Program Features

Frey's Inquiry Investigations™ Module *Genetics and Inheritance* engages your students in active and meaningful learning. Each of the four units in the program focuses on a different theme and contains an exciting collection of classroom-tested activities that let students experience the wonders of science through direct, hands-on experience.

These standards-based units link to core science concepts, making them an excellent complement to your existing curriculum. Best of all, you won't need a strong background in science to use this program—the comprehensive Curriculum Guide that comes with the module provides teacher-friendly instructions on how to teach the activities.

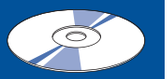
Each Unit includes

- Comprehensive investigation literature with planning and preparation tips, step-by-step instructions, expected outcomes, cross-curricular integration, and assessment strategies.
- A reproducible Student Guide for each unit with complete background information, step-by-step procedures, data tables, analysis questions, and options for open-ended student-designed investigations that challenge students to use their critical thinking skills. Also included are related websites and *Read More About It* sources for students to obtain additional information.
- A collection of safe and fun inquiry-based lab investigations with real-world applications.
- Enough high-quality science materials for a class of up to 40 students working in groups.
- A handy Storage Center to neatly store all materials.

The Curriculum Guide includes

- Comprehensive, unit-specific teacher and student guides.
- Materials lists, a comprehensive Glossary, Useful Equivalents, Symbols, and Equations, Science Safety, and How to Record, Analyze, and Report Data.
- Two Comprehensive Inquiry Activities—Case of the Royal Mystery, and Calculating the Frequency of Human Traits in a Population.

Also included with the Inquiry Investigations™ Module *Genetics and Inheritance* is the Curriculum Resource CD-ROM*, which includes…



Content Tutorials:

- Topic-related content featuring detailed illustrations that cover key concepts in genetics and inheritance.
- Hyper-linked glossary of key concepts and terms.

Assessment Monitoring:

- Test questions that can be accessed in either Practice or Test Mode; questions allow students to demonstrate content knowledge.
- Customized tests and worksheets with five question types (essay, multiple choice, concept map, matching, and labeling), as well as dynamic web-deliverable multi-media tutorials and presentations.

Correlation to National and State Science Standards:

- Key concepts correlated to the National Science Education Standards (NSES) and a link to the Frey Scientific website for selected State standards.

Teacher Resources:

- Image gallery containing printable illustrations and images relating to a genetics and inheritance topic area.
- Dynamic animations that reinforce key concepts in genetics and inheritance.
- Experimental results section that provides useful teacher tips for each activity as well as in-depth experimental data analysis. Where applicable, graphs, tables, and images are provided to enhance each activity.

Virtual Laboratory

Mendelian Genetics—Law of Dominance

Mendelian Genetics—Law of Independent Assortment

- Explore the object-based virtual lab environment. The virtual labs allow students to interactively perform every step of each lab activity by manipulating lab equipment on their virtual workbench.
- Use the electronic notebook to record and analyze results.

**System Requirements: Windows 2000 or higher, VISTA-compatible, Mac 9.2 or higher (including OSX), 128 MB RAM.*

The Curriculum Guide contains the following sections – Teacher Guide, Appendix, Student Resources, and a Curriculum Resource CD-ROM. Each section has the same general format, let's take a closer look –

A Closer Look at the Teacher Guide…

Science Concepts and Skills

- Overview of key concepts and skills presented in each lab

Science Standards

- A list of the National Science Education Standards covered in each lab

Materials

- Comprehensive list of the materials needed for each lab

Time Requirements

- Amount of time needed for preparation and activities

Pre-lab Preparation

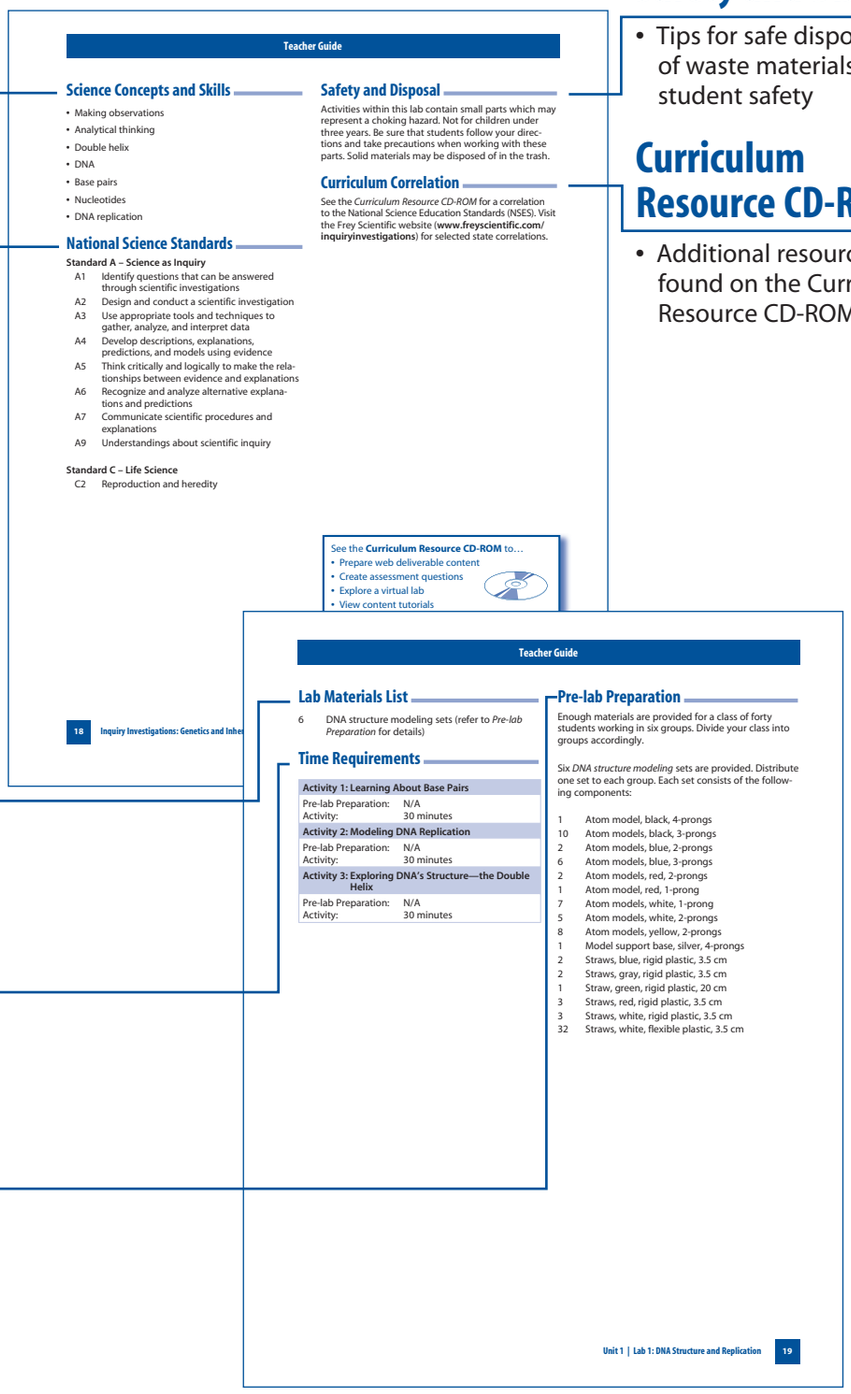
- Overview of any necessary pre-lab preparation

Safety and Disposal

- Tips for safe disposal of waste materials and student safety

Curriculum Resource CD-ROM

- Additional resources found on the Curriculum Resource CD-ROM



Teacher Guide

Science Concepts and Skills

- Making observations
- Analytical thinking
- Double helix
- DNA
- Base pairs
- Nucleotides
- DNA replication

National Science Standards

Standard A – Science as Inquiry

A1 Identify questions that can be answered through scientific investigations
A2 Design and conduct a scientific investigation
A3 Use appropriate tools and techniques to gather, analyze, and interpret data
A4 Develop descriptions, explanations, predictions, and models using evidence
A5 Think critically and logically to make the relationships between evidence and explanations
A6 Recognize and analyze alternative explanations and predictions
A7 Communicate scientific procedures and explanations
A9 Understandings about scientific inquiry

Standard C – Life Science

C2 Reproduction and heredity

Safety and Disposal

Activities within this lab contain small parts which may represent a choking hazard. Not for children under three years. Be sure that students follow your directions and take precautions when working with these parts. Solid materials may be disposed of in the trash.

Curriculum Correlation

See the *Curriculum Resource CD-ROM* for a correlation to the National Science Education Standards (NSES). Visit the Frey Scientific website (**www.freyscientific.com/inquiryinvestigations**) for selected state correlations.

See the **Curriculum Resource CD-ROM** to…
- Prepare web deliverable content
- Create assessment questions
- Explore a virtual lab
- View content tutorials

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Teacher Guide

Lab Materials List

6 DNA structure modeling sets (refer to *Pre-lab Preparation* for details)

Time Requirements

Activity 1: Learning About Base Pairs	
Pre-lab Preparation:	N/A
Activity:	30 minutes
Activity 2: Modeling DNA Replication	
Pre-lab Preparation:	N/A
Activity:	30 minutes
Activity 3: Exploring DNA's Structure—the Double Helix	
Pre-lab Preparation:	N/A
Activity:	30 minutes

Pre-lab Preparation

Enough materials are provided for a class of forty students working in six groups. Divide your class into groups accordingly.

Six *DNA structure modeling* sets are provided. Distribute one set to each group. Each set consists of the following components:

1 Atom model, black, 4-prongs
10 Atom models, black, 3-prongs
2 Atom models, blue, 2-prongs
6 Atom models, blue, 3-prongs
2 Atom models, red, 2-prongs
1 Atom model, red, 1-prong
7 Atom models, white, 1-prong
5 Atom models, white, 2-prongs
8 Atom models, yellow, 2-prongs
1 Model support base, silver, 4-prongs
2 Straws, blue, rigid plastic, 3.5 cm
2 Straws, gray, rigid plastic, 3.5 cm
1 Straw, green, rigid plastic, 20 cm
3 Straws, red, rigid plastic, 3.5 cm
3 Straws, white, rigid plastic, 3.5 cm
32 Straws, white, flexible plastic, 3.5 cm

Unit 1 | Lab 1: DNA Structure and Replication 19

A Closer Look at the Teacher Guide…

Objective

- Specific student goals of the activity

What you need

- Specific materials used in each activity

Safety and Disposal

- Important safety information specifically related to each activity

What to do

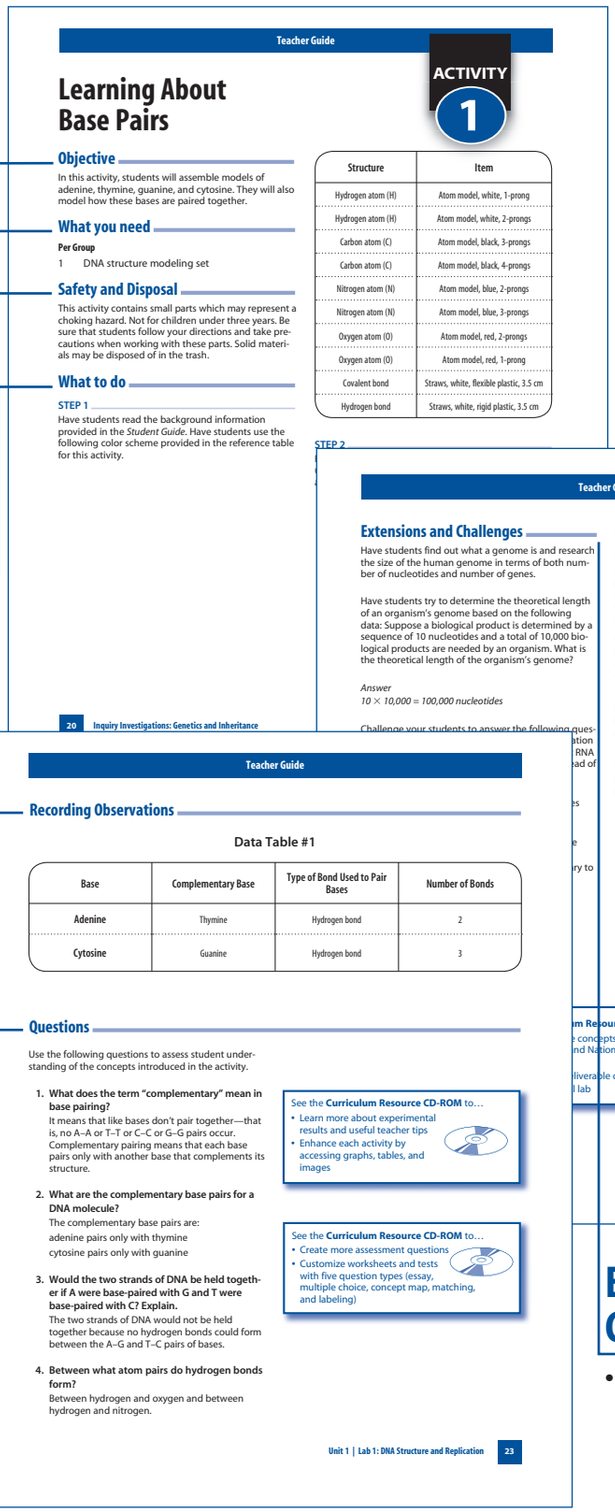
- Teacher friendly step-by-step procedures for each activity

Recording Observations

- Sample student data for each activity

Questions

- Questions to assess student understanding of the activity



Teacher Guide

ACTIVITY 1

Learning About Base Pairs

Objective

In this activity, students will assemble models of adenine, thymine, guanine, and cytosine. They will also model how these bases are paired together.

What you need

Per Group

1 DNA structure modeling set

Safety and Disposal

This activity contains small parts which may represent a choking hazard. Not for children under three years. Be sure that students follow your directions and take precautions when working with these parts. Solid materials may be disposed of in the trash.

What to do

STEP 1

Have students read the background information provided in the *Student Guide*. Have students use the following color scheme provided in the reference table for this activity.

Structure	Item
Hydrogen atom (H)	Atom model, white, 1-prong
Hydrogen atom (H)	Atom model, white, 2-prongs
Carbon atom (C)	Atom model, black, 3-prongs
Carbon atom (C)	Atom model, black, 4-prongs
Nitrogen atom (N)	Atom model, blue, 2-prongs
Nitrogen atom (N)	Atom model, blue, 3-prongs
Oxygen atom (O)	Atom model, red, 2-prongs
Oxygen atom (O)	Atom model, red, 1-prong
Covalent bond	Straws, white, flexible plastic, 3.5 cm
Hydrogen bond	Straws, white, rigid plastic, 3.5 cm

STEP 2

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Teacher Guide

Extensions and Challenges

Have students find out what a genome is and research the size of the human genome in terms of both number of nucleotides and number of genes.

Have students try to determine the theoretical length of an organism's genome based on the following data: Suppose a biological product is determined by a sequence of 10 nucleotides and a total of 10,000 biological products are needed by an organism. What is the theoretical length of the organism's genome?

Answer

10 × 10,000 = 100,000 nucleotides

Challenge your students to answer the following ques-

Cross-Curricular Integration

Language Arts

One of the major differences between RNA and DNA is the type of sugar used to build each molecule. Have students research and make educated guesses about this difference based on what they know about suffixes and root words.

History

Have students research the discovery of the structure of DNA, including the competing proposals of protein versus nucleic acids, and the competing international teams of scientists working to solve the puzzle.

Biotechnology

Have students research the Human Genome Project. Discuss with the class the benefits and possible disadvantages of the Human Genome Project.

Chemistry

Have students research and investigate why hydrogen bonds denature when exposed to extreme heat.

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Unit 1 | Lab 1: DNA Structure and Replication 29

Teacher Guide

Recording Observations

Data Table #1

Base	Complementary Base	Type of Bond Used to Pair Bases	Number of Bonds
Adenine	Thymine	Hydrogen bond	2
Cytosine	Guanine	Hydrogen bond	3

Questions

Use the following questions to assess student understanding of the concepts introduced in the activity.

1. **What does the term "complementary" mean in base pairing?**
   It means that like bases don't pair together—that is, no A–A or T–T or C–C or G–G pairs occur. Complementary pairing means that each base pairs only with another base that complements its structure.
2. **What are the complementary base pairs for a DNA molecule?**
   The complementary base pairs are:
   adenine pairs only with thymine
   cytosine pairs only with guanine
3. **Would the two strands of DNA be held together if A were base-paired with G and T were base-paired with C? Explain.**
   The two strands of DNA would not be held together because no hydrogen bonds could form between the A–G and T–C pairs of bases.
4. **Between what atom pairs do hydrogen bonds form?**
   Between hydrogen and oxygen and between hydrogen and nitrogen.

See the **Curriculum Resource CD-ROM** to…
- Learn more about experimental results and useful teacher tips
- Enhance each activity by accessing graphs, tables, and images

See the **Curriculum Resource CD-ROM** to…
- Create more assessment questions
- Customize worksheets and tests with five question types (essay, multiple choice, concept map, matching, and labeling)

Unit 1 | Lab 1: DNA Structure and Replication 23

Cross-Curricular Integration

- Suggestions of how to relate the key concepts of the lab to other disciplines

Extensions and Challenges

- Additional activity suggestions to reinforce the key concepts presented in the lab

A Closer Look at the Appendix…

Laboratory Notebook

- Useful tips on how to record, organize, and understand data

The Laboratory Notebook: Recording, Analyzing, and Reporting Data

Data sets are unbiased information gathered through the scientific process that can lead to knowledge and understanding. To be useful, data must be recorded, organized, graphed, analyzed, and reported.

Recording Data

Science deals with verifiable observations. All scientists must keep clear and accurate records of their observations. It is critical that these notebook recordings are made at the time of observation.

Recording data can be done manually through the reading of an instrument, such as a thermometer, and writing down measurements in a lab notebook or data book. Some data measurement probes and instruments (temperature, balance, pH, dissolved oxygen to name a few) can sample and transmit data to a computer for storage in a data table.

At times, your investigation may require the use of a video or photo camera to record visual information. Try to include some dimensional reference (a ruler or other feature) in your shots to provide the correct perspective. Digital photo cameras and scanners allow an investigator to capture experimental results.

Organizing Data

Make sure data sets are presented in tables listed in correct relation to each other. Sometimes your investigations may call for the collection of very large data sets. One way to manage this pile of data is through a database—a large, complex list of facts and information. A database can be a card file or an electronic program that can both recall and merge data. FileMaker Pro (by FileMaker, Inc) or Excel (by Microsoft) are powerful database programs that combine database management and desktop-to-Web network publishing

reproducibility of a result. For example, if you measure a quantity several times and the values agree closely with one another, your measurement is precise. Accuracy describes how close a measured value is to the true or known value. The closer a measured value is to the true value, the more accurate it is. Let's investigate this further.

For example, examine the data sets below.

Procedure 1:	20.1
	20.1
	20.2
	20.0
Procedure 2:	24.5
	25.6
	26.1
	25.1

If the true value is 25.3, then data collected from procedure 2 is more accurate but less precise than the data collected from procedure 1. In this case the precision is poor but the accuracy is good. An ideal procedure is both accurate and precise.

Data Books

The best method of record-keeping is to record observations in a laboratory notebook or data book. Ideally, this should be a stiff-covered book, permanently bound, not loose-leaf, preferably with square grid pages.

Keep records in a diary form, recording the date first. If you make observations for two or more investigations on the same day, use numbers or abbreviations of the titles as subheadings.

Data may be recorded as words. In the laboratory, time is short. Make notes as brief as possible—but to the point. You may choose to sketch your observations. Drawings, digital images, and digital video are all useful data recording techniques.

Graphing Data

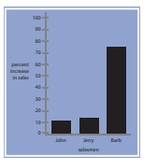
- Examples of ways to graphically present data

Graphing Data

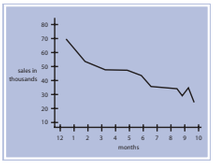
When you make a graph, the first step is to determine which kind to create. What you want to show and the kind of data you have will determine which graph type is most useful:

Circle graph – useful in showing parts or proportions of a whole.

Bar graph – useful for comparing quantities and changes over time.



Line graph – useful for comparing two sets of data or showing changes and trends over time.



Analyzing Data

When you analyze data you look for trends or patterns. You also look to see whether or not your data supports your reasoned guess—your hypothesis. If you have access to a computer, special analysis programs or spreadsheets (e.g., Microsoft Excel®) allow you to tabulate, manipulate (perform mathematical calculations), and graph your data.

Laboratory Reports

Discoveries become a part of science only if they are reported to others. In writing, scientists must express themselves clearly so that others can repeat their procedures exactly. Scientific reports usually follow the following form:

- **Title**
- **Introduction**: how the problem arose and a summary of past investigative work.
- **Materials and equipment**
- **Procedure**: complete and exact account of what was done in gathering the data.
- **Results**: data obtained from the procedure, often in the form of tables and graphs.
- **Discussion**: points out the relationship between the data and the purpose of the investigation.
- **Conclusion**: summary of the meaning of the results, often suggesting further work that might be done to clarify issues that the data may have uncovered.
- **References**: published scientific reports that have been specifically mentioned in the report.

Laboratory Reports

- General outline for scientific reports

A Closer Look at the Appendix…

Useful Equivalents, Symbols, and Equations

- Quick reference guide of common conversions, symbols, and equations

Useful Equivalents, Symbols, and Equations

Equivalents and Symbols

Mass

1 kilogram (kg)	=	1,000 grams (g)
1 gram (g)	=	0.001 kg
1 milligram (mg)	=	0.001 g
1 microgram (µg)	=	0.000001 g
1 dalton (Da)	=	1 g/mol
1 base pair (bp)	=	660 daltons
1 helical turn	=	10.4 base pairs

Liquid Volume

1 kiloliter (kL)	=	1,000 L
1 milliliter (mL)	=	0.001 L
1 mL	=	1 cm^3
1 microliter (µL)	=	0.000001 L

Length

1 kilometer (km)	=	1,000 m
1 centimeter (cm)	=	0.01 m
1 millimeter (mm)	=	0.001 m
1 micrometer (µm)	=	0.000001 m

Temperature

$T_{Fahrenheit} = (9/5 \times T_{Celsius}) + 32$

$T_{Celsius} = 5/9(T_{Fahrenheit} - 32)$

Table 1: Common Symbols

Quantity	Common Symbol	SI Unit
Temperature	T	˚C
Base pairs	bp	
Dalton	Da	g/mol
Molarity	M	mol/L

Table 2: Common Equations

Quantity	Formula	SI Unit
Hardy-Weinberg	$p^2 + 2pq + q^2 = 1$	N/A

p = the frequency of a dominant allele in a population

q = the frequency of a recessive allele in a population

p^2 = the frequency of homozygous dominant individuals in a population

2pq = the frequency of heterozygous individuals in a population

q^2 = the frequency of homozygous recessive individuals in a population

Glossary

- Comprehensive glossary of key terms

Glossary

A

Adenine (A) One of the four nitrogen-containing bases that is found in DNA and RNA; can pair only with thymine in DNA and only with uracil in RNA.

Albino A genetic disorder that causes defective pigmentation in the individual. An albino usually has translucent skin, white or colorless hair, and pink eyes with deep-red pupils.

Allele One of at least two different versions of a gene for a particular character.

Alzheimer's disease (AD) The most common form of dementia. A neurologic disease characterized by loss of mental (cognitive) ability severe enough to interfere with normal activities of daily living. AD usually occurs in old age, and is marked by a decline in cognitive functions such as remembering, reasoning, and planning.

Amino acid The subunits of proteins; each amino acid contains a central carbon atom to which a hydrogen, a variable side-chain (R-group), a carboxyl group, and an amino group are attached.

Anaphase I The third phase of mitosis, in which homologous chromosomes are pulled to opposite poles of the cell by spindle fibers.

Anaphase II The third phase of meiosis II, in which the sister chromatids separate.

Anemia Blood lacking or deficient in red blood cells or hemoglobin; decreased ability to transport oxygen throughout the body.

Anode The electrode in an electrochemical cell at which oxidation occurs. The positive (+) electrode.

Antibody Any of a large number of proteins that are produced by specialized white blood cells after stimulation by an antigen (foreign protein) and act specifically against the antigen in an immune response.

Antigen A protein molecule that is recognized by an antibody molecule.

Antiparallel The sequences of nucleotides are orientated in the opposite direction to one another on the strands of the DNA double helix.

Antiserum The liquid part of the blood containing specific antibodies.

Autoradiogram An image on an x-ray film or plate resulting from the emissions of a radioactive isotope in close contact with the emulsion.

Autosomal dominant A form of a gene on a non-sex chromosome that, if present, always expresses the trait for which it codes.

Autosomal recessive The form of a gene on a non-sex chromosome that is masked, or not expressed, if a copy of the dominant allele is also present in a diploid cell; the recessive allele can be expressed only if two copies of it are inherited from the parents.

Autosome A chromosome that is not a sex chromosome.

B

Bacteriophage A virus that infects a bacterium.

Barr body The remnant of the inactivated X chromosome present in each of a female's body cells. It is used as a test of genetic femaleness in athletes.

Base (Nitrogenous base);One of the components of DNA; the four nitrogen-containing bases in DNA are cytosine, thymine, guanine, and adenine; RNA has one other nitrogenous base, uracil, and lacks thymine.

Base pair (BP); Two nitrogenous bases that are connected by a hydrogen bond.

A Closer Look at the Student Guide…

Objectives

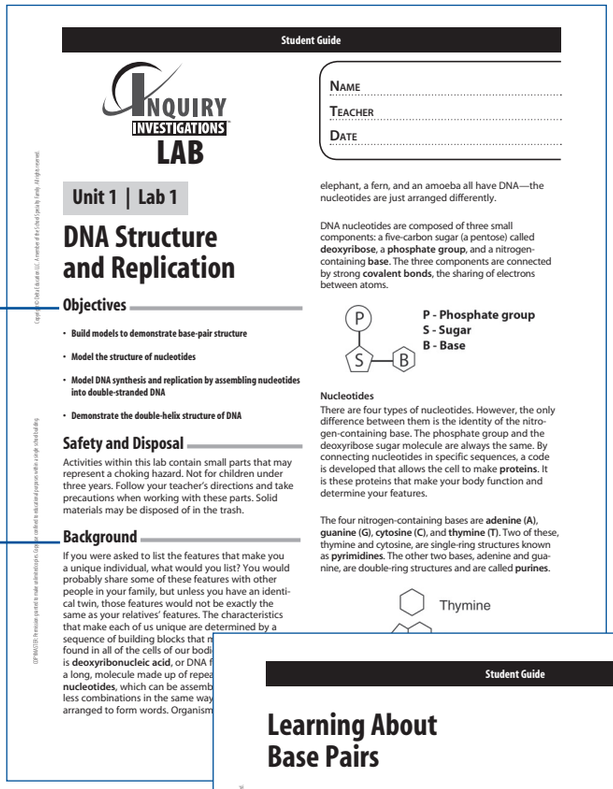
- Key concepts and student goals for the lab

Background

- Science information related to the lab topic

What to do

- Step-by-step procedures for each activity



Student Guide

INQUIRY INVESTIGATIONS LAB

Unit 1 | Lab 1

DNA Structure and Replication

NAME

TEACHER

DATE

Objectives

- Build models to demonstrate base-pair structure
- Model the structure of nucleotides
- Model DNA synthesis and replication by assembling nucleotides into double-stranded DNA
- Demonstrate the double-helix structure of DNA

Safety and Disposal

Activities within this lab contain small parts that may represent a choking hazard. Not for children under three years. Follow your teacher's directions and take precautions when working with these parts. Solid materials may be disposed of in the trash.

Background

If you were asked to list the features that make you a unique individual, what would you list? You would probably share some of these features with other people in your family, but unless you have an identical twin, those features would not be exactly the same as your relatives' features. The characteristics that make each of us unique are determined by a sequence of building blocks that n found in all of the cells of our bodi is **deoxyribonucleic acid**, or DNA a long, molecule made up of repea **nucleotides**, which can be assemb less combinations in the same way arranged to form words. Organism

elephant, a fern, and an amoeba all have DNA—the nucleotides are just arranged differently.

DNA nucleotides are composed of three small components: a five-carbon sugar (a pentose) called **deoxyribose**, a **phosphate group**, and a nitrogen-containing **base**. The three components are connected by strong **covalent bonds**, the sharing of electrons between atoms.

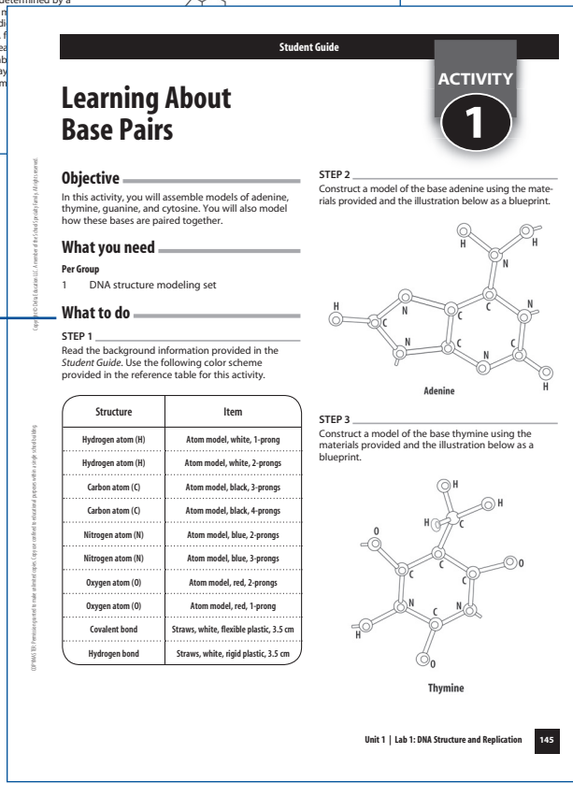
P - Phosphate group
S - Sugar
B - Base

Nucleotides

There are four types of nucleotides. However, the only difference between them is the identity of the nitrogen-containing base. The phosphate group and the deoxyribose sugar molecule are always the same. By connecting nucleotides in specific sequences, a code is developed that allows the cell to make **proteins**. It is these proteins that make your body function and determine your features.

The four nitrogen-containing bases are **adenine (A)**, **guanine (G)**, **cytosine (C)**, and **thymine (T)**. Two of these, thymine and cytosine, are single-ring structures known as **pyrimidines**. The other two bases, adenine and guanine, are double-ring structures and are called **purines**.

Thymine



Student Guide

ACTIVITY 1

Learning About Base Pairs

Objective

In this activity, you will assemble models of adenine, thymine, guanine, and cytosine. You will also model how these bases are paired together.

What you need

Per Group

1 DNA structure modeling set

What to do

STEP 1

Read the background information provided in the *Student Guide*. Use the following color scheme provided in the reference table for this activity.

Structure	Item
Hydrogen atom (H)	Atom model, white, 1-prong
Hydrogen atom (H)	Atom model, white, 2-prongs
Carbon atom (C)	Atom model, black, 3-prongs
Carbon atom (C)	Atom model, black, 4-prongs
Nitrogen atom (N)	Atom model, blue, 2-prongs
Nitrogen atom (N)	Atom model, blue, 3-prongs
Oxygen atom (O)	Atom model, red, 2-prongs
Oxygen atom (O)	Atom model, red, 1-prong
Covalent bond	Straws, white, flexible plastic, 3.5 cm
Hydrogen bond	Straws, white, rigid plastic, 3.5 cm

STEP 2

Construct a model of the base adenine using the materials provided and the illustration below as a blueprint.

Adenine

STEP 3

Construct a model of the base thymine using the materials provided and the illustration below as a blueprint.

Thymine

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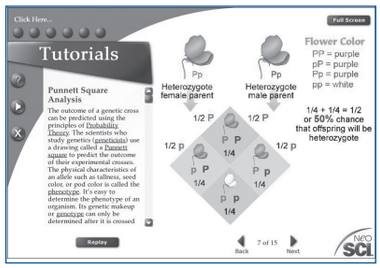
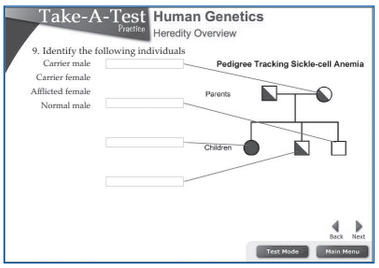
A Closer Look at the Curriculum Resource CD-ROM*…



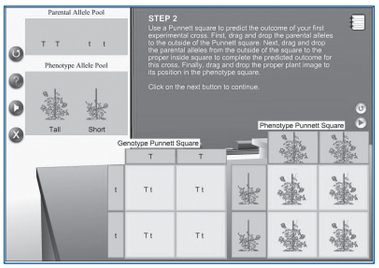
Content Tutorials

- Comprehensive tutorials offering self-paced, individualized lessons through illustrations and animations
- Hyper-linked glossary of key concepts and terms



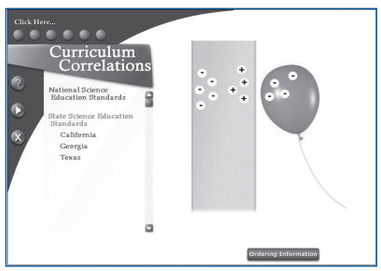
Assessment Monitoring

- Access test questions in either Practice or Test Mode to provide students with exam experience
- Create customized tests and worksheets with various question types, as well as dynamic multimedia tutorials and presentations—saving them on a disk or in web-ready format for easy Internet access



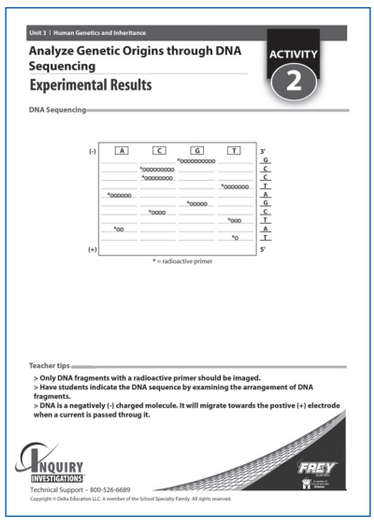
Virtual Laboratory

- Explore the object-based virtual lab environment. The virtual labs allow students to interactively perform every step of each lab activity by manipulating lab equipment on their virtual lab workbench.
- The electronic notebook allows students to record and analyze data.



Correlations to National and selected State Standards

- Key concepts correlated to the National Science Education Standards and 25 selected State standards linked to the Frey Scientific website (**www.freyscientific.com/inquiryinvestigations**)



Experimental Results

- Useful teacher tips for each activity, as well as in-depth experimental data analysis
- Graphs, tables, and images are provided to enhance each activity.

*CD-ROM System Requirements: Windows 2000 or higher, VISTA-compatible, Mac 9.2 or higher (including OSX), 128 MB RAM