also use chalk to represent the cell membrane.
5. Mark off a circle inside the cell to represent the nucleus.
6. Place ribosome signs inside the cell membrane.

Interdisciplinary Connections

Social Studies Research the history and the importance of the Morse code and compare the similarities and difference in how DNA codes its information.

Language Arts Study an alphabet which is different from ours and determine what coding differences, if any, are inherent.

Art Create a set of models to simulate protein production within the cell. Use these mode ls to explain the process of protein synthesis to the class.

6.2 Using Gene Expression DNA Codes for Proteins – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Emphasize that DNA has two primary functions: replication for cell division and providing the coded information in genes for the production of specific proteins.

Introduce protein synthesis by having students complete *Mini Activity: Run to the Ribosome.* For the DNA role, use cards with a different color on each side: one color to represent the DNA code and the other color to represent the messenger RNA code.

Follow up with *Activity 5-1: Making Protein.*

Select appropriate Projects if time permits.

At the end of the section refocus students' attention on the key ideas.

Mini-Activity

Run to the Ribosome The following activity is an excellent activity to use in preparing students for Activity 5-1. This activity is strongly recommended. We placed it here, rather than in the student edition, due to the need for teacher involvement in getting students started.

1. Locate the space where this activity will take place. Use a string, chalk, or tape to represent the cell membrane. Mark off a smaller circle inside the larger cell membrane to represent the nucleus (for example, a circle 3 meters in diameter). Place a chair inside the cytoplasm to represent the ribosome.
2. Select 1 person to represent DNA, 1 person to represent mRNA, and 5 students to represent tRNA. The rest of the students represent amino acids.
3. In order for the DNA to specify the production of a protein, the DNA selects 3-letter codes. DNA writes each code on a 5[U+0080][U+009D] × 7[U+0080][U+009D] card.
4. Each tRNA selects one of the 3-letter codes held by DNA and records the complementary triplet on a 5[U+0080][U+009D] × 7[U+0080][U+009D] card. For example, if the 3-letter code is GUA, the complementary triplet would be CAU.
5. The amino acids each make a name tag and write one of the 5 codes recorded by tRNA. Have all amino acids and tRNA assemble in the cytoplasm.
6. DNA stacks the cards in a sequence. Now the race begins. DNA gives mRNA the code sequence (stack of cards). The mRNA leaves the nucleus taking the code (stack of cards) to the ribosome (chair) in the cytoplasm and places the cards on the floor in the sequence determined by DNA.
7. Each of the 5 tRNAs finds an amino acid having the same code on their name tag. The tRNAs take their amino acid to the ribosome. Each tRNA has the amino acid stand on the appropriate card. The tRNA leaves the ribosome.
8. The amino acids hold hands forming a protein (polypeptide chain). The completed protein leaves the ribosome.

6.3 Activities and Answer Keys

Activity 5-1: Making Protein

PLAN

Summary Students perform in a play that simulates where and how proteins are made within the cell. They demonstrate the functions of DNA and RNA in the synthesis of protein. Students identify the important functions of proteins in the body, using hemoglobin as an example.

Objectives

Students:

✓ simulate the process of protein synthesis.

✓ identify the roles of DNA, RNA, and amino acids in the synthesis of protein.

✓ explain why proteins are important in the body.

Student Materials

- Activity Report
- Signs:

DNA (GGT-CTC-CTC)

Make Protein Messenger RNA (mRNA)

Transfer RNA (tRNA)/Proline

Transfer RNA (tRNA)/Glutamic Acid 1

Transfer RNA (tRNA)/Glutamic Acid 2

Amino Acid Proline (reverse side: The)

Amino Acid Glutamic Acid 1 (reverse side: Protein)

Amino Acid Glutamic Acid 2 (reverse side: Hemoglobin)

Ribosome (3)

- String or rope
- Resource (Optional)

Teacher Materials

- Resource (Optional)
- Activity Report Answer Key

Advance Preparation

1. Make signs for each of the roles. If the signs are to be computer-generated, print the roles on 8.5[U+0080][U+009D]× 11[U+0080][U+009D] sheets of paper. Staple or glue the sheets onto a piece of construction paper. Color code for roles requiring more than one player, such as tRNA and its corresponding amino acid. An alternative is to print the role names onto colored construction paper.
2. Punch two holes in each sign and attach a piece of string so that the sign can be worn around the player's neck.
3. Prepare a copy of the selected script for each player (10 copies). Highlight each player's part throughout the script. It might be helpful to provide scripts for all members of the class. As an option use the Resource provided as the script.
4. Arrange the string/rope in a large circle to represent the cell membrane. You could also use chalk to represent the cell membrane.
5. Mark off a circle inside the cell to represent the nucleus.
6. Place ribosome signs inside the cell membrane.

Estimated Time One class period

Interdisciplinary Connections

Physical Education or Visual/Performing Arts may have a classroom large enough to accommodate this activity.

Art Create a set of models to simulate protein production within the cell. Use these models to explain the process of protein synthesis to the class.

Language Arts Write a narrative describing the "synthesis of protein."

Prerequisites and Background

Students should have some knowledge of cell structures involved in protein synthesis. Students should know that proteins are composed of amino acids. Knowledge of the process of protein synthesis is helpful.

Background Information

Review transcription (the process of DNA making mRNA) and translation (the process of mRNA being "read" at the ribosome to form proteins). In this play, Act I simulates transcription (DNA making mRNA). Act 2 simulates translation (mRNA making protein).

mRNA processing (removal of introns and splicing of exons) is omitted from this play as it is a topic better addressed in more advanced classes and high school.

The hemoglobin molecule is a large protein composed of 574 amino acids. This activity refers to a sequence of only three of these amino acids to illustrate how proteins are made.

In the DNA sequence for hemoglobin, if one of the DNA triplets "CTC" mutates to "CAC" then a corresponding change in the mRNA results ("GAG" becomes "GUG"). Instead of glutamic acid, the amino acid valine is introduced. This change of one amino acid is sufficient to alter the shape and consequently the function of the hemoglobin (protein) molecule so drastically that it becomes severely limited in its ability to carry oxygen efficiently. People with this mutation can have sickle-cell anemia, a very serious blood disorder.

Helpful Hints

- This activity can be done inside or outside the classroom.
- To involve more students, consider having students sit along the cell membrane to view the play or use students instead of string to represent the cell membrane.
- Consider videotaping the play.
- Encourage students to write another play to show how another protein, such as insulin, is formed.
- To illustrate mutations, students can change the sign of the DNA code CTC to CAC. The effect of such a mutation is described in the Background Information.
- Invite students to do research on types of hemoglobin and disorders of hemoglobin resulting in different kinds of anemia such as sickle-cell, pernicious, and Thalassemia.

IMPLEMENT

Step 1 You may want students to write their own scripts, or you can use the prepared scripts on the Resource.

Step 2 As a class, describe what script will be used. Make copies of the selected script.

Step 3 Arrange a place on the floor for students to make a human marrow cell that produces hemoglobin by placing a string or rope in a large circle to represent the cell membrane. This will become a part of their set as they perform their plays.

Step 4 Cast the students or choose a few students to do the casting. Allow students time to become familiar with their respective roles after receiving the script. Have them practice their roles.

Step 5 After students have completed the procedure described, consider having the students practice and present Acts I and II using several messenger RNAs, transfer RNAs, and amino acids. These presentations should help students learn that protein synthesis occurs simultaneously at many sites within a cell.

Repeat the play, rotating the roles to help students learn how proteins are made.

Make adjustments to the script to double the number of players. Also consider adding codes for other amino acids in hemoglobin.

ASSESS

Use the script created, performances of the play, research on protein disorders, and written answers on the Activity Report to assess if students can

✓ demonstrate and explain how proteins are synthesized in the cell.

✓ identify the roles of DNA, mRNA, tRNA, and amino acids in the synthesis of protein.

✓ explain why proteins are important in the body.

✓ describe the effects of mutations on protein function.

Activity 5-1: Making Protein Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Why are proteins important to the cells in your body? Give examples.
2. What makes one protein different from another?
3. Use words and/or drawings to show that you know how proteins are made in your cells. Include in your answer the following: DNA, mRNA, tRNAs, ribosomes, amino acids, and protein.
4. What do you think would happen if your body incorrectly made a protein, such as hemoglobin?

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is a protein?

2. What is an amino acid?
3. What are the differences between tRNA and mRNA? Where are they produced and where do they do their work inside the cell?

Activity 5-1 Resource: Script Making Protein (Student Reproducible)

Instructions to the players are in *italics*. These lines should not be read aloud.

Act I: A Day in the Life of DNA

Narrator: Proteins are important to the cell. Remember that proteins are made out of building blocks called amino acids. Most of the necessary amino acids are in the food you eat. How are these amino acids put together into the specific proteins your body needs? How do cells in your body make protein, such as hemoglobin?

The answer is through the activities of DNA and RNA in your cells. Let us look at what must happen when DNA tells your cells to make (synthesize) a new protein using amino acids.

Imagine that we can see inside the nucleus and hear what DNA is saying. . .

Scene 1: DNA in the Nucleus

DNA: I am DNA! I carry the code for making proteins including hemoglobin that carries oxygen in your red blood cells. Let us follow the events in the making of the protein hemoglobin inside cells in your bone marrow. Since I am such a big important molecule, I cannot leave the nucleus. Therefore, I will send my code for making hemoglobin with my friend, mRNA. First I make mRNA so it can carry information for hemoglobin. Then I watch while mRNA leaves the nucleus to go out into the cell cytoplasm.

*(Holds up a **Make Protein** sign and reads the message.)*

Make Protein.

*(DNA turns around and takes hold of one hand of messenger RNA and rotates around. DNA lets go of mRNA's hand. mRNA takes the **Make Protein** sign from DNA, turns around, and walks out of the nucleus toward one of the ribosomes of the cell.)*

Act II: A Day in the Life of Amino Acids

Narrator: Scene 1: mRNA at the Ribosome

mRNA: I am mRNA! I have the coded message from DNA that specifies the order of amino acids necessary to make the protein hemoglobin. Now, I have reached the ribosome, where proteins are actually made. Let's get started making a hemoglobin molecule!

I will demonstrate making part of the protein hemoglobin using only 3 amino acids instead of its 574 required amino acids.

First I need the amino acid proline. Proline's tRNA, where are you?

(tRNA/Proline finds the amino acid Proline. Transfer RNA uses left hand to grab Proline's right hand. tRNA/ Proline holding hands with Proline, goes to the ribosome where messenger RNA is located.)

Proline: Here we are!

mRNA: Come here! I need you now!

(mRNA, with his or her left hand, grabs the right hand of Proline's tRNA.

mRNA swings left hand forward in order to use right hand to grab Proline's left hand. mRNA releases tRNA to leave the ribosome.)

Narrator: Scene 2: mRNA at the Ribosome, looking for Glutamic Acid 1

mRNA: Now I need the amino acid Glutamic Acid. Glutamic Acid 1 and tRNA, where are you?

(mRNA looks around for Glutamic Acid 1 and its tRNA.)

(tRNA/Glutamic Acid 1 finds Glutamic Acid 1. Transfer RNA uses left hand to grab Glutamic Acid 1's right hand. tRNA/Glutamic Acid 1 holding hands with Glutamic Acid 1 goes to the ribosome where messenger RNA is located.)

Glutamic Acid 1: Here we are!

mRNA: Come here! I need you now!

(mRNA with his/her left hand grabs the right hand of Glutamic Acid 1's tRNA.)

Now it is time for the two amino acids to join! Watch the amino acid chain begin!

(mRNA swings left hand forward in order to use right hand to grab Glutamic Acid 1's left hand.

Glutamic Acid 1 tells Proline to let go of mRNA. Glutamic Acid 1 grabs left hand of Proline with the right hand, and mRNA with the left hand.

Glutamic Acid 1 tRNA is free to leave the ribosome.)

Notice that two significant events just happened:

1. Proline has been brought to mRNA by its tRNA.
2. Glutamic Acid has been brought to mRNA by its tRNA and joined to Proline.

Now the amino acid chain is ready to grow!

Narrator: Scene 3: mRNA at the Ribosome, looking for Glutamic Acid 2

mRNA: I am mRNA! I have the coded message from DNA that tells the order of amino acids necessary to make the protein hemoglobin. I have started making hemoglobin, the special protein that helps your blood carry oxygen to cells throughout the body.

It takes hundreds of amino acids to make the one protein. My job is not over. We have more work to do. Now I need another Glutamic Amino Acid. Glutamic Acid 2 and tRNA, where are you?

(mRNA looks around for Glutamic Acid 2 and its tRNA.

tRNA/Glutamic Acid 2 finds Glutamic Acid 2. Transfer RNA uses left hand to grab Glutamic Acid 2's right hand. tRNA/Glutamic Acid 2 holding hands with Glutamic Acid 2 goes to the ribosome where messenger RNA is located.)

Glutamic Acid 2: Here we are!

mRNA: Come here! I need you now!

(mRNA with his/her left hand grabs the right hand of Glutamic Acid 2's tRNA.)

Now it is time for the third amino acid to join the amino acid chain. Watch the amino acid chain grow!

(mRNA swings left hand forward in order to use right hand to grab Glutamic Acid 2's left hand.

Glutamic Acid 2 tells Glutamic Acid 1 to let go of mRNA. Glutamic Acid 2 grabs left hand cf Glutamic Acid 1 with the right hand, and mRNA with the left hand.

Glutamic Acid 2 tRNA is free to leave the ribosome.)

Notice that three significant events have now happened:

1. Proline has been brought to mRNA by its tRNA.
2. Glutamic Acid 1 has been brought to mRNA by its tRNA and joined to Proline.
3. Glutamic Acid 2 has been brought to mRNA by its tRNA and joined to Glutamic Acid 1.

All tRNAs are now available again to find their specific amino acid.

This is how a protein is made! If this protein really was hemoglobin, the protein chain would be made up of 574 amino acids linked together.

Narrator: Scene 4: Completion of the Amino Acid Chain

This process will be continued many times in order to place the 574 amino acids correctly to make the hemoglobin protein.

Now, let's imagine that our protein is finished.

Notice that each tRNA has returned to the cytoplasm to find its complementary amino acid for making another protein.

Also, see how the mRNA is now able to code for another hemoglobin protein.

(mRNA moves to another ribosome, to begin the process again.)

Narrator: Scene 5: Finale

These are only three amino acids of the 574 amino acids required to make the protein hemoglobin!

Proline, Glutamic We are now protein! We are now protein!

Acid 1 and Glutamic Acid 2 (The Amino Acid Group):

(The amino acid group turn over their signs and read their message.)

The Protein Hemoglobin

(After reading their message, they leave the ribosome.)

Narrator: You have just witnessed how DNA makes mRNA and sends mRNA with its code for making protein to the ribosomes. Hemoglobin is only one of thousands of different proteins made by the different cell types in your body.

Activity 5-1 Report: Making Protein (Student Reproducible)

1. Why are proteins important to the cells in your body? Give examples.

2. What makes one protein different from another?

3. Use words and/or drawings to show that you know how proteins are made in your cells. Include in your answer the following: DNA, mRNA, tRNAs, ribosomes, amino acids, and protein.

4. What do you think would happen if cells in your body incorrectly made a protein, such as hemoglobin?

CHAPTER 7 Expressing Dominant and Recessive Genes - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

7.1 Planning

Key Ideas

- Pedigrees are important tools for geneticists to use in tracing traits and variations from one generation to the next.
- Genes have different forms, called alleles. Two alleles make up a gene pair for a specific trait.
- A dominant allele expresses its trait whenever it is present in a gene pair. Two recessive alleles must be present in order to express that trait.
- Gregor Mendel's work studying inheritance in garden peas in the 1860s laid the foundation for the modern science of genetics.

Overview

Students apply principles of heredity to create and study family pedigrees. They analyze information about family members and investigate inheritance of particular traits, such as hair and eye color. They learn to use a Punnett square, an important tool of geneticists, to predict offspring from genetic crosses involving dogs that have different coat colors. Students use colored beans to model and explain the differences in inheritance patterns of dominant and recessive alleles. After reviewing Gregor Mendel's work studying inheritance patterns of garden peas, students apply their knowledge to explain how research on chromosomes and genes can now be used to verify and extend the work of Mendel, whose data dates back to the 1860s.

Objectives

Students:

✓ explain the biological significance of gene alleles.

✓ explain how variations are inherited.

✓ examine pedigrees and explain inherited variations.

✓ demonstrate how to use a Punnett square to predict outcomes of crosses between dogs having different coat colors.

✓ model differences in the expression of dominant and recessive alleles.

✓ explain how Gregor Mendel's explanations for variations in garden peas can be verified using modern biological research on genes, alleles, and chromosomes.

Vocabulary

alleles, dominant allele, genotype, heredity, linked genes, pedigree, recessive allele

Student Materials

Activity 6-1 Expression: Dominant and Recessive

- Activity Report
- 20 white beans; 20 red beans; 2 jars or cups; Paper and pen/pencil

Teacher Materials

Activity 6-1 Expression: Dominant and Recessive

- Activity Report Answer Key

Advance Preparation

See Activity 6-1 in the student edition

Activity 6-1 Expression: Dominant and Recessive

- Obtain red and white beans and place 10 of each color in a separate cup.
- Gather one set of student materials for each group of students.
- Have extra red and white beans available.
- Coordinate this interdisciplinary activity with the math teacher.

Interdisciplinary Connections

Math Complete activities relating to probability, using percentages and fractions.

Social Studies Examine a pedigree chart for the Russian Czar Nicholas and his wife Alexandra showing the members of the royal family and the pattern of inheritance of hemophilia.

7.2 Using Expressing Dominant and Recessive Genes – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Begin this section with *Mini Activities: Family Pedigree One* and *Family Pedigree Two,* followed by a discussion of student's results.

Introduce express ion of dominant and recessive alleles by completing *Mini Activity: Dominant and Recessive Alleles.*

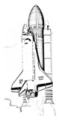
Follow up with *Activity 6-1: Expression: Dominant and Recessive.*

You may want to explain how to use Punnett squares in solving genetics problems to prepare students for completing the *Apply Your Knowledge* question dealing with Punnett squares.

Emphasize that the Punnett square is used to predict the genotype and phenotype probabilities for each offspring.

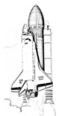
Select appropriate Projects if time permits.

At the end of the section refocus students' attention on the key ideas.



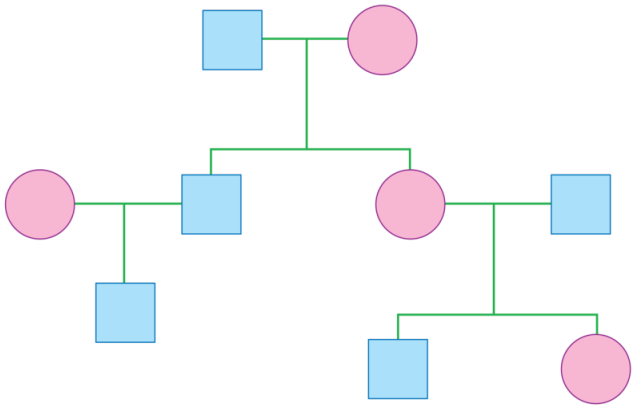
Mini-Activity

Family Pedigree One Students examine a family pedigree on hair color variation and answer a series of questions about the pattern of inheritance of red hair across four generations.



Mini-Activity

Family Pedigree Two Students create a family tree or pedigree given information on a married couple and their successive generations of children and grandchildren.



7.3 Activities and Answer Keys

Activity 6-1 Expression: Dominant and Recessive

PLAN

Summary Students learn how gene expression for a particular trait is influenced by dominant and recessive alleles. They use red and white beans to represent two alleles for bean color. The red is the dominant allele (R), while the white is the recessive allele (r). Through 15 random selections of beans (alleles), from parents who are both heterozygous for the trait, students record the genotype and the resulting phenotype of the offspring. They recognize that there is a random assortment of allele combinations each time an offspring is created. They analyze the pattern of inheritance of this trait in offspring from heterozygous parents, and then compare it to the pattern of inheritance of this trait in offspring from one parent who is homozygous for the trait, while the other is heterozygous.

Objectives

Students:

✓ record the results of 15 random draws from the two gene pools.

✓ explain that for each offspring produced, there is a random selection of the allele contributed by each parent.

✓ predict which variation will be expressed in each offspring based on the genotypes drawn.

✓ calculate the percent of each genotype and each phenotype in the 15 offspring.

✓ explain the inheritance pattern of the recessive allele.

Student Materials

- Activity Report
- 20 white beans
- 20 red beans
- 2 jars or cups
- Paper and pen/pencil

Teacher Materials

Activity 6-1: Expression: Dominant and Recessive

- Activity Report Answer Key

Advance Preparation

1. Obtain red and white beans and place 10 of each color in a separate cup.
2. Gather one set of student materials for each group of students.
3. Have extra red and white beans available.
4. Coordinate this interdisciplinary activity with the math teacher.

Estimated Time One class period

Interdisciplinary Connection

Math Complete activities relating to probability, calculating percentages, and fractions in math class.

Prerequisites and Background Information

Students should know how to calculate percentages or have some skills working with fractions. Students should know how to use a table.

IMPLEMENT

Step 1 Instruct students to put the beans back in the jars after they have made each selection as all 20 beans need to be in each jar at the time of each draw.

Consider the case where one parent is homozygous with the dominant allele. Ask students to answer this question without performing the experiment, writing their responses on the Student Report or discussing the consequences in class.

Steps 2-5 Continue to emphasize that each draw represents a chance (random) event.

Steps 6-9 Make sure students are recording their choices and completing the Activity Report.

Extend Activity 6-1 by having students build an imaginary animal. They decide on 4 traits and determine what the dominant and recessive alleles are for those traits. Then they assign the dominant allele to the red bean and the recessive to the white bean for each trait. They continue as before but now every 4 draws represents the expression of the four traits of the imaginary animal. The following is an example:

Helpful Hints

- Guide students in using their tables for recording data.
- The beans can be replaced with small balls of crumpled paper of two colors.

TABLE 7.1: ANIMAL: Snuggleuptous

TRAIT	DOMINANT	RECESSIVE
hair	curly (C)	straight (c)
tail	long (L)	short (I)
color	black (B)	white (b)
height	tall (T)	short (t)

ASSESS

Use the completion of the activity, the analysis of the data tables, and the answers on the Activity Report to assess if students can

✓ accurately record data on the 15 offspring produced for the two different cases presented.

✓ explain that for each offspring produced, there is a random selection of the allele contributed by each parent.

✓ predict which variation of the trait will be expressed in each offspring based on its genotype.

✓ calculate the percent of each genotype and each phenotype in the 15 offspring for the two different cases presented.

✓ explain the inheritance pattern of the recessive allele.

Activity 6-1 Expression: Dominant and Recessive Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. Record your observations in the table below.

TABLE 7.2:

	Color of 1st bean	Color of 2nd bean	Gene pattern (genotype)	Color pattern (phenotype)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

2.
3. Record your observations in the table below

TABLE 7.3:

	Color of 1st bean	Color of 2nd bean	Gene pattern (genotype)	Color pattern (phenotype)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

4.

5. What do the jars containing the 20 beans represent?
6. Why was only one bean at a time taken out of each jar?
7. What does the pair of genes represent?
8. Refer to Table 1. List all possible phenotypes and genotypes.
9. Refer to Table 1. Calculate the percent for each phenotype and for each genotype by using the formula: number observed divided by the total number times 100. List the percentages of each phenotype and genotype below:
10. After completing the 15 crosses between the jar with 20 white beans and the one with 10 red and ten white (Step 8), look at the data in Table 2 and explain why so many more pairs of white were drawn, considering white represents the recessive allele for the trait.

What Do You Think?

The phrase "Every human gene must have an ancestor" is found in the book *Language of Genes*. What does the phrase mean to you? Write a story or poem about real or imagined ancestors who might have had one or more variations you carry in your DNA today. Be creative. Have fun imagining who these people might have been and what they might have been like.

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Sometimes a baby with blue eyes is born to two parents with brown eyes. Grandparents smile and say "blue eyes skip a generation." Is this myth correct? Can you explain how two brown-eyed parents could have a blue-eyed child?

Apply Your KNOWLEDGE

Using Punnett squares, show the results of crossing a homozygous tall (TT) and a homozygous short (tt) pea plant. Then show the results of back crossing the F_1 pea plants to each parental type.

Parents — Tall pea plant = IT; Short pea plant = tt

Gametes — Tt

	T	T
t	Tt	Tt
t	Tt	Tt

F_1 Pea Plants

	T	T
T	TT	TT
t	Tt	Tt

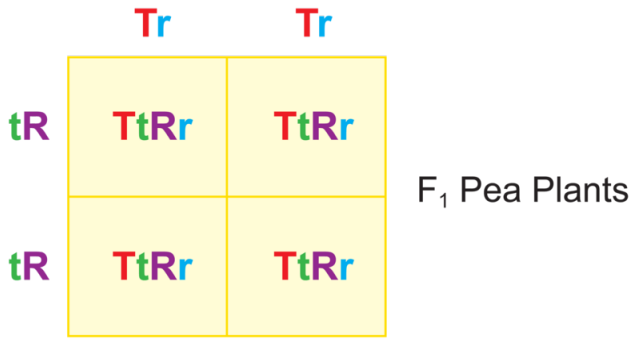
	t	t
T	Tt	Tt
t	tt	tt

Results of back crosses to each parental genotype

Use the Punnett square technique to show the results of crossing a tall pea plant with two tall alleles (TT) that has two alleles for wrinkled seeds (rr) with a short pea plant (tt) that has two alleles for round seeds (RR).

Parents TTrr × ttRR

Gametes Tr tR



What do you think is the importance of genetic maps?

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What are alleles? Why are they important?
2. What is the difference between dominant and recessive alleles?
3. Although Gregor Mendel didn't know about meiosis or mitosis, his discoveries provided the foundation for modern genetics. What did he find?

Activity 6-1 Report Expression: Dominant and Recessive (Student Reproducible)

1. Record your observations in the table below.

TABLE 7.4:

	Color of 1st bean	Color of 2nd bean	Gene pattern (genotype)	Color pattern (phenotype)
1				
2				
3				
4				
5				
6				
7				
8				

TABLE 7.4: (continued)

	Color of 1st bean	Color of 2nd bean	Gene pattern (genotype)	Color pattern (phenotype)
9				
10				
11				
12				
13				
14				
15				

2. Record your observations in the table below.

TABLE 7.5:

	Color of 1st bean	Color of 2nd bean	Gene pattern (genotype)	Color pattern (phenotype)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

3. What do the jars and the beans represent?

4. Why was only one bean at a time taken out of each jar?

5. What does the pair of genes represent?

6. Refer to Table 1. List all possible phenotypes and genotypes.

7. Refer to Table 1. Calculate the percent for each phenotype and for each genotype by using the formula: number observed divided by the total number times 100. List the percentages of each phenotype and genotype below:

8. After completing the 15 crosses between the jar with 20 white beans and the one with 10 red and 10 white (Step 8), look at the data in Table 2 and explain why so many more pairs of white were drawn, considering white represents the recessive allele for the trait.

CHAPTER 8 Single Gene Disorders - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

8.1 Planning

Key Ideas

- Single gene disorders are classified by geneticists into dominant, recessive, and sex-linked, depending on their pattern of inheritance.
- Dominant patterns of inheritance occur when the genetic defect is a dominant allele.
- Recessive patterns of inheritance occur when the genetic defect is a recessive allele.
- Sex-linked patterns of inheritance occur when the genetic defect is located on the X or Y chromosome.

Overview

Building on their knowledge of dominant and recessive genes, students learn about the inheritance patterns of single gene disorders. They study and investigate dominant, recessive, and sex-linked patterns of inheritance in humans, and some of the disorders caused by each type of defect. Students simulate the expression of dominant and recessive alleles. They also examine how X-linked disorders are transmitted through successive gene rations.

Objectives

Students:

✓ distinguish between dominant, recessive, and sex-linked patterns of inheritance for single gene disorders.

✓ simulate the expression of dominant and recessive alleles.

✓ examine how X-linked disorders are transmitted.

Vocabulary

heterozygous, homozygous, X-linked

Student Materials

Activity 7-1: Exploring a Single Gene Disorder

- Activity Report
- 2 strips of colored construction paper; 2 strips of clear plastic
- Computer with Internet connection (Optional)

Teacher Materials

Activity 7-1: Exploring a Single Gene Disorder

- Activity Report Answer Key
- Resource materials and Web sites providing information on genetic disorders

Advance Preparation

See Activity 7-1 in the student edition,

Activity 7-1: Exploring a Single Gene Disorder

- Collect resource materials and identify useful Web sites.

Interdisciplinary Connection

Health Single gene disorder case histories can be discussed.

8.2 Using Single Gene Disorders – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Complete *Mini Activities: X-linked Inheritance Patterns-Color Blindness* and *Hemophilia*.

Select appropriate Projects if time permits.

Review the big ideas of this section by discussing student answers to the *Review Questions.*

At the end of the section refocus students' attention on the key ideas.

8.3 Activities and Answer Keys

Activity 7-1: Exploring a Single Gene Disorder

PLAN

Summary Students investigate single gene disorders and how they are responsible for causing genetic conditions in humans. They simulate the expression of dominant and recessive alleles using strips of colored construction paper and clear plastic. Students then select an example of a single gene disorder to investigate in depth.

Objectives

Students:

✓ show the four possible combinations of genes representing dominant and recessive alleles and describe the variation expressed.

✓ explain what is meant by a single gene disorder.

✓ list examples of single gene disorders.

✓ investigate a single gene disorder.

Student Materials

- Activity Report
- 2 strips of colored construction paper
- 2 strips of clear plastic
- Computer with Internet connection (optional)

Teacher Materials

- Activity Report Answer Key
- Resource materials and Internet Web sites providing information on genetic disorders.

Advance Preparation

Collect resource materials and identify useful Internet Web Sites that provide information on genetic disorders (see Helpful Hints).

Estimated Time One class period plus individual research time

Interdisciplinary Connection

Health Education Students write a medical case history involving an individual with chromosomal or genetic disorders and present findings to the class.

Prerequisites and Background

Students should be aware that there are thousands of single gene disorders in humans. There are also diseases that involve more that a single gene. Computer skills would be helpful.

IMPLEMENT

Steps 1-6 Explain that the clear strip represents a recessive allele and that the colored strip represents a dominant allele.

Steps 7-8 Many single gene disorders could be good research topics for this activity. We advise students to review their choice with the teacher for those not included in the activity.

For one of the single gene disorders listed in the activity, assign students to either

- complete a written report, based on their research, or
- prepare an oral or multimedia presentation of the disorder, based on their research.

For each disorder, provide students with evaluation criteria for their presentation or written report that includes the following

- cause,
- symptoms,
- current treatment options,
- prognosis,
- new treatments under investigation,
- availability of prenatal diagnosis,
- the chromosome number where the gene is located,
- resources in your community available to help people with this disorder and their families.

Helpful Hints

Suggestions for research sources: Contact the local March of Dimes organization for information about genetic disorders. This can be done by phone (1-888-MODIMES or 1-888-663-4637). It can also be done using a search engine and entering a search for March of Dimes. An example of a March of Dimes Web site: resourcecenter@modimes.org.

Presentation Guidelines

Use your preferred guidelines for helping students develop their communication presentations, or consider rubrics for areas such as the following.

- Student exhibits mastery of content knowledge during presentation and in fielding answers to student questions.
- Presentation is shared well with all members of the class.
- Presentation style is clear, easy to understand, and engages audience.
- Audiovisual materials are neatly prepared, clear, and effective in reinforcing content.
- Presentation is efficiently organized and logical.

ASSESS

Use the completion of the activity and the single gene disorder written report and/or presentation to assess if students can

✓ demonstrate the four possible combinations of genes representing dominant and recessive alleles and describe the variation expressed in each.

✓ explain what is meant by a single gene disorder.

✓ identify examples of single gene disorders.

✓ perform independent research on a single gene disorder.

✓ present the findings of their research in a written report or presentation to the class.

Activity 7-1: Exploring a Single Gene Disorder Activity Report Answer Key

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What do you observe when you place one colored strip on another?
2. What do you observe when you place a colored strip on a clear strip?
3. What do you observe when you place a clear strip on a colored strip?
4. What do you observe when you place a clear strip on another clear strip?
5. The single gene disorder I will investigate is

A suggested response will be provided upon request. **Please send an email to teachers-requests@ck12.org.**

Apply Your KNOWLEDGE

Look at Figures 7.2 and 7.3. What are the chances that the daughters of the couple will have the genetic disease? What are the chances that the sons of the couple will have the genetic disease? What proportion of the daughters will carry but not express the genetic disease? Why do more males than females have X-linked genetic diseases?

Mini-Activity

Hemophilia Students answer several questions about the X-linked trait hemophilia.

X-linked Inheritance Pattern-Color Blindness Students answer several questions about the genotype of males and females who are colorblind and their children.

Journal Writing

Imagine that you are completely colorblind. You see a world of black and white all the time. Write a poem about your impressions of the world-a world where color has no meaning, but which exists in shades of gray.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the difference between a dominant inheritance pattern and a recessive inheritance pattern?
2. What is the chance that a son and daughter will be colorblind if their parents are not colorblind, but their mother's father is colorblind?

Activity 7-1 Report: Exploring a Single Gene Disorder (Student Reproducible)

1. What do you observe when you place one colored strip on another?
2. What do you observe when you place a colored strip on a clear strip?
3. What do you observe when you place a clear strip on a colored strip?
4. What do you observe when you place a clear strip on another clear strip?
5. The single gene disorder I will investigate is _____.

CHAPTER 9 Other Genetic Conditions and Genetic Counseling - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

9.1 Planning

Key Ideas

- Some genetic conditions are caused by the interaction of several genes. The interaction makes predicting the condition of the offspring more difficult.
- Chromosomal disorders leading to other genetic conditions are caused by errors that occur during the process of meiosis. Sometimes a piece of a chromosome is missing, an entire chromosome is missing, or an extra chromosome is present in the offspring.
- Nongenetic birth defects are caused by factors that affect the maternal environment in which the fetus grows and develops.
- Genetic counselors can help couples and families learn more about their risks for genetic diseases and help families living with a genetic disease find good medical treatments.
- Population geneticists are concerned with variations in gene frequencies in different populations of people around the world.

Overview

Using examples of human genetic conditions, students differentiate between multiple gene disorders and those caused by chromosomal abnormalities. They explore the relationship between genetic predisposition to a disease and the effects of the environment on the actual expression of that disease. Students explore how a genetic counseling team of geneticists and medical specialists identify genetic diseases. They learn how these teams offer support and information to families on options for treatment and ways of living with these kinds of conditions. Students learn that population geneticists study variations in gene frequencies in populations around the world. Finally, each student selects a chromosome to study and contacts the Human Genome Project to perform research on information known about a gene on that chromosome. This research provides a bridge to Section 9, where the Human Genome Project is discussed in more detail.

Objectives

Students:

✓ distinguish between multiple gene disorders and chromosomal disorders.

✓ explain how environmental factors can cause birth defects.

✓ discuss the purpose and methods of genetic counseling.

✓ identify the research focus of a population geneticist.

✓ contact the Human Genome Project and perform research on a specific gene.

Vocabulary

genetic counseling, population geneticists

Student Materials

Activity 8-1: Investigating the Human Genome Project

- Human Genome Project addresses
- Computer with Internet connection; or letter paper, envelope, and stamp
- Presentation materials

Teacher Materials

Activity 8-1: Investigating the Human Genome Project

- Human Genome materials: Map of the Human Genome
- Other free materials available upon request
- "Maps to Medicine" (Optional)
- "To Know Ourselves" (Optional)

Advance Preparation

See Activity 8-1 in the student edition,

Activity 8-1: Investigating the Human Genome Project

- Plan early to arrange for a guest speaker such as a scientist, geneticist, medical geneticist, or genetics educational outreach speaker from the Human Genome Project or March of Dimes.
- Ask for help from your school or community resource center to begin gathering information about the Human Genome Project and genetic diseases.
- Contact your local March of Dimes organization to explore available education information about genetic diseases. Their telephone number should be listed in your local telephone book. This can also be done by phone (1-888-MODIMES or 1-888-663-4637), or by using a search engine and entering a search for March of Dimes. Following are two examples of March of Dimes Web sites.

  resourcecenter@modimes.org modimes.org/ pub/genetics.htm

- Consider your local hospital and university resources for enhancing student career information about opportunities in genetics and human medicine.
- Optional: Request free copies of "The Genome Project: Maps to Medicine" (NIH Publication No. 96-3897) and/or a video about the Human Genome Project through the following address or phone number:

Office of Communications National Center for Human Genome Research National Institutes of Health Building 31 Room 4BO9 9000 Rockville Pike Bethesda, MD 29892 Telephone number: 301-402-0911

- Optional: Request free copies of "To Know Ourselves" an informative and well illustrated publication from the U.S. Department of Energy and the Human Genome Project by contacting:

  DOE Human Genome Project Department of Energy 19901 Germantown Road ER-72 Germantown, Maryland, 20874

- Genome information Internet Web sites include, but are not limited to the following:

DOE sites

http://www.er.doe.gov/production/ober/hug_top.html

http://www.ornl.gov/TechResources/Human_Genome/home.html

http://www.ornl.gov/hgmis/links.html

NIH site: National Human Genome Research Institute

http://www.nhgri.nih.gov/

Interdisciplinary Connections

Art Draw a chromosome map on a large poster. Mark and label the genes which have been identified by Human Genome Project to date.

Math Research funding sources for the Human Genome Project.

Compare the cost of the Human Genome Project with other large-scale scientifically based projects such as parts of the space program.

Social Studies Investigate how information generated from the Human Genome Project and the resulting genetic testing might affect health insurance programs and/or job opportunities.

9.2 Using Other Genetic Conditions and Genetic Counseling – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

In discussing genetic conditions and genetic counseling, consider assigning career opportunities in genetics as a topic for student investigation.

Schedule time for student presentations on *Activity 8-1 : Investigating the Human Genome Project.*

Emphasize the big ideas of this section by discussing student answers to the *Review Questions*.

At the end of the section refocus students' attention on the key ideas.

What Do You Think?

Insurance companies compensate people for medical expenses. Should they be allowed to screen people for genetic disorders before agreeing to insure them?

What Do You Think?

If you carried a recessive gene for a genetic disorder and your spouse did too, would you risk having children? Why or why not?

9.3 Activities and Answer Keys

Activity 8-1: Investigating the Human Genome Project

PLAN

Summary Each student selects a chromosome and gathers information about that chromosome from the Human Genome Project. Based on the information received, students conduct further research on one of the genes on that chromosome. They explain the scientific discoveries leading to the identification of that gene and investigate the trait (genetic expression) of the gene. If the gene selected has a known disorder, students can focus on the symptoms, diagnosis, and treatments (current and future) of the disorder. Students present the results of their research to the class.

Objectives

Students:

✓ select a human chromosome for investigation.

✓ summarize Human Genome Project information on that chromosome.

✓ plan and conduct research on a gene.

✓ prepare and present their research findings to the class.

Student Materials

- Human Genome Project addresses
- Computer with Internet connection; or letter paper, envelope, and stamp
- Presentation materials

Teacher Materials

Human Genome materials: Map of the Human Genome; Other free materials available upon request: "Maps to Medicine" and "To Know Ourselves"

Advance Preparation

Plan early to arrange for a guest speaker such as a human genome scientist, geneticist, medical geneticist, or genetics educational outreach speaker from the Human Genome Project or March of Dimes.

Ask for help from your school or community resource center to begin gathering information about the Human Genome Project and genetic diseases.

Contact your local March of Dimes organization to explore available education information about genetic diseases. Their telephone number should be listed in your local telephone book. This can also be done by phone (1-888-MODIMES or 1-888-663-4637), or by using a search engine and entering a search for March of Dimes. Following are two examples of March of Dimes Web sites.

resourcecenter@modimes.org.

modimes.org/pub/genetics.htm

- Consider your local hospital and university resources for enhancing student career information about opportunities in genetics and medicine.
- Optional: Request free copies of "The Genome Project: Maps to Medicine" (NIH Publication No. 96-3897) and/or a video about the Human Genome Project through the following address or phone number:

Office of Communications

National Center for Human Genome Research

National Institutes of Health

Building 31

Room 4BO9

9000 Rockville Pike

Bethesda, MD 29892

Telephone number: 301-402-0911

- Optional: Request free copies of "To Know Ourselves" an informative and well illustrated publication from the U.S. Department of Energy and the Human Genome Project by contacting:

DOE Human Genome Project

Department of Energy

19901 Germantown Road ER-72

Germantown, MD, 20874

- Genome information Internet Web sites include, but are not limited to the following:

DOE sites

http://www.er.doe.gov/production/ober/hug_top.html

http://www.ornl.gov/TechResources/Human_Genome/home.html

http://www.ornl.gov/hgmis/links.html

NIH site: National Human Genome Research Institute

http://www.nhgri.nih.gov/

Estimated Time

Variable, this activity could be assigned early and take place over the course of the genetics unit. It could include the following.

- one-half to one period to draft a class letter
- one-half to one period to distribute Human Genome Information received, and discuss research
- at least one class period using the computer at school or at home to research their gene
- one period for finalizing student presentations
- one period for student presentations

These suggestions for class time can be shortened if students complete parts of the assignments at home.

Helpful Hints

- Help students construct a class letter requesting the desired information from the Human Genome Project. Correspondence with the Genome Center should go through the teacher (that explains the reason for a class letter).
- Encourage students to use different presentation formats and ways of organizing their presentations. Be sure to go over requirements for any visual aids (such as transparencies, overhead projectors, posters, TV and VCR, etc.), use of a computer, and time limitations. You may want to give students class time to plan, implement, and finalize their presentations.

Interdisciplinary Connections

Art Students can draw a map of their chromosome on a poster and label genes that have been identified.

Social Studies Students can investigate how information generated from the Human Genome Project and resulting genetic testing might affect health insurance programs and/or job opportunities.

Math Students can include research information on the tax based funding sources for the Human Genome Project and how these moneys are being spent.

Prerequisites and Background

If Sections 1-8 have not yet been completed when this activity is assigned, students may need extra help with their research at first, but should become more independent as they go through the unit. Computer skills would be helpful.

IMPLEMENT

Consider beginning this activity early in the genetics unit, to allow students time for their research and preparation for their presentations.

Plan ahead if you wish to invite a guest speaker on genetic research, a scientist from the Human Genome Project, or a genetic counselor. (See suggestions in Advance Preparation section.)

Steps 1-2 The members of Human Genome Project are very busy, so creating a letter as a class is the best approach for contacting the project for information.

Steps 3-4 This activity is designed to be implemented using your choice of a variety of methods including computer with a search engine, Web site addresses, postal mail, telephone, and local community resources. Schedule the presentations and consider having students present to other classes, other teachers, or consider inviting guests.

ASSESS

Use the completion of the research and the project presentation to assess if students can

✓ summarize Human Genome Project information on a chromosome.

✓ plan and conduct research on a gene.

✓ prepare and present an organized and informative report on the results of their research.

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is the difference between a multiple gene disorder and a chromosomal disorder?
2. What are some risk factors for acquiring certain diseases, such as cancer or heart disease?

3. Why is genetic counseling useful?
4. What do population geneticists do?

CHAPTER 10 Genetic Engineering - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

10.1 Planning

Key Ideas

- Genetic engineering is the process by which genes can be made to produce proteins in the laboratory by using recombinant DNA procedures.
- Recombinant DNA technology places a desired gene into a bacterial plasmid, which then expresses the protein for which it codes.
- Recombinant DNA technology is used to produce many proteins, some of which safely and effectively treat human genetic diseases.
- The goals of the Human Genome Project are to map all human genes and determine the DNA sequence of all of the chromosomes of the human genome.
- The new genetic technologies have created the need for each person to learn about genetics in order to make responsible and informed decisions on how these technologies should be used by our society.

Overview

Students conclude their studies of human genetics through an exploration of the new genetic technologies, such as recombinant DNA. They describe and explain the importance of genetic engineering in producing proteins. They identify the procedures used in making recombinant DNA. Students discuss how bacterial plasmids and a bacterial host are used to produce a variety of useful and important proteins. Students consider potential problems inherent in the use of recombinant DNA technology. They then apply their knowledge of genetics to societal issues by participating in a mock senate hearing on genetic engineering. Students research different points of view on the new technologies, and present their recommendations on the future of genetic engineering.

Objectives

Students:

✓ describe and explain the importance of genetic engineering.

✓ discuss how bacteria are used in genetic research.

✓ identify and discuss the steps in making recombinant DNA.

✓ pose and answer questions about the effects of recombinant DNA on individuals in society.

✓ educate another person using a “big idea” from the genetics unit.

✓ participate in a mock Senate hearing on whether new laws are needed to regulate gene research and genetic engineering.

Vocabulary

cloning, gene mapping, genetic engineering, genome

Student Materials

Activity 9-1: Biotechnology in the U.S. Senate

- Resources about genetics, genetic diseases, biotechnology, cloning of plants, animals and humans, recombinant DNA technology, gene therapy, and ethical opinions.
- Costumes and props

Teacher Materials

Activity 9-1: Biotechnology in the U.S. Senate

- Resource
- Additional resources including current magazines and newspaper articles on biotechnology collected and organized into categories
- Costumes and props

Advance Preparation

See Activity 9-1 in the student edition

Activity 9 -1: Biotechnology in the U.S. Senate

- Have students bring in current articles from newspapers, Internet resources, and magazines, as described in the "Science in the News" assignment at the beginning of the Genetics unit. These articles provide a source of current information on the pros and cons of genetic engineering.
- Assemble folders with information pertaining to each of the roles. Gather from the "Science in the News" assignments information relating to genetics.
- Research and list possible Web sites for current information on biotechnology.

Interdisciplinary Connections

Social Studies Conduct a debate on the question, "How far should we go in biotechnology research?" Create a timeline to show the major events in genetic research over the past 50 years.

Language Arts Students write a letter to a congressional representative expressing their concerns about, or their support for the government's position on funding genetic research. Also, they write a paper on "What it means to be

human."

10.2 Using Genetic Engineering – Student Edition (Human Biology)

Draw students' attention to the key ideas by using posters or overhead transparencies.

Schedule time for preparation and presentation of *Activity 9-1: Biotechnology in the U.S. Senate.*

Review the big ideas of this section by discussing student answers to the *Review Questions.*

At the end of the section refocus students' attention on the key ideas.

Mini-Activity

Role-Play! Issues in Genetic Engineering Students in groups of five discuss the question, "Does scientific research, especially in the area of genetics, always serve the best interest of people?" Each student plays a role.

What Do You Think?'

Think of a plant or genetic condition that might be improved through DNA technology. Write a paragraph describing the improvements you would make. Also discuss some of the risks that might be involved in this genetic engineering project.

Journal Writing

You are a United States senator arguing about continued funding for the Human Genome Project. Should the project continue to receive funding? If so, should the funding be limited to certain types of research? As a government funded project, should the project be required to make all of its findings public?

Mini-Activity

Gene Information Students imagine that it is the year 2010 and the Human Genome Project has been successful. They discuss whether or not they would like to be tested to see if they have a genetic predisposition to develop cancer and what recessive alleles they are carrying.

Explaining Genetics Students choose one big idea from the unit and design an informational cartoon, poster, or story to share with someone not in their class.

10.3 Activities and Answer Keys

Activity 9-1: Biotechnology in the U.S. Senate

PLAN

Summary In this culminating activity students apply their knowledge of genetics as they participate in a mock Senate hearing. Science, politics, business, technology, journalism, and ethics all come together in this investigation. Each student assumes a role in this simulation and performs research on their point of view. After hearing from various individuals and interest groups, a senate subcommittee makes recommendations to the Senate regarding laws regulating certain aspects of biotechnology, such as government funding for biotechnology research, and for placing restrictions on types of research, etc. The committee considers recombinant DNA technology (gene splicing), gene testing, gene therapy, and cloning of plants, animals, and humans. The overriding question is "How far should we go in biotechnology research?"

Objectives

Students:

✓ perform research on the advances in biotechnology.

✓ consider ethical dilemmas of biotechnology research.

✓ participate in a mock senate hearing.

✓ evaluate and respond to the question "How far should we go in biotechnology research?"

Student Materials

- Resources on genetics, genetic diseases, biotechnology, cloning of plants, animals, and humans, recombinant DNA technology, gene therapy, and ethical opinions
- Costumes and props

Teacher Materials

- Resource
- Additional resources including current magazines and newspaper articles on biotechnology collected and organized into categories.

Advance Preparation

Assign students to bring in current articles from newspapers, Internet resources, and magazines from the "Science in the News" assignment given in the beginning of the Genetics unit. These articles and resources provide a source of current information on the pros and cons of biotechnology research.

Assemble folders with information pertaining to each of the roles gathered from the "Science in the News" assignments relating to genetics.

Research and list possible Web sites for current information on biotechnology.

Arrange the classroom so that the senators, the vice-chairperson, and the chairperson are at a long table in front of the class. Place two chairs near the long table so that they can be seen by the class members and by the senators. Place name cards on the long table for each of the senators using the students' last names, as in Senator Jones.

Place names of all the witnesses on the desks. Witnesses leave their seats when called to the witness stand and return to their seats when dismissed by the committee.

Estimated Time Two to three class periods for the role-play The time needed for the research will vary.

Interdisciplinary Connections

Social Studies Conduct a debate on the question of "How far should we go in biotechnology research?"

Create a timeline that includes the major events in genetic research over the last 50 years or since Watson and Crick.

Language Arts Write a letter to a congressional representative expressing concerns about support for the government's stand on genetic research.

Write a paper on "What it means to be human," and how this relates to cloning.

Prerequisites and Background Information

This kind of hearing has been conducted in Congress for issues involving human cloning and genetically altered plants. These issues are currently under debate within the scientific community.

IMPLEMENT

Steps 1-2 Assign student roles or have students specify their preferences for roles. One way to do this is to read over the "Description of Roles," and ask students to choose three roles that interest them. Then assign a few students to do the casting for the entire class according to student interest.

Have students begin the research at least one week ahead of the scheduled Senate hearing.

Remind students that this activity is a way for them to display all that they have learned in this unit. Encourage them to use scientific terms when appropriate to their roles.

Schedule research time in the library and the computer lab for use of current journals and magazines. The Internet is a source for the most current information, since few books are up to date.

Set up folders, each with a role name-botanist, molecular biologist, etc.-containing pertinent articles and information relevant to that role. Make these available to the students in class or in the library.

While students are engaged in the library or computer research, make a point of meeting with each student to discuss what is expected. Use the Resource as a guide, encouraging students to add their own "creativity" to their roles.

Steps 3-4 Borrow a gavel and a podium if possible for the Senate committee chairperson to use to keep order.

Instruct the senators to make up a list of the order in which to call the witnesses.

Every class member begins the hearing with notes of some Sort. Remind the chairperson to have the senators make a list of questions for the witnesses. Be sure that each witness has a senator in charge of his or her questioning.

Instruct each witness to have a resource sheet on his or her role with whatever information he or she wishes to bring to the witness stand. The journalist and the reporter will produce their products at the end of the proceedings.

Release the senators after all witnesses have been called. The senators should have the information needed to make recommendations.

Senators discuss the information presented and present their recommendations by reading them to the class. This presentation will most likely take place the next class period, since the committee needs to submit recommendations in writing signed by each member.

Helpful Hints

- Use the videos from the PBS series called *The Secret of Life.*
- The segment "The Immortal Thread" presents an overview of genetics and the role of DNA. It discusses DNA as the single thread that binds together all forms of life. The program investigates scientists' attempts to find genetic structures common to a variety of living creatures, as well as the ambitious effort to identify the function of every single human gene. The segment "Children by Design" is about gene therapy for cystic fibrosis and the "bubble boy" disease-also genetic engineering (recombinant DNA technology for human growth hormone and insulin). This video is extremely helpful in providing background material for the Senate hearing.
- *The Mouse That Laid the Golden Egg* is a video about genetic engineering.
- *DNA Is Here to Stay* and *Amazing Schemes within Your Genes* are short books, published by Cold Spring Harbor Laboratories in Cold Spring Harbor, New York.
- Students can develop their character roles by making up names, assuming the identity of their character, and by wearing costumes.
- Cut up the individual roles on a copy of the Resource so that each person has an appropriate job description.
- Keep the folders and any special resource materials in the classroom until the time of the Senate hearing so that students have available references.

ASSESS

Use the research findings of students and their presentation in the Senate hearing role-play to assess if students can

✓ conduct research on a particular point of view.

✓ present a well-organized and informative explanation of their point of view on biotechnology research, based on scientific evidence or ethical and societal concerns.

✓ evaluate and answer the question "How far should we go in biotechnology research?" in the context of the role the student plays.

Mini-Activity

Concept Map Students generate a list of 10 concepts that have been presented in the genetics unit and use a concept map to explain how they are related. You may want to review the key ideas from each section to help students start this Mini Activity. Have students present their concept maps and explanations to the class.

Journal Writing

Do you think the Human Genome Project is more likely to help or hurt humankind? Why? Defend your choice?

Review Questions/Answers

- Sample answers to these questions will be provided upon request. **Please send an email to teachers-requests@ck12.org to request sample answers.**

1. What is recombinant DNA? Why is it important?
2. Why are bacteria used in genetic research?

3. What are five necessary steps in making recombinant DNA?
4. Why is mapping human genes important to scientists' knowledge of the human genome?

Activity 9-1 Resource: Biotechnology in the U.S. Senate (Student Reproducible)

DESCRIPTION OF ROLES

Chairperson arranges the agenda and conducts the hearing, keeping order and questioning on track; keeps track of time and the order of the witnesses; ensures that the vice-chairperson and the senators have specific questions to ask the witnesses.

Vice-chairperson takes the chairperson's place in the event of his/her absence. Otherwise this person has the same responsibilities as the other senators.

Senators (3 for 4)

- are responsible for questioning the expert witnesses to get the information needed to make recommendations to the Senate.
- ensure that all witnesses are treated respectfully. This is not a trial, but a forum for their education in the field of biotechnology.

Research Scientist for the Food and Drug Administration has a high-level job in the Food and Drug Administration Lab evaluating projects within biotechnology companies. He or she:

- is responsible for the safety of products and is concerned about the health of humans, animals, and plants.
- believes science is not just about gathering information but about using it responsibly.
- believes cloning will reduce biodiversity, and thus upset the balance of nature.
- has concerns about such issues as "ordering" genetically engineered babies.

Citizen Action Group includes individuals who are concerned about:

- the social issues of cloning.
- the cloning of humans, animals, and plants.
- the loss of biodiversity.

The group opposes cloning and wants to make certain that the journalist knows their point of view.

Journalist is responsible for writing a human interest story in a newspaper or magazine covering the hearing proceedings. This article will be submitted after the recommendation of the Senate committee has been delivered to the full Senate.

Medical Doctor

- will be asked about available treatments and cures for genetic diseases.
- has opinions about the positive and negative aspects of bioengineering as they relate to medical treatment for his/her patients.
- has concerns that as we find genes for diseases such as breast cancer, Alzeimers disease, etc. we have information but not necessarily cures.
- will be asked about the confidentiality of medical records.
- has concerns about the cost of some gene therapies and their availability to lower-income citizens.

The Medical Doctor introduces the growth hormone recipient and the person with diabetes, both of whom have benefited from genetic engineering.

Growth Hormone Recipient is a 20-year-old male who has received the genetically engineered human growth hormone. He will speak of his experiences before and after treatment with the genetically engineered human growth hormone.

Diabetic who leads a normal life because of genetically engineered human insulin.

Insurance Company Executive discusses insurance coverage based on preexisting genetic conditions. This executive wants to reassure the committee that the insurance companies do not intend to use genetic testing information when deciding to insure people. Many people are afraid that this will happen.

Molecular Biologist has developed and can use cloning techniques for plants, animals, and humans. The biologist needs to explain the "how to" to senators on the basics of bio-engineering-specifically addressing cloning and gene therapy. The biologist supports genetic engineering because he or she thinks it will help to wipe out genetic diseases and that gene therapy will benefit many people.

Botanist (a scientist who investigates and works with plants) explains how genetic engineering on plants is accomplished and the benefits and drawbacks, if any. The botanist describes examples of plant products produced by genetic engineering and gives examples of safe use already in the marketplace or on the storeshelves.

Member of Congress (or member of the House of Representatives in a state such as California where hundreds of bioengineering firms are located) His or her reelection depends on keeping biotechnology business profitable, which will be good for the state economy. The member of congress supports the molecular biologist's company and its research in his/her state.

Recorder sits facing the witnesses and records the events of the proceedings with a tape recorder, video camera, written log, or word processor. A typed copy of the proceedings will be given to the Chairperson at the end of the hearing.

CHAPTER 11 Additional Resources Genetics - Teacher's Guide (Human Biology)

CHAPTER OUTLINE

11.1 Using GroupWork Activities

Learning science is a process that is both individual and social. Like researchers, engineers, mathematicians or physicians who work in teams to answer questions and to solve problems, students in science classrooms often need to interact with their peers to develop deeper knowledge of scientific concepts and ideas. The GroupWork activities were developed to foster an environment in which groups of students work cooperatively to:

- plan experiments,
- collect and review data,
- ask questions and offer solutions,
- use data to explain and justify their arguments,
- discuss ideas and negotiate conflicting interpretations,
- summarize and present findings,
- and explore the societal implications of the scientific enterprise.

The GroupWork environment is one in which students are "doing science" as a team. Suggestions about when to introduce these group activities are included in the Teacher Activity Notes.

Format and Organization of GroupWork Activities

Each GroupWork activity includes teacher activity notes, an activity guide, an individual report, resource materials, and at times, data sheets. The activity guide contains instructions for the group's task and questions to be discussed as students plan for and work on a group product. Resource materials are varied. They might include textual information, visual resources such as photos, drawings, graphs or diagrams, video, or audiotapes. Individual reports by students are an integral part of each activity to be completed in class or as part of a homework assignment. Planning information for the teacher is found on the Teacher Activity Notes page.

Sets of GroupWork activities are organized around a central concept or a basic scientific question-a "big idea." Ideally, as students rotate to complete these activities, they encounter this central idea, question, or concept in different scientific contexts or in different social settings. These rotations provide students with multiple opportunities to grapple with the material, explore related questions and dilemmas, look at different representations, and think of different applications. Figure 1 shows how students rotate from activity to activity around the "big idea."

The GroupWork activities were designed to be open-ended to foster the development of higher-order thinking skills. Such open-endedness allows students to decide as a group how to go about completing the task, as well as what the final group product might be. Open-ended group activities increase the need for interaction as students serve as resources for one another, draw upon each other's expertise and knowledge, and take advantage of their different problem-solving strategies. When groups are heterogeneous and include students with many different intellectual abilities, the repertoire of strategies and previous experiences is rich and diverse. As students interact with their peers, they learn how to communicate effectively, justify their arguments when challenged, and examine scientific problems from different perspectives. Such interaction scaffolds students' knowledge of scientific concepts and principles.

These GroupWork activities then are quite different from traditional lab activities that include more step-by-step procedures and are crowded with details. In addition to reading, writing, and computing (the traditional academic abilities), students use many different intellectual abilities to complete their task. They make observations, pose questions, plan investigations; they use and create visual models, access and interpret scientific information from different sources and from different media, and convey scientific findings in diagrams, graphs, charts, or tables. The use of a wide array of resource materials provides students with additional ways to access and use information, as well as with additional opportunities to demonstrate their intellectual competence and be recognized for their

contributions. We have included in the Teacher Activity Notes a partial list of some of the multiple abilities students might be observed using in these group activities.

When group activities are open-ended, rich, and intellectually demanding, a single student will not be able to complete the task in a timely fashion by himself or herself. Making students responsible as a group to interpret a challenging task and to design a common product or group presentation increases group interdependence. Teachers know, however, that it is also important to hold each student personally accountable for contributing to the group's success and for mastering the concepts or the big idea of the activity. To do so, students are required to complete individual written reports in which they respond in their own words to key discussion questions and summarize what they have learned in the group activity. These written responses can be useful for teachers in gauging and monitoring student knowledge and progress.

Role of the Teacher Planning ahead and organizing the classroom for GroupWork is important for the successful implementation of group activities. We suggest that you refer to Elizabeth Cohen's book, *Designing Group Work: Strategies for Heterogeneous Classrooms,* published by Teachers College Press in 1994. (See also Lotan, R.A., J.A. Bianchini, and N. C. Holthuis (1996). "Complex Instruction in the Science Classroom: The Human Biology Curriculum in Action," in R.J. Stahl, (Ed.) *Cooperative Learning in Science. A Handbook for Teachers*, Addison-Wesley Publishing Company.)

Many teachers have realized that when students work in groups, direct instruction is no longer practical. The teacher can't be everywhere at once, telling students exactly what GroupWork to do and how to do it. Thus, teachers delegate authority to students and students take responsibility for their own behavior and their own learning. Rather than constantly turning to the teacher for help, students talk with each other to find out what they should be doing and to solve the challenging problems assigned to them. Teaching students to work collaboratively and to be responsible to one another as a group is an important prerequisite for successful GroupWork. Students also support the smooth ope ration of groups when they have learned to play different roles in their groups effectively. For example, the facilitator sees to it that everyone in the group knows what has to be done and gets help when necessary. The recorder keeps notes of the group's discussions and checks to see if individual reports have been completed. The materials manager sees to it that the group has all the equipment necessary and that the tables are cleared at the end of the lesson. The reporter presents the findings of the group during wrap-up time. When the activity involves hazardous materials, a safety officer might be needed. Every student must have a role to play, and roles rotate so students learn how to perform each role competently.

Delegating authority doesn't mean that the teach er withdraws from the class or completely stays out of the action. Instead of being the focal point of the classroom, the teacher carefully observes the students as they work in the groups, stimulates and extends their thinking, and provides specific feedback.

Equalizing Participation among Members of the Group Making sure that all members of the group have access to the materials and that one group member doesn't take over or dominate the group while another withdraws are among the principal challenges of GroupWork. Teachers can increase participation of students by explaining how the different intellectual abilities are relevant to the successful completion of the task. The teacher states that while no one group member has all the abilities, everyone in the group has some of the intellectual abilities necessary to complete the task successfully. Furthermore, after careful observation of the students' work in groups, the teacher can publicly acknowledge those students who have made relevant contributions and explain specifically how these contributions made the group move forward and become more successful. It is important that the teacher be able to notice the intellectual contributions of students who have low academic or peer status, and who are frequently left out of group interactions. These strategies are particularly relevant in untracked classrooms, where students have a wide range of previous academic achievement (mainly in reading) or where significant proportions of students are English-language learners. Teachers, classmates, and the low-status students themselves need to understand that when many different intellectual abilities are necessary to complete a task successfully, everybody's contribution becomes critical to the success of the group. As more previously low-achieving students feel and are expected to be competent, their participation in the group increases, and subsequently their learning achievements increase as well.

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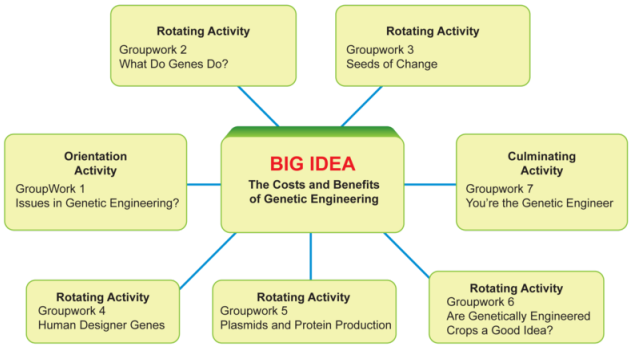


Figure 1: Activity Rotation in GroupWork.

TABLE 11.1:

Activity	Duration	Materials	Activity Summary
1. Orientation Activity: Issues in Genetic Engineering	40 minutes	Newspaper and/or magazine articles on topics in genetic engineering.	Students bring in current articles on genetic engineering. In groups, they discuss their articles and present a convincing argument for using genetic engineering to the class.
2.What Do Genes Do?	40 minutes	Supplies such as gum drops, jelly beans, gummy bears, egg cartons, or cotton balls to create nucleotides and amino acids ; cardboard; poster paper; markers	Students compare the structure and function of genes to the Morse code. They create a poster to explain how genes work.
3. Seeds of Change	45 minutes	Will vary Have on hand a selection props, costumes, and art supplies.	Students study the genetic engineering of apples and apply the information to teach the class how genes are implanted in plants.
4. Human Designer	45 minutes	Videotape, VCR, and TV; pasta noodles; poster board or butcher paper,paints or pens, and glue	A videotape provides students with Genes information ab out splicing genes into animal cells. Students create a model of the process.
5. Plasmids and Protein Production	40 minutes	2 plastic test tubes with caps; labels; masking tape; marker; scissors; red yarn,pink yarn, and yellow yarn	Students use yarn and scissors to model a genetic engineering process, inserting a human gene into a plasmid. They are asked to consider the possible costs and benefits of this procedure.

TABLE 11.1: (continued)

Activity	Duration	Materials	Activity Summary
6. Are Genetically Engineered Crops a Good Idea?	45 minutes	None	Students debate the costs and benefits of genetically engineered foods. They are asked to ret1ect on their own decision-making processes.
7. Culminating Activity: You're the Genetic Engineer	50 minutes	Will vary	Students are given a genetic engineering assignment. Using information from previous activities, they decide how to accomplish their task, and debate the costs and benefits of their projects.

Groupwork 1: Teacher Activity Notes

Orientation-Issues in Genetic Engineering

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students bring in current articles on genetic engineering. In groups, they discuss their articles and present a convincing argument for using genetic engineering to the class.

Group Size 4 to 5 students

Objectives

Students:

- define genetic engineering.
- describe ethical and moral issues related to genetic engineering.
- explain strategies for presenting the use of genetic engineering to the general public.

Multiple Abilities

- Analyzing an issue, logically identifying the possible problems, making connections between ideas and concepts (reasoning ability)
- Interpreting information provided in an article (conventional academic ability)
- Explaining clearly and fully, using words precisely (communication skills)

Student Materials

- Activity Guide
- Individual Report
- Newspaper or magazine articles on the topic of genetic engineering

Estimated Time 40 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Ask students to read the section in the text on genetic engineering before beginning these activities.
2. Before or after the group presentations, discuss with students the topic of genetic engineering.You may wish to first ask students what engineers do. They design, build, manipulate, and create such things as bridges, buildings, roads, and machines. Likewise, genetic engineers design, build, manipulate, and create genetic material in plants, animals, and bacteria. In the discussion, broach the idea that genetic engineering has advantages and disadvantages as well as involves ethical and moral questions. For example, if we can alter our genetic code, who decides what gene types are preferable? Are blue eyes better than brown? Is brown skin better than white? Is assertiveness a good trait or a bad one?

Extension Questions

- What article did you choose? Why?
- What do the topics covered in each article have in common?
- How does the media treat the topic of genetic engineering? Can you tell if the author(s) is for or against the particular type of genetic engineering described in the article?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- identify the kinds of scientific projects and experiments considered to be within the realm of genetic engineering.
- describe the possible ethical and moral issues that can arise from these technologies.
- explain the various ways the media presents these issues.

Groupwork 1 : Activity Guide (Student Reproducible)

Orientation-Issues in Genetic Engineering

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Dee Ann A.Splicem is the president of the company Genes-R-Us. She has recently announced that she wishes to increase profits by starting some projects on the cutting edge of genetic engineering but is concerned with public opinion about the moral and ethical issues involved. The company has hired your group as consultants.

Materials

- Individual Report
- Newspaper or magazine articles on the topic of genetic engineering

Procedure

1. Dr. Splicem has requested a report on the current trends and projects in genetic engineering. To get an idea of the range of topics and issues in this area, present your article to the rest of the group. Summarize it and give your opinion of the risks and benefits involved in this research.

2. After reviewing each group member's article, select the article (pick only one) that your group agrees should be reviewed by Genes-R-Us.

- Discuss the moral and ethical issues that may arise as a result of this research.
- Discuss and decide which research area described in the article "Genes -R-Us" should be pursued. Everyone should agree with the decision.

3. Create a presentation for Dr. Splicem that includes:

- a summary of the article.
- any moral or ethical issues that may arise as a result of this research.
- reasons why Dr.Splicem's company should do research in the area you've described.
- strategies for convincing the general public to support the research at "Genes-R-Us."

Groupwork 1: Individual Report (Student Reproducible)

Orientation-Issues in Genetic Engineering

Big Idea: TheCosts and Benefits of Genetic Engineering

1. Based on what you read in the articles, what is genetic engineering?

2. Why do you think Genes-R-Us should or should not begin work on the genetic engineering project described in your article?

3. what moral or ethical issues are involved in the research you described?

Groupwork 2: Teacher Activity Notes - What Do Genes Do?

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students compare how information is stored in genes with how it is stored in the Morse code. They create a poster to explain how genes work.

Group Size 4 to 5 students

Objectives

Students:

- identify the structure and function of genes.
- explain how changes in the nucleotide sequence of a gene affects the structure and function of the protein it codes for.

Multiple Abilities

- Making connections between ideas/concepts (reasoning ability)

- Conceiving of an idea for an illustration, creating a visually attractive poster which conveys information through its picture(s) (artistic/creative ability)
- Explaining clearly and fully, using words precisely (communication skills)

Student Materials

- Activity Guide
- Resource
- Individual Report
- Poster paper; colored pens or crayons; other art supplies

Estimated Time 40 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Students need to be familiar with reading and using Morse code before beginning this activity.
2. We suggest assigning each group a different Morse code message, a or b in Table 2 of the Resource. The messages in the Morse codes in Table 2 of the Resource read:
   (a) Storm ahead. Set course due north.
   (b) Storm overhead. Set course due south.
3. This activity is not intended to teach students all about the specifics of how genes code for proteins; students should have gained such knowledge already from the text, labs, or other activities. Rather, they should gain more in depth knowledge that a) genes code for proteins, and b) by changing the code slightly (e.g., a mutation), a different protein results.

Background Information

The Morse code is a process for sending and receiving messages. Short dot and long dash signals are used to represent letters, numerals, and punctuation marks. The code was developed around 1840 by Samuel F. B. Morse and his assistant, Alfred Vail, for communication by electric telegraph. Today, it is used for radio telegraphy for ships at sea, for amateur radio telegraphy, for mobile radio operations, and for visual signaling by blinker light. However, Morse code is being supplanted at sea by long range voice communications via satellite.

Extension Questions

- What are the benefits of using an analogy to Morse code to explain how information is stored in genes? The limitations?
- What other examples from everyday life could be used to model how genes work?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- explain the structure and function of genes.
- explain how a slight change in the nucleotide sequence of a gene affects the structure and function of the protein it codes for.
- compare and contrast how information is stored in genes with how it is stored in the Morse code.

Groupwork 2: Activity Guide - What Do Genes Do? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Why do genetic engineers alter the genes in certain microorganisms, animals, and plants? In order to answer this question, we first need to learn about the structure, function, and products of genes. The purpose of this activity, then, is to take a look at what genes are and how they work.

Materials

Poster paper, colored pens or crayons, other art supplies

Procedure

1. Complete the Table 1 on the Resource in order to answer the following questions about the Morse code and genes:

- How is information stored in a string of Morse code? How is it stored in a gene?
- What is the function of the Morse code? What is the function of a gene?
- What happens when a string of the Morse code is changed? When a gene is changed? How do you know?

2. Translate the sample Morse code messages on the Resource, then answer the following questions.

- How could a change in one DNA nucleotide affect a protein?
- How does this compare to your Morse code sentence?
- What are the benefits of using Morse code to explain how information is stored in genes? What are the limitations?

3. Create a presentation using a Morse code message you've written to explain to your class what happens to a protein when there is a mutation (change) in the DNA code for the gene.

Groupwork 2: Resource - What Do Genes Do? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

TABLE 11.2: Table 1

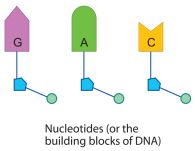
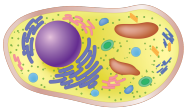
	Genetic Code	Morse Code
Information is first stored as:	 Nucleotides (or the building blocks of DNA)	●−−●●●−−●● ●−●●●−●●
The information is then translated into:	 Amino acids in a protein	"WE WILL ARRIVE...."

TABLE 11.2: (continued)

Genetic Code	Morse Code

The result of this process:



a. To better understand how Morse code (and genes) work, translate the following string of code. Use Table 2 to help in the translation.

●●●– – – –●–●– –●–●●●● ● ●– –●● ●–●–●–
●●● ●– – ●–●– – – –●●–●–● ●●● ●–●● ●●–●
–●– – –●–●–●●●●–●–●–

_____

_____

_____

b. What hap pens when clots and clashes in the string of Morse code (gene) are changed? Translate the revised string of code.

●●● – – – –●–●– – – – – –●●●– ● ●–● ●●●● ● ●– –●●
●–●–●– ●●●
● – –●–●– – – –●●–●–● ●●●●
–●● ●●–● ●●●– – – –●●– –●●●● ●–●–●–

TABLE 11.3: International Morse Code

A ●–	O – – –
B –●●●	P ●– –●
C –●–●	Q – –●–
D –●●	R ●–●
E ●	S ●●●
F ●●–●	T –
G – –●	U ●●–
H ●●●●	V ●●●–
I ●●	W ●– –
J ●– – –	X –●●–
K –●–	Y –●– –
L ●–●●	Z – –●●
M – –	Period ●–●–●–
N –●	

Groupwork 2: Individual Report - What Do Genes Do? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

1. What was the Morse code message in Table 2, a? The revised message in Table 2, b? How would these different messages change what sailors did on a ship?

2. How is the information stored in a gene similar to and different from the information stored in a Morse code?

3. What happens when the gene code changes slightly? How does a change, called a mutation, affect the protein product?

Groupwork 3: Teacher Activity Notes - Seeds of Change

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students study the genetic engineering of apples. They then apply the information to create a simulation teaching the class how genes are implanted in plants.

Group Size 4 to 5 students

Objectives

Students:

- explain why genetic engineers might want to alter the genes of plants.
- discuss the advantages and disadvantages of genetically altering plants.

Multiple Abilities

- Conceiving of an idea for a simulation, generating alternatives, using props, directing the simulation (artistic/creative ability)
- Analyzing an issue, identifying problems and benefits, making connections between ideas and concepts (reasoning ability)
- Interpreting information provided in pictures (visual/spatial ability)

Student Materials

- Activity Guide
- Individual Report
- Resource
- Art supplies such as butcher paper, colored pens, crayons; props and costumes

Estimated Time 45 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

Students may need assistance in brainstorming traits that could be improved in plants. Some possible traits are

- genetic resistance to fungus.
- genetic resistance to insect pests.
- drought resistance.
- frost resistance.
- more seeds per stock.
- more accessible fruits to harvesting machines.
- more durability during harvesting and transport.

Extend This Activity

- Take a field trip to a laboratory or company where they are creating genetically engineered plants.

Extension Questions

- What difficulties may arise when "western scientists" attempt to genetically alter the staple crops of a third world country?
- Why do people fear that the continued genetic engineering of plants will reduce the genetic

diversity of species?

ASSESS

Use the group presentation, individual report, and group discussion to assess whether students can

- identify and explain why genetic engineers might want to alter the genes of a plant.
- discuss the advantages and disadvantages of genetically altering plants.

Groupwork 3: Activity Guide - Seeds of Change (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Genetic engineers usually work with the genes of one of the following three organisms: bacteria, animals, and plants. Your group is the Research and Development team for Super Crops seed company. Your company already has produced a cotton plant that produces larger tufts of cotton per stalk than the original plant did. You need to genetically engineer a new crop plant variety that farmers will buy and plant over large areas of land.

Materials

- Activity Guide
- Individual Report
- Resource
- Art supplies such as butcher paper, colored pens, crayons

Procedure

1. In your group, decide which major crop plant to focus on: corn, wheat, or rice. Brainstorm and list all the possible problems you imagine a farmer could have in trying to grow and harvest that plant.

2. Examine the Resource showing examples of various plants both before and after they have been genetically engineered. Using your list of problems from Procedure 1, construct a table that presents what traits a genetically engineered plant would have that could solve each of these problems. Remember that genetic engineering combines one or more of the existing traits in various plants.

3. Using your table of traits, design a "super crop plant" that you could engineer using existing traits. Create an advertisement poster for your new and improved crop plant. Make sure you include:

- a diagram of the plant labeling all the new traits.
- an explanation of why these traits will help farmers grow more product.
- an explanation of the advantages and disadvantages of genetically altering this plant.

Groupwork 3: Individual Report - Seeds of Change (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

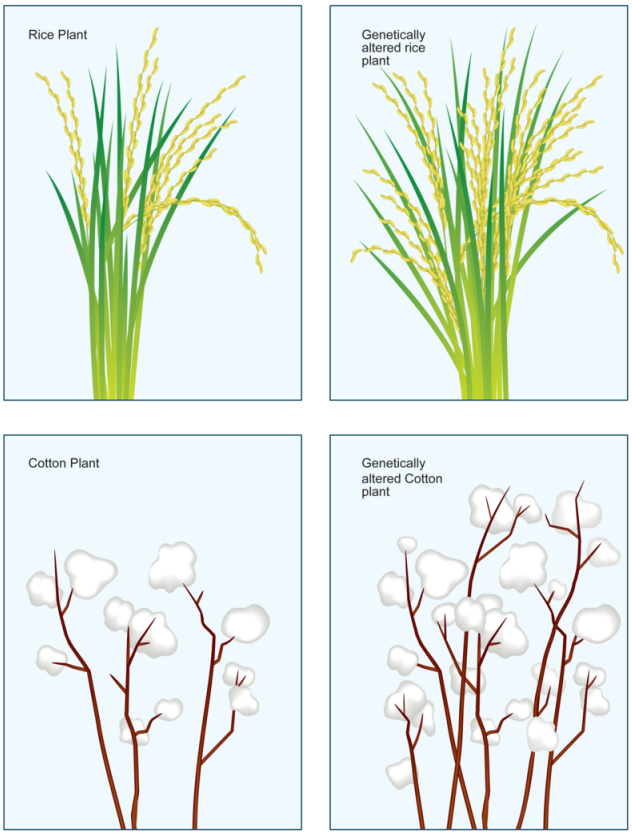
1. What traits might people want to introduce into plants ? Why?

2. What problems may arise when scientists try to splice new genes into the genetic material of plants? Provide at least three.

3. Do you think genetically engineered plants are a good idea? Why or why not?

Groupwork 3: Resource - Seeds of Change (Student Reproducible)

Big Idea: The Costs and Benefits 01 Genetic Engineering



Groupwork 4: Teacher Activity Notes - Human Designer Genes

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary A videotape provides students with information about splicing genes into animals (specifically humans). Students create a model of the process using art supplies.

Group Size 4 to 5 students

Objectives

Students:

- explain why genetic engineers might want to alter the genes of humans.
- discuss the advantages and disadvantages of genetically altering human genes.

Multiple Abilities

- Drawing an idea, creating a model, interpreting information provided in a video, creating a 3-dimensional object from 2-dimensional pictures (spatial/visual ability)
- Conceiving of an idea for a diagram, generating alternatives (artistic/creative ability)
- Putting yourself in someone else's shoes, learning how someone feels even though his or her situation is different from your own (interpersonal skills)

Student Materials

- Activity Guide
- Individual Report
- Videotape, VCR, and TV
- Dried pasta noodles; poster board or butcher paper; paints or pens; and glue

Estimated Time 45 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

Locate a videotape that describes how genetic engineering is being used to find a cure for hemophilia. (You may decide to use a video that describes a different but related subject.) The video can be very brief: 3-5 minutes should be sufficient.

Background Information

Research is being conducted today to find improved treatments for patients suffering from hemophilia. The video describes one such treatment that has only been tested on mice. The experimentation involves using retroviruses. The retroviruses have their harmful genes removed and replaced with the corrective gene for tone type of hemophilia. The modified retroviruses with transformed DNA (containing the corrective gene) infect cells that were being cultured. The infected cells are grown into a skin graft. This skin graft in mice produces and secretes the blood protein (Factor

8) that some hemophiliacs lack. The hope is that the skin graft will work in hemophilic patients just like in mice. If so, it will provide hemophilic patients with life-long treatment.

Extension Questions

- What characteristics of your audience should you consider as you plan your lesson?
- What if a piece of DNA from an extinct animal, like a dinosaur or plant could be spliced into a living organism? What are the possible outcomes? What are the costs and benefits to doing this?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- describe the process geneticists use to alter the genes of people.
- explain why genetic engineers might want to alter the genes of a people.
- discuss the advantages and disadvantages of genetically altering human genes.

Groupwork 4: Activity Guide - Human Designer Genes (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Genetic engineers usually work with the genes of one of the following three organisms-bacteria, animals (such as humans), and plants. In this activity you explore how and why the genes of *animals* are changed.

Materials

- Individual Report
- Videotape, VCR, and TV
- Dried pasta noodles; poster board or butcher paper; paints or pens; and glue

Procedure

1. As a group, watch the videotape provided. Discuss the main points of the video. Then, outline or draw the steps needed to change the genetic material of an animal cell.

2. Your task is to teach the class how and why the genes of humans are changed. Using the materials provided, create a display that shows the steps that occur when a gene is spliced into human DNA. Your presentation should answer the following questions:

- Why would we want to genetically engineer human cells?
- What diseases or disorders can be cured using this technology?
- What problems may arise from this technology?

Groupwork 4: Individual Report - Human Designer Genes (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

1. Explain with words and/or a drawing how the genes of a human can be changed.

2. What are the benefits of using genetic engineering to alter the genes of a human? What problems may arise from this technology?

3. If a friend could be cured of her or his genetic disease (cystic fibrosis, muscular dystrophy, or hemophilia) through gene therapy, would you urge her or him to undergo the treatment? Explain.

Groupwork 5: Teacher Activity Notes - Plasmids and Protein Production

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students use yarn and scissors to model a genetic engineering process, inserting a human gene into a plasmid. They are asked to consider the possible costs and benefits of this procedure.

Group Size 4 to 5 students

Objectives

Students:

- explain why genetic engineers might want to alter the genes of bacteria.
- discuss the advantages and disadvantages of genetically altering bacteria genes.

Multiple Abilities

- Making connections between ideas/concepts (reasoning ability)
- Building a three-dimensional model from a two-dimensional diagram (spatial-visual ability)

Student Materials

- Activity Guide
- Resources 1 and 2
- Individual Report
- 2 plastic test tubes with caps; labels; masking tape; marker; scissors; red yarn, pink yarn, and yellow yarn

Estimated Time 40 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. For each group, create the following.

- Make two circles of red yarn (bacterial chromosomes) by tying the ends together.
- Make one small circle of pink yarn (plasmid).
- Label a plastic test tube Bacterium # 1. Inside this test tube, place a large circle of red yarn (bacterial chromosome) and a small circle of pink yarn (plasmid). Students should extract from Bacterium #1 the plasmid to be used in the recombinant process.
- Label a second test tube Bacterium #2. Inside this test tube, place a large circle of red yarn (bacterial chromosome). Students should insert the recombinant plasmid into this bacterium.
- Cut a piece of yellow yarn (piece of human DNA). Label a section of the yarn Gene for Human Insulin. On either side of this label make a black dot (sites where restriction enzyme will cut DNA).

2. In trying to make their recombinant plasmids, students should approximately follow these steps:

- Extract plasmid from Bacterium #1.
- Cut plasmid at one site with enzyme I, or restriction enzyme (scissors). Cut piece of human DNA at both ends of human gene for insulin (at black dots).
- Insert human gene into plasmid. Use DNA ligase or enzyme II (tape) to keep human gene in place.
- Insert recombinant plasmid into Bacterium #2.

3. You may need to introduce students to some of the genetic engineering vocabulary before this activity (e.g., plasmid, bacterial chromosome, restriction enzymes).

Background Information

- In bacteria, the genes found on chromosomes differ from animal chromosomes in that they lack the surrounding proteins (thus, bacterial chromosomes are sometimes referred to as "naked" DNA).
- In addition to the chromosomal material, a bacterial cell may contain one or more plasmids. A plasmid is a circular, extrachromosomal DNA molecule that is capable of replicating autonomously within bacterial cells. Plasmids are commonly used in genetic engineering because they can be manipulated (new genetic material can be added, such as genes making the bacterial resistant to antibiotics) and because the bacterial cell can make many copies.
- A restriction enzyme is an enzyme that will cut a plasmid in a very specific spot so that new DNA can be inserted.

Extension Questions

- How are a plasmid and chromosome different? Do humans have plasmids?
- Why must the human gene be inserted into the plasmid? Why can't the human gene be inserted directly into the bacterium?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- describe the process geneticists use to insert a human gene into bacterial plasmid DNA.
- explain the purpose of inserting a human gene into bacteria.
- discuss the advantages and disadvantages of inserting human genes into bacteria.

Groupwork 5: Activity Guide - Plasmids and Protein Production (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Genetic engineers sometimes use bacteria to produce large amounts of a particular protein. In the case of human insulin, for example, engineers insert the gene for insulin into the DNA of bacterial cell. The bacterial cell then produces large amounts of insulin that can be used safely and cheaply for people with diabetes. In this activity, you act as genetic engineers. You use yarn, test tubes, scissors, and tape to model how bacteria are genetically engineered to produce insulin.

Materials

- Resources 1 and 2
- Individual Report
- 2 plastic test tubes with caps; labels; masking tape; marker; scissors; red yarn, pink yarn, and yellow yarn

Procedure

1. As a team, discuss the "Model of Genetic Engineering" resource card. It describes those parts needed to create a bacterium that produces the human protein insulin.

2. Create a model of a bacterium with the ability to produce the human protein insulin. Use the Resources and carefully record the steps that your team takes.

3. Discuss the following questions:

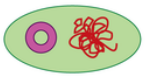
- How is the human gene for insulin inserted into the plasmid of a bacterium?
- What do genetic engineers do once they have bacteria with the desired gene?
- Why insert a human gene for insulin into a bacterium? What are the possible benefits and/or risks?
- Do you think scientists should use bacteria in genetic engineering? Mice? Monkeys? Humans? Where and how should scientists draw the line?

4. Prepare your presentation. Describe the process your team used to create bacteria with the information to produce human insulin. Include the costs and benefits of this genetic technology.

Groupwork 5: Resource 1 - Plasmids and Protein Production (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

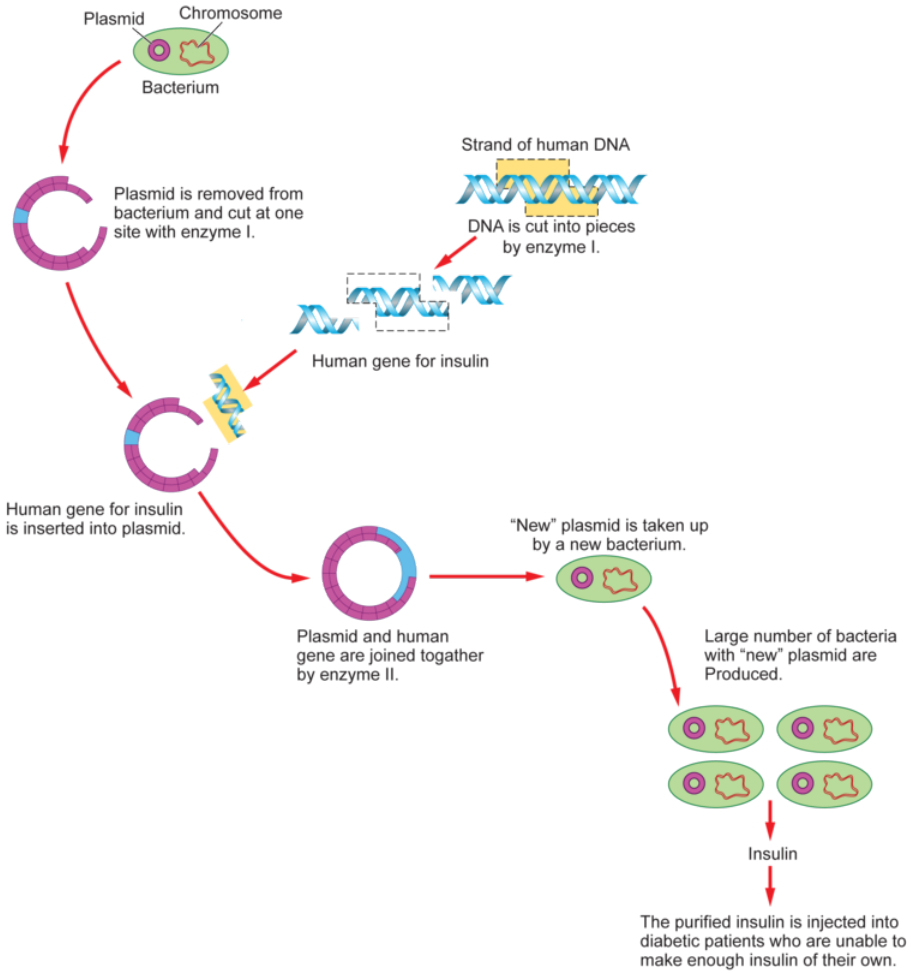
Model of Genetic Engineering

Cell and cell parts		Tube-and-yam model
 Bacterium	is represented by →	 Plastic test tube and cap
 Bacterial chromosome (DNA)	is represented by →	 Circle of red yarn
 Bacterial plasmid (DNA)	is represented by →	 Small circle of pink yarn
 Piece of human DNA	is represented by →	 Piece of yellow yarn
 Gene for insulin Human gene for insulin	is represented by →	 Yellow yarn between the two black dots
	is represented by →	 Scissors
	is represented by →	 Tape

Groupwork 5: Resource 2 - Plasmids and Protein Production (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

11.1. USING GROUPWORK ACTIVITIES



Groupwork 5: Individual Report - Plasmids and Protein Production (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

1. How is a human gene inserted into a bacterium? Explain using words and a diagram.

2. Why insert a human gene into a bacterium? What are the benefits? The costs?

3. Do you think scientists should use bacteria in genetic engineering? Mice? Monkeys? Humans? Where should scientists draw the line? Explain.

Groupwork 6: Teacher Activity Notes - Are Genetically Engineered Crops a Good Idea?

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students debate the costs and benefits of genetically engineered foods. They are asked to reflect on their own decision-making process.

Group Size 4 to 5 students

Objectives

Students:

- determine and present reasons for and against the genetic engineering of foods.
- explain their own opinion about genetic engineering.

Multiple Abilities

- Reading and interpreting source material (traditional academic ability)
- Explaining clearly and fully, being verbally persuasive (communication skills)

Student Materials

- Activity Guide
- Resource-Teams 1, 2, 3, and 4
- Individual Report

Estimated Time 45 minutes

Suggested Use

- This set of activities works well near the end of the unit.

Implement

1. If students have little debate experience, discuss how to conduct a debate before introducing this activity. Emphasize the importance of incorporating scientific information, supporting statements with evidence, and listening carefully to the opposing position.
2. Depending on student's reading abilities, you may want to assign the Resources as homework the day before the activity.
3. After the activity, encourage students to further reflect on their decision-making process. Point out that scientific information alone cannot resolve complex issues related to biotechnology-that people's values and goals also play a part.
4. Feel free to create new Resources on other biotechnology issues.
5. This activity requires students to work in groups of 4 so that they can divide into 2 equal teams.

Background Information

- The quotes and examples used in the four debate articles are real. They were pulled from the following articles :

Alex Barnum, "Brave New Foods," *San Francisco Chronicle* (1992): BI-B6.

Alex Barnum, "What Bioengineers Have in Store for Food Crops, " *San Francisco Chronicle* (1992): B6.

Tom Dworetzky, "Hi-tech Farming: How're You Gonna Keep 'Em Down on the Farm once They've Had *E. Coli?"* *Omni* (1993): 15 (4), 8.

Sibella Kraus, "Brave New Vegetables," *San Francisco Chronicle* (1992).

Linda Marsa, "Food Fight: Burger Deluxe, Hold the Biotech," *Omni* (1993): 15 (8), 18.

Susan Katz Miller, "Activists Join Forces Against Animal Patents," *New Scientists* (1993): 137 (1860),8.

Gail Vines, "Guess What's Coming to Dinner?" *New Scientist* (1992): 136 (1847), 13-14.

Extension Questions

- Does science and science alone hold the answer to the question: Should genetically engineered foods be sold? Explain.
- What have you learned from this activity about the interaction of science, technology, and society?
- Would studying basic genetics help a person to learn more about this biotechnology issue? Explain.

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can:

- determine and present reasons for and against the genetic engineering of foods.
- explain their own opinion about genetic engineering.

Groupwork 6: Activity Guide - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

The biotechnology firm, GenGrow, wishes to market a "new and improved" tomato. The GenGrow tomato contains an antifreeze gene taken from a fish, the Arctic flounder. This gene makes the tomato hold up better when frozen and thawed. Should genetically altered foods, like the GenGrow tomato, be sold in supermarkets? In this activity, you debate this question.

Materials

- Resource-Team 1, 2, 3, or 4
- Individual Report

Procedure

1. Divide the group into two teams of equal size. Debate Team 1 argues *in favor* of producing and selling genetically engineered foods. Debate Team 2 argues *against* the production of such foods.

2. Prepare to debate. With your partner, read the appropriate resource materials. Decide how to present your position.

3. Stage a short debate. Team 1 should explain its position to Team 2 for 5 minutes. Team 2 may then ask questions for 2 minutes. The two teams should then switch roles. Team 2 should explain its position, and Team 1 ask questions.

4. You now know more about both sides of this complex issue. As one group, arrive at an answer to the following question. Should genetically altered foods be sold?

5. For your presentation, describe the process your team went through to decide if genetically altered foods should be sold. Use the following questions as a guide:

- How did your group reach this decision? What kinds of information did you use?
- How did a group member convince others to change their minds?
- How could your team's decision-making process be improved?
- How should society go about trying to answer similar questions about genetic engineering? Should your decision-making process serve as a model?

Groupwork 6: Resource-Team 1 - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Biotechnology: A Better Way to Breed

Imagine red tomatoes that stay firm and full of flavor for weeks, corn that seems fresh-picked days later, coffee plants that produce naturally decaffeinated beans, tiny vegetables sold as snacks, melons that need no pesticides, and grains that make their own fertilizer. Are such foods possible?

According to genetic engineers, these and many other foods will soon be available to the average consumer. Biotechnology, they explain, is a new and powerful tool for improving the production, quality, and quantity of foods.

"In many ways, biotech is part of the continuum of plant [and animal] breeding that started at the dawn of agriculture with plant selection," says Dina St. Clair, plant geneticist at the University of California at Davis. Early farmers paired only the best male and female animals and planted seeds from only the best plants in order to get the most genetically strong offspring. "Hybridization, or cross-breeding of plants, which started having a commercial impact in the 1930s, was the next step."

Biotechnology, supporters continue, is more effective than traditional breeding practices in three important ways. First, genetic engineering makes the breeding process more specific and precise. Second, it makes things happen a lot faster. In traditional breeding, for example, it takes many generations to establish a new trait in a plant or animal. But in bioengineering, as long as a single gene controls the trait, the process takes only one generation. Third, genetic engineers can cross genes between organisms that could never mate in nature. They can, for example, insert a gene from a tobacco plant into the cells of a sheep.

Jerry Caulfield, president and CEO of the biotechnology company Mycogen, tries to reassure consumers about biotech plants and animals. He explains that, years ago, people became very upset when Luther Burbank began crossing fruit trees to develop new varieties. Today, these varieties of fruit, like the Santa Rosa plum, are very popular. He continues, "The public is always critical and afraid of change. We need to evaluate risk by separating the probable from the possible." The public needs to understand the benefits and risks of biotech foods so that they can make informed decisions.

The federal government has already begun to see the advantages of using biotechnology to breed plants and animals. In 1992, the Food and Drug Administration (FDA) announced that bioengineered foods would be treated like any other food. They could be shipped and sold without regulations or labeling requirements.

Groupwork 6: Resource-Team 2 - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

A Bright Future for Genetically Engineered Foods

Bioengineered foods will soon be found on your local grocery store shelves. Supporters-biotechnology companies, academic researchers, and members of the Food and Drug Administration (FDA)-are excited. They claim that such foods hold great promise for farmers, the public, and the environment alike.

The first step toward these brave new foods was taken in 1987. That year, Calgene became the first biotechnology company to receive a USDA permit to field test a genetically engineered crop. By 1992, the USDA had granted over 340 such permits. Today, biotech companies are busy creating a less expensive form of vanilla, potatoes that do not bruise easily, sheep that produce more wool, and peaches that resist frost. These companies are scrambling to get their products to market.

According to supporters, bioengineering can benefit the public by producing better tasting foods. Calgene's Flavr Savr® tomato is just one example. Usually tomatoes are picked and shipped to warehouses while they are still green and hard to bruise. Processors then spray the tomatoes with a chemical to begin the ripening process. As a result, the tomatoes ripen from the outside in rather than the inside out. They are often tough and tasteless. In contrast, the Flavr Savr® tomato has been genetically altered to spoil less quickly. It can be ripened naturally on the vine and still not turn mushy when shipped. It tastes close to home-grown.

Bioengineered crops can also help save the environment. Many bioengineered foods are being changed to resist pests (to not need pesticides), to produce their own fertilizer, and/or to better survive processing. These bioengineered crops will help preserve and protect the environment by allowing farmers to use fewer, less harmful chemicals.

Finally, bioengineering can benefit farmers and food processors. Bioengineered foods will reduce their costs and offer them greater flexibility in managing businesses. For example, Australian researchers are working to create sheep that produce more wool. They hope that these woolier sheep will allow farmers to make the same profit with half as many animals.

However, supporters of biotechnology worry that the public will not welcome bioengineered foods, that many people understand little about genetic engineering. Most of today's consumers, for example, graduated before splicing a gene was taught in high school biology. In addition, a national survey completed in 1992 for the Agriculture Department found the public had "a very low level of awareness and understanding" of biotechnology. Sixty-four percent of the 1,228 households surveyed said that they supported the use of biotechnology in food production. Twenty-nine percent said that they were opposed. Answers depended on education and income: people with more education and higher incomes approved of genetic engineering more often.

The 1990s may very well be the decade of bioengineered foods. To a large extent, the fate of these foods will depend on the public. Will people buy biotech goods? In a way, consumers will answer this question by putting their money where their mouths are.

Groupwork 6: Resource-Team 3 - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Chefs Toss Biotech Foods in Trash

These days, opponents of biotechnology are not taking news of genetically altered foods sitting down. Many are actively protesting their development and marketing.

"Who needs to grow tomatoes in Antarctica?" one chef asks. "Aren't scientists trying to fix a problem that does not exist? Genetically engineered foods will not benefit farmers or the American public. They will only increase the profits of biotech companies."

It appears many other top chefs agree. Over 2,000 have banned together as part of a "Pure Food Campaign." These chefs have agreed to display the campaign's logo (see picture to right) on their menus. They have also agreed to push the U.S. Food and Drug Administration (FDA) to rethink its decision not to test or label biotech fruits and vegetables.

These chefs decided to take action for four reasons. First, they want to know exactly what is in the food they buy and exactly what the consequences of these foods are. They feel responsible for what they serve their customers.

Second, these chefs worry about getting sued. "If food producers are so proud of these Brave New World products, why are they so afraid to label them?" demands Jeremy Ripkin, a biotech opponent. Suppose, he continues, a chef unknowingly serves rice with a peanut gene in it. If a customer has an allergic reaction to the peanut, the restaurant could be held responsible. The restaurant could be sued even though it knew nothing about the peanut gene. That's not fair.

Third, biotech foods raise religious concerns. Suppose a strict vegetarian, Orthodox Jew, Muslim, or Buddhist is served a vegetable implanted with an animal gene. Is the vegetable no longer a vegetable? Can the customer refuse the meal?

Finally, many chefs think genetically engineered foods are not needed in restaurants. Catherine Brandel, chef at Chez Panisse in Berkeley, explains. "This type of food has nothing to do with us. Why would we want shelf-life and season extenders, when we can buy fresh produce and meats from local growers every day?"

Groupwork 4: Resource-Team 4 - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Has Science Run Amok?

Is biotechnology just another example of science run amok? So-called scientific progress has already created such global problems as nuclear arms, environmental pollution, and species extinction. The world can scarcely stand another of science's mistakes.

Some consumer groups, environmental activists, religious groups, small farmers, and animal rights groups have decided that using biotechnology to change plants and animals is too risky. They have banded together to oppose genetically engineered foods.

What possible problems could biotech foods pose? First, opponents explain, bioengineered foods may cause environmental disaster. Genetic engineers could ignore limits imposed by nature, mate unrelated organisms, and produce dangerous creatures. It is easy to imagine, they continue, scientists eventually creating an organism that they then could not control. A single organism could upset the balance of an ecosystem. It could destroy life as we know it.

After all, opponents continue, scientists cannot even control natural species under experimental conditions. The current problems caused by African killer bees in South and now North America is just one example. Thirty years ago, a geneticist brought bees from Africa to South America for experimental purposes. Within a year, despite precautions, some of the killer bees escaped.

Second, opponents are worried bioengineered foods will cause economic problems. Perhaps a few giant companies will gain control of the world's food supply. Perhaps new biotechnology products will eliminate jobs. Some biotech scientists, for example, have begun working on BST, a bovine growth hormone that increases cows' output of milk. The dairy industry is against BST. Higher production of milk by a given cow would mean fewer cows and fewer farmers. People in the dairy industry do not want to lose their jobs.

Third, critics argue that relying on genetically engineered plants and animals is less effective than relying on nature's own system of biodiversity. Time and time again, they explain, nature has been shown superior to the work of humans. In the early 1970s, for example, a variety of corn widely grown in the Midwest was wiped out by a blight. The problem: Humans had made all the corn plants genetically identical.

Fourth, opponents claim that biotechnologists have not thought enough about animals' welfare. How many animals have to suffer before a biotech company achieves its desired cow? What kinds of tests must such animals go through? And, should scientists be able to create animals that are slow to learn, remember, and sense so that they suffer less in cages and pens? Is it right, for example, to create a sheep with the intelligence of a shrimp? Who will stand up for the animals' rights?

Finally, many opponents of biotechnology are convinced biotech foods are unnecessary. In many cases, they explain, bioengineers are attacking problems that do not exist or that already have solutions. For example, scientists have wasted time and money trying to produce corn that grows without fertilizer. They have tried to insert the genes of a bean plant into corn. However, there already is a simple solution to this problem. Farmers could follow the practices of Native Americans: They could plant corn and beans together.

Groupwork 6: Individual Report - Are Genetically Engineered Crops a Good Idea? (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

1. What was your position in the debate?

2. Describe the decision-making process your team used in Procedure 4. Was the process effective? Explain.

3. As an individual, how would you answer the following question? Should genetically altered foods be sold? Provide reasons for your answer.

4. How might the debate over genetically engineered foods affect scientists? The public? Yourself? Explain.

Groupwork 7: Teacher Activity Notes - Culminating Activity - You're the Genetic Engineer

Big Idea: The Costs and Benefits of Genetic Engineering

PLAN

Summary Students are given a genetic engineering assignment of their own. Using information from previous activities, they decide how to accomplish their task as well as debate its costs and benefits.

Group Size 4 to 5 students

Objectives

Students:

- describe how they would design and conduct a genetic engineering project.
- explain the advantages and disadvantages of completing this type of project.

Multiple Abilities

- Putting yourself in someone else's shoes, understanding how someone else feels even though his or her situation is different from your own (interpersonal skills)
- Making connections between ideas/concepts (reasoning ability)
- Being persuasive, explaining clearly and fully, using words precisely (communication skills)

Student Materials

- Activity Guide
- Project Assignment from Teacher Resource
- Individual Report

Estimated Time 50 minutes

Suggested Use

- This set of activities works well near the end of the unit.

IMPLEMENT

1. Cut out each of the five project assignments found on the Teacher Resource. Give each group ONE of the five project assignments.
2. The projects assigned to students are openended and complex. You may want to give students about 30 minutes to discuss how to accomplish the research and development project they've been assigned. Then, check for understanding by rotating around to each of the groups to ask for their proposed plan.

Background Information

Obviously, some projects described on the Resource are more realistic than others: Tay-Sachs, for example, is a real disease, while a Human Youth Hormone is not known to exist. Still, for each project, there is a reasonable and logical course of action:

- Engineering bacteria to produce large amounts of Human Youth Hormone: As described in the "Plasmids and Protein Production" activity, scientists might lyse bacteria, withdraw their plasmids, and insert a gene to produce this human youth hormone. This altered plasmid would then be inserted into new bacteria. Refer students to Activity 5 if they have difficulty imagining how scientists would accomplish this.
- Curing people with the genetic disease Tay-Sachs: Children with Tay-Sachs disease lack the enzyme hexosaminidase A. Without this protein, lipids accumulate in the brain and an affected infant begins to suffer seizures, blindness, and the degeneration of motor and mental functions. Similar to the process described in the "Human Designer Genes" activity, scientists might insert the DNA lacking in Tay-Sachs patients into a skin cell. This cell can then be cultured until a small swatch of skin is produced. This swatch is then grafted onto the individual, producing the necessary enzyme.
- Crossing wheat (an important crop worldwide) with corn: Scientists might use the method described in the "Seeds of Change" activity.
- Altering the genetic code of human cells so that they produce an enzyme for thinness: Similar to the process described to cure Tay-Sachs disease, scientists might insert a gene to produce the thinness enzyme into a skin cell. This skin cell would then be cultured and grafted onto a human.
- Inserting a gene for intelligence into human brain cells: The difficult, and perhaps impossible, aspect of this project would be identifying a gene that is linked to intelligence. Have students first consider how they would go about doing this and if they think it is possible (i.e., if intelligence is genetic). Then, they might discuss how this gene would be inserted into brain cells, presumably during the very early stages of embryonic development.

Extend This Activity

- Ask an adult (preferably a scientist from the community) to play the role of Dr. Splicem. This way, when students present their group products, she can help to evaluate them.

Extension Questions

- Are there any specific groups of people that might be positively or negatively impacted by this research or new development? For example, certain religions may be morally against insetting a gene into human brain cells.
- How might the world look different 100 years from now if the company's genetic engineering project were successful?
- Do all group members agree that this is a worthwhile project? Why or why not?

ASSESS

Use the group presentation, individual report, and group discussion to assess if students can

- simulate the specific processes geneticists use to alter the genes of plants, animals, and bacteria.
- determine why genetic engineers might want to alter the genes of a plant, animal, or bacteria.
- evaluate the feasibility of such projects.
- explain the advantages and disadvantages of altering genes.

Groupwork 7: Activity Guide - Culminating Activity - You're the Genetic Engineer (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

Introduction

Once again, your group has returned to Genes-R-Us. Dr. Splicem liked your work as consultants so much, she has hired you to be genetic engineers for her company. She has assigned your team a project.

Materials

- Individual Report
- Project Assignment

Procedure

1. Dee Ann A. Splicem has decided the following five projects would make Genes-R-Us both world- famous and rich:

- Engineering bacteria to produce large amounts of Human Youth Hormone.
- Curing people with the genetic disease Tay-Sachs.
- Crossing wheat (an important crop worldwide) with corn.
- Altering the genetic code of human cells so that they produce an enzyme for thinness.
- Inserting a gene for intelligence into human brain cells.

2. The Project Assignment states which project your group has been assigned. Discuss the following:

- Based on what you have learned in the other activities, how would you design and complete this genetic engineering project?
- What are the positive and negative consequences of undertaking this project?

3. Hold a press conference for the public (your classmates). Your press conference should explain to people how your group is going to accomplish its task, as well as the advantages and disadvantages this project will have for society.

Groupwork 7: Teacher Resource - Culminating Activity - You're the Genetic Engineer

Big Idea: The Costs and Benefits of Genetic Engineering

1 Dr. Splicem has assigned your group the following project:

To engineer bacteria to produce large amounts of Human Youth Hormone, a hormone to keep people looking and feeling younger.

2 Dr. Splicem has assigned your group the following project:

To cure children with the genetic disease Tay-Sachs. This disease is caused by the lack of an enzyme called hexosaminidase A. Without this enzyme, lipids accumulate in an infant's brain, causing seizures, blindness, and/or degeneration of motor and mental skills. Tay-Sachs disease appears before the age of one, and death occurs within several years. There is no treatment for Tay-Sachs disease at this time.

3 Dr. Splicem has assigned your group the following project:

To cross wheat (an important crop worldwide) with corn in order to produce both on the same plant.

4 Dr. Splicem has assigned your group the following project:

To alter the genetic code of human cells so that they produce an enzyme for thinness.

5 Dr. Splicem has assigned your group the following project:

To insert a gene for intelligence into human brain cells. You will first need to consider if and how you could identify a gene for intelligence. Then, discuss how and when this gene would be inserted into brain cells.

Groupwork 7: Individual Report - Culminating Activity - You're the Genetic Engineer (Student Reproducible)

Big Idea: The Costs and Benefits of Genetic Engineering

1. How did your group complete the genetic engineering project assigned by Dr. Splicem?
2. How will this project benefit society? What problems may arise as a result of this project?
3. Does this project raise any moral dilemmas for the public? Scientists? Yourself? Explain.

11.2 Projects

The following Projects are an assortment of long-term activities that can be completed individually, in groups or as a class. We have provided starting points for research and development; you and the students can work together to create a more detailed plan of action. Consider the following two recommendations. First, because of the amount of work involved in a Project, students should choose one of great interest to them. Second, to encourage excellence and promote student-student learning, students should present their finished projects to the rest of the class, to the school and to the community, if appropriate.

Project 1: Research Questions and Action Projects

Project 1 differs from the others: it is a list of possible research topics organized according to some key ideas and addressed to students.

In assigning a Research Question or Action Project, we ask that you allow students to choose their topic either one provided or one of their own. You might also:

1. Specify the length of the piece.
2. Make clear the purpose and the audience.
3. Suggest sources and ideas for information.
4. Provide in-class time for compiling information and writing.
5. Require students to exchange papers and provide written feedback.
6. Provide a breakdown of due dates for the following stages: choice of topic, outline, rough draft, and final draft.
7. Permit students to supplement a written report with a skit, piece of artwork, piece of music, dance,video, or multimedia presentation.

ASSESS

Provide the students with evaluation criteria that include:

- accuracy of the content based on guiding questions.
- clarity of writing.
- effective organization of main ideas.
- use of detailed examples or evidence cited to support their conclusions.

Project 1: Teacher Activity Notes - Research Questions

1. **The Field of Genetics** This unit describes the field of science called *Genetics*. What is genetics? When did it become a discipline? Who were its founders? How do today's research questions, methods, and results compare to those of the past? In what direction is this field headed?
2. **Patterns of Expression** Gregor Mendel is considered a pioneer in the field of genetics. Research his life. How was Mendel able to see regularities in inherited traits? How was his work perceived by others? How did the society in which Mendel lived shape his research and results? Would Mendel be able to conduct science in the same way if he lived today? Explain.

3. **Nature versus Nurture** As mentioned by the author of this text, scientists have long argued over whether genes or the environment are more important in determining human variation. Pick one aspect of the nature versus nurture debate to research. What do different scientists say about the influence of genes versus the environment? How do their different opinions affect scientific research? Applications of such research? How society- government, education, medicine-treats different people? Is it necessary to resolve this debate? Explain.
4. **DNA and Genes** In 1953, Watson and Crick constructed a model of the structure of DNA. How did Watson and Crick come up with their model? What other scientists were trying to explain the structure of DNA at this time? What were their contributions? Why was determining the structure of DNA considered so important? How has the Watson and Crick model of DNA influenced biology? The creation of new industries and technologies? People's everyday lives?
5. **The Microscope** The microscope played an important role in the construction of Sutton's theory of chromosomes. Research the history of the microscope. Who invented the microscope? Why? How has this piece of technology been used by scientists over time? What does the microscope prove about the relationship between science and technology? How has your knowledge of the importance of the microscope changed as a result of your research?
6. **Jumping Genes** Scientists have discovered that most organisms, if not all, have "jumping genes" that can move from one DNA molecule to another within the nucleus. What do scientists think the function of these jumping genes might be? How do jumping genes help scientists' gain more knowledge about human diseases? Who was the first scientist to explain the presence of jumping genes? How did the scientific world first react to this scientist's findings? Why?
7. **Making Proteins Inside and Outside Cells** Scientists are able to make proteins in test tubes through a process called *in vitro translation.* How do scientists make proteins outside a cell? For what are such proteins used? Explain.
8. **Gene Function** Interview someone in your community who breeds animals or plants. Then, research this area in greater detail. How is the science of genetics used in breeding plants and animals? What are some benefits and drawbacks of breeding?
9. **Human Blood Types** Humans have a variety of blood types. Use reference books and the Internet to prepare a report that includes the names of these blood types, how they are inherited and how they differ from one another. What is your blood type? Can you determine your parents' blood types from your own? Why is blood type important?
10. **Genetic Applications** Research a genetic disorder like cystic fibrosis, hemophilia, Huntington's disease, sickle-cell anemia, or one of your choice. How is the disease identified? What kinds of people get this disease? What are its effects? How is it treated? What research is being conducted to prevent and/or cure this disease? Is trying to eliminate this disease a worthwhile effort? Explain.
11. **The Human Genome Project** Research the Human Genome Project. Who funds this project? Why? What are its goals? What kinds of research do scientists working on this project perform? Is the quest for a map of the human genome a worthwhile goal? Would money be better spent elsewhere? Do you support the project?
12. **A Genetic Engineering Change** Research one genetic engineering technology. When was this technology developed? To what use is it put? Do you consider such a technology worthwhile? Does it have troubling political or moral implications?
13. **Genetic Engineering** Read newspaper and magazine articles about genetic engineering published in recent years. What are some of the major themes in these articles? Examples include the promise of technological innovation, the prospect or absence of financial profits, and health concerns. Do articles in science magazines treat news about genetics differently than other publications? According to these articles, is genetic engineering a good thing? Explain.

Project 2: Teacher Activity Notes - Careers in Genetics

Summary Students work in groups to research careers in genetics and genetic engineering. They then present a summary of a day in the life of a person with their chosen career.

Interdisciplinary Connections

Social Studies, Health

Estimated Time

One week to collect information on the chosen occupation, prepare questions, and conduct interviews

One week to create and perform presentations

Student Materials

Contact names and phone numbers of professionals in occupations related to genetics; Internet access

Teacher Materials

None required

Advanced Preparation

To help students start their research, locate several people with careers in genetics who are willing to be interviewed for this project.

Product

- Presentation describing what is involved in a particular career in genetics
- List of research questions or interview questions
- Summaries from interviews performed
- Research papers (Optional)

IMPLEMENT

Step 1 Divide students into groups and have each group pick a career related to genetics. Examples include a geneticist, genetic counselor, genetic engineer, animal breeder, forensics lab technician, and an agriculture specialist.

Step 2 If possible, have each member of the group conduct one of the following:

a. Interview a career counselor to determine what education/ training is required to enter this profession.

b. Interview a person in this occupation to discover his or her thoughts about the job. Go to the interview with a set of questions prepared by the group. Phone interviews are also effective.

c. Shadow a person in this occupation for a half day or day. What does he or she do? When? Where? How? Why?

d. Interview several people that interact with members of this profession. For example, talk to a patient of a genetic counselor. How do people in this occupation influence the lives of others? How do they help those with whom they come in contact?

Require that students record their research or interview questions and answers as they gather information.

Step 3 Have each group create a presentation using visuals, pictures, dialogues, descriptions, videos, or audios. They should describe accurately and completely what their group learned about the career they chose to study.

Note: Because this activity requires members of a group to share and synthesize information, provide students with time in class as well as a structure for sharing information. You may also assign students individual papers that describe their specific assignment and results.

ASSESS

Use the presentations and the written reports to assess if students can

- design interview and research questions that reflect their knowledge of genetics
- demonstrate organized, thorough research skills by efficiently using the resources available to them.
- present a concise but thorough explanation of what the career involves, what educational background or qualifications are needed, and how this career contributes to our society.

Project 3 Teacher Activity Notes - A Lesson in Genetics

Summary Students use their knowledge of genetics to design and teach a lesson or read a new children's book to elementary school children.

Interdisciplinary Connection

Health

Estimated Time

One week to brainstorm and prepare a lesson or write a children's book

One week to make presentations to younger classes and to write an evaluation of their performance

Student Materials

Reference books; construction paper, cardboard or tag board for book covers; colored pens, pencils, or crayons; props for lesson

Teacher Materials

None req uired

Advanced Preparation

One to two weeks prior to starting this project, contact teachers at a local elementary school to make sure your students can actually teach the unit to young students. This project may fulfill public/community service requirements in those schools that have them.

Product

Presentations made to younger students or children's book.

IMPLEMENT

Step 1 Divide students into groups and have them brainstorm questions they think children in the second and/or third grade may have about genetics. Young children often have many questions about genes and how they are passed on. Why do I have brown eyes? How come some people are twins? Why am I color-blind but my sister is not? Why are some people born with diseases?

They should keep in mind that the younger students may not know the vocabulary or the science behind genes.However, they still have plenty of questions about themselves and how they are similar to or different from one another.

Step 2 Tell students to pick those questions which can be grouped together to form a skit or children's story, for example; "Why puppies from the same litter can be different colors." Each group must conduct any necessary research and write a script or story with props or visuals.

Step 3 Allow students to spend two to three class periods preparing their presentations or books.

Step 4 The product will be more meaningful if students can actually present or give their books to the elementary children personally. Make all arrangements for students to conduct their lesson. Schedule blocks of time with the second or third grade teachers who are convenient for everyone. Arrange for transportation to and from the elementary school. If it is not possible to arrange a field trip, have students present their products to each other and then send the books or lesson to an elementary school teacher-they will certainly be appreciated!

Suggested Follow-up Activities

Other students in the school may be interested in learning more about genetics. Students can revise their book or lesson to present it to an older audience.

ASSESS

Use the completed lesson or book and the group work to assess if students can

- identify major concepts in the study of genetics.
- design an organized, creative, content-based story or lesson that explains one or more of the basic concepts in genetics.
- present an organized, creative, and appropriate lesson or story to an audience.

11.3 Additional Resources

Textbooks

- Purves, Orians, and Heller, *Life, fifth edition.* Sunderland, Mass.: W. H. Freeman and Company.
- Tortora and Anagnostakos, *Principles of Anatomy and Physiology*, Harper and Row Publishers.
- *Biological Sciences, A Molecular Approach,* BSCS 7th Blue Version, Lexington, Mass.: DC Heath.

Books

- *Cells "R" Us and DNA Is Here to Stay,* Cold Spring Harbor Laboratories, Cold Spring Harbor, NewYork.

Internet Sites

The National Cystic Fibrosis Foundation

6931 Arlington Road

Bethesda, MD 20814

1-800-344-4823

http://www.cff.org/

- American Cancer Society including the video -*The Intricate Cell* http://www.cancer.org
- Human Genome Project Information http://www.ornl.gov/TechResources/Human_Genome/home.html
- March of Dimes http://www.modimes.org/

Video

- National Geographic- *The Cell*

11.4 Genetics Glossary

alleles different forms of genes. A gene pair is made up of a pair of alleles.

amino acids the building blocks of proteins.

cells the building blocks of living organisms that perform the functions of the body needed to keep it functioning.

characteristics the distinctive qualities of living things.

chromosomes the cell parts that carry the genes.

cloning making copies of a gene by using bacteria.

continuity the phenomenon of living organisms producing offspring with similar characteristics.

deoxyribonucleic acid (DNA) the molecule responsible for the inheritance of traits.

diversity the variation (or difference) among living organisms.

dominant allele an allele that is always expressed regardless of whether the other allele of its pair is the same or different.

fertilization the event of an egg cell, ovum, combining with a sperm cell.

gamete cells the cells used to reproduce.

gene a segment or a piece of DNA that codes for a specific trait.

gene mapping the process of determining the location of a gene on a chromosome.

genetic counseling a profession that is concerned with helping people who may have genetic-related conditions.

genetic engineering the process of getting genes to produce their proteins their proteins in the laboratory.

genetics the study of the biological causes of continuity and diversity among living things.

genome all the DNA genes of a species.

genotype the genetic makeup for a given individual.

heredity the process of passing on traits and variations from one generation to the next.

heterozygous members of a gene pair are different (e.g., Tt).

homozygous members of a gene pair are the same (e.g., TT or tt).

karyotype a portrait of the chromosomes of a cell.

linked genes genes close together on the same chromosome and inherited together.

meiosis the process that produces gamete cells.

mitosis cell division in which the nucleus divides, producing two cells each with the same number and exact type of chromosomes as the parent cell.

mRNA messenger RNA that moves from the nucleus to the cytoplasm carrying the coded message from the DNA in the nucleus to the cytoplasm.

nucleotides four different complex chemical molecules that make up a DNA molecule. The four complex chemical molecules are adenine, guanine, cyostine, and thymine.

nucleus the part of a cell that contains the genetic information.

ova female gamete cells.

pedigree a family tree that shows relationships among members of a family.

population geneticists geneticists who are concerned about how and why some alleles are found in people in certain parts of the world and not others.

protein synthesis the process of making proteins.

recessive allele an allele that will only be expressed if the other allele of its pair is the same, also recessive.

replication the duplication of DNA that occurs just before a cell divides.

ribosomes structures where amino acids are joined together to make a protein.

RNA a molecule very much like DNA, composed of nucleotides in a Single-strand molecule rather than a double-stranded helix.

species a group of living organisms that has similar characteristics and can interbreed (reproduce among themselves).

sperm male gamete cells.

trait a characteristic that can be passed from generation to generation.

tRNA transfer RNA that carries amino acids to the ribosomes where protein is assembled.

variation the characteristics that make members of the same species different from one another. Variations are the different forms of a trait.

X-linked genes for these traits are part of the X chromosome, but are not on the Y chromosome. This is because the X chromosome is larger and possesses more genes.

zygote a fertilized egg.