

Lesson A7–2

Understanding the Basis for Biotechnology Research

Unit A. Agricultural Literacy

Problem Area 7. Recognizing the Impact of Technology on Agriculture

Lesson 2. Understanding the Basis for Biotechnology Research

New Mexico Content Standard:

Pathway Strand: Plant Systems

Standard: I: Apply principles of anatomy and physiology to produce and manage plants in both a domesticated and natural environment.

Benchmark: I-C: Explain and use basic methods for reproducing and propagating plants.

Performance Standard: 1. Determine the role of genetics in plants. 2. Describe the components and functions of plant reproductive parts. 3. Identify and practice methods of asexual/sexual propagation. 4. Describe the principles of plant micro-propagation. 5. Apply principles and practices of biotechnology to plant propagation.

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Identify and explain terms associated with genetics.
2. Identify the components of DNA and describe its structure.
3. Explain how DNA is replicated when cells divide.

List of Resources. The following resources may be useful in teaching this lesson:

Recommended Resources. One of the following resources should be selected to accompany this lesson:

Cooper, Elmer L. *Agriscience Fundamentals and Applications*. Albany, New York: Delmar Publishers, 1997. (Textbook, Unit 3)

Lee, Jasper S. and Diana L. Turner. *AgriScience*, Third Edition. Danville, Illinois: Interstate Publishers, Inc., 2003. (Textbook and Activity Manual, Chapter 15)

Biondo, Ronald J. and Jasper S. Lee. *Introduction to Plant and Soil Science and Technology*, Second Edition. Danville, Illinois: Interstate Publishers, Inc., 2003. (Textbook and Activity Manual, Chapter 4)

Other Resources. The following resources will be useful to students and teachers:

Plant Genetics III: Plant Reproduction and Heredity. University of Illinois, Urbana, Illinois: Vocational Agriculture Service.

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of Student Lab Sheets

Terms. The following terms are presented in this lesson (shown in bold italics):

Adenine
Alleles
Cell
Chromosomes
Cytosine
Dominant
Double helix
DNA
Genes
Genotype
Guanine
Heredity
Heterozygous
Homozygous
Meiosis
Mitosis
Mutation

Nucleic acid bases
Nucleotide
Nucleus
Phenotype
Recessive
Thymine

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Display to the class a length of spaghetti. Inform them that DNA is a long linear molecule. If the DNA from one cell was the diameter of the spaghetti, it would be long enough to go around the entire planet Earth.

Summary of Content and Teaching Strategies

Objective 1: Identify and explain terms associated with genetics.

Anticipated Problem: What terms are commonly used with genetics research?

- I. The basis of molecular biotechnology is the genetic material found in individual cells.
 - A. A *cell* is a basic unit of life containing living material bound by a membrane. The cell also contains genetic material.
 1. Within each cell there is a **nucleus** that contains genetic material.
 2. The long molecule that carries the genetic material is **DNA** or deoxyribonucleic acid.
 3. The DNA is organized into tightly coiled strands known as **chromosomes**.
 4. Segments of the chromosomes that code for specific traits of the organism are **genes**.
 - B. The genetic material in the cell determines the appearance of an organism and all chemical processes.
 1. Genes that govern variations of the same characteristics and that occupy corresponding locations on the chromosomes are **alleles**.
 2. Alleles may be dominant or recessive. The trait coded by a **dominant** allele is always expressed, while those of a **recessive** allele are only expressed when the two alleles are the same.
 3. When the two alleles are the same they are said to be **homozygous**. When they are different they are **heterozygous**.
 4. The genetic constitution of an organism is called the **genotype**. Genotype is most often expressed in symbols.
 5. The actual appearance of an organism with respect to the alleles is the **phenotype**.

Use TM: A7–2A and TM: A7–2B as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Use LS: A7–2A and LS: A7–2B to strengthen student understanding of gene expression. Relate the lab results to various aspects of agricultural biotechnology.

Use text material to strengthen student understanding of concepts. Unit 3 and Unit 28 in *Agriscience Fundamentals and Applications*, Chapter 15 in *AgriScience*, and Chapter 5 in *Introduction to Plant and Soil Science and Technology* are recommended.

Objective 2: Identify the components of DNA and describe its structure.

Anticipated Problem: What is the make up of DNA and how is it structured?

- II. The structure of the DNA molecule has made the reproduction and transfer of genetic material possible.
 - A. The building blocks of DNA are nucleotides.
 - 1. Each **nucleotide** molecule includes a phosphate group, sugar in the form of deoxyribose, and one of four nucleic acid bases. Long chains of nucleotides make up DNA.
 - 2. The **nucleic acid bases** in nucleotides include **adenine**, **cytosine**, **guanine**, and **thymine**. How the nucleic acid bases are arranged on the DNA molecule determines the functions of the genes.
 - B. The structure of a DNA molecule is extremely long and linear.
 - 1. The arrangement of the nucleotides creates a **double helix** or a twisted ladder appearance.
 - 2. Adenine always pairs with thymine, and cytosine always pairs with guanine.

Use text material to strengthen student understanding of concepts. Unit 3 in *Agriscience Fundamentals and Applications*, Chapter 15 in *AgriScience*, and Chapter 5 in *Introduction to Plant and Soil Science and Technology* are recommended.

TM: A7–2C and TM: A7–2D can be used in class as visual material for lecture and discussion. An alternative approach is to transfer the information from the transparency masters to a multimedia presentation. Laboratory experiments “Constructing a DNA Model” and “Extracting DNA from Wheat Germ” found in the *Introduction to Plant and Soil Science Activity Manual* provide hands-on activities to reinforce student understanding of the structure of DNA.

Objective 3: Explain how DNA is replicated when cells divide.

Anticipated Problem: How is DNA replicated when cells divide?

- III. Replication of DNA allows for duplication of individual cells and reproduction of species.
 - A. New cells in an organism created through division must carry the same genetic material as the parent cell.

1. Cellular division resulting in exact duplicate cells is **mitosis**.
 2. Cellular division resulting in sex cells is **meiosis**.
 3. During replication, the DNA molecule basically unzips and a copy is made.
- B. Replication of DNA is vital for all life.
1. Passing genetic material on to offspring through sexual reproduction is known as **heredity**.
 2. Sometimes genetic material of the DNA molecule is not copied accurately. This is called a **mutation**.

Make an overhead transparency or create a multimedia presentation from TM: A7–2E. Use the transparency or multimedia presentation as visual material for lecture and discussion. Recommended text materials include Unit 3 in Agriscience Fundamentals and Applications, Chapter 15 in AgriScience, and Chapter 5 in Introduction to Plant and Soil Science and Technology.

Review/Summary. Focus the review and summary of the lesson around the student learning objectives. Call on students to explain the content associated with each objective. Use their responses as the basis for determining any areas that need reteaching. Questions at the end of each chapter in the recommended textbooks may also be used in the review/summary. Use the lab activities in reviewing and reinforcing student learning.

Application. Application can involve one or more of the following student activities using attached lab sheets:

Transmission of Characteristics—LS: A7–2A

Inheritance of Physical Characteristics LS: A7–2B

Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1=g, 2=i, 3=d, 4=f, 5=j, 6=e, 7=c, 8=h, 9=b, 10=l, 11=k, 12=a

Part Two: Completion

1=adenine, cytosine, guanine, thymine

2=Recessive

3=heterozygous

4=genotype

5=mitosis

6=nucleus

7=DNA, deoxyribonucleic acid

8=chromosomes

9=genes

Test

Lesson A7–2: Understanding the Basis for Biotechnology Research

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

- | | | |
|----------------|-----------------|---------------|
| a. alleles | e. double helix | i. meiosis |
| b. cell | f. genes | j. mutation |
| c. chromosomes | g. heredity | k. nucleotide |
| d. dominant | h. homozygous | l. phenotype |

- _____ 1. Passing characteristics on to offspring through sexual reproduction.
- _____ 2. Cellular division resulting in sex cells.
- _____ 3. The trait coded by an allele that is always expressed.
- _____ 4. Segments of the chromosomes that contain the traits of the organism.
- _____ 5. Genetic material of the DNA molecule not copied accurately.
- _____ 6. The twisted ladder structure of DNA.
- _____ 7. Tightly coiled strands of DNA.
- _____ 8. When the two alleles are the same.
- _____ 9. The basic unit of life containing living material bound by a membrane.
- _____ 10. The actual appearance of an organism with respect to the alleles.
- _____ 11. A molecule that includes a phosphate group, sugar in the form of deoxyribose, and one of four nucleic acid bases.
- _____ 12. Genes that govern variations of the same characteristics and that occupy corresponding locations on the chromosomes.

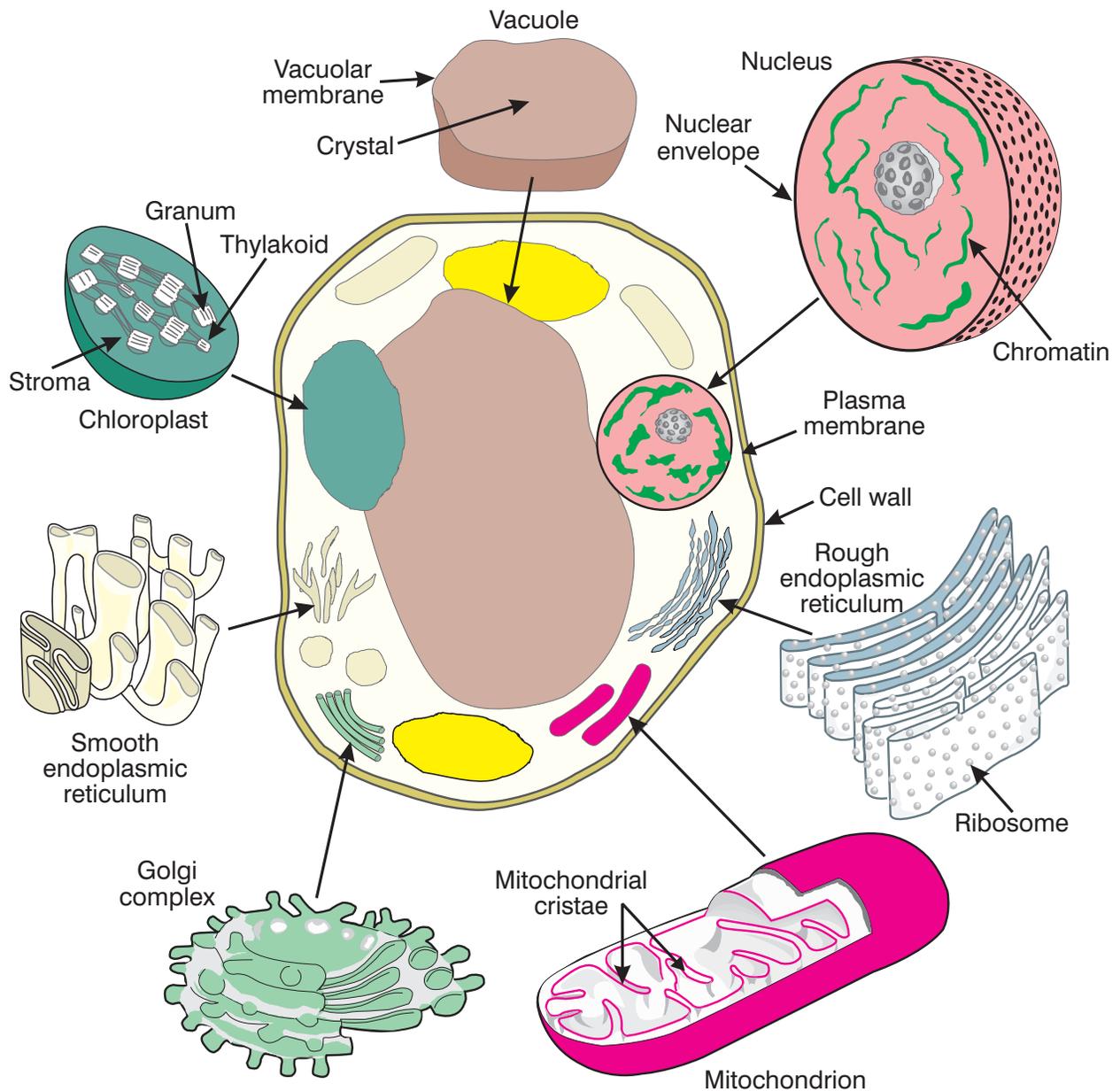
Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

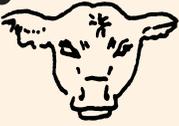
1. The four nucleic acid bases in nucleotides are _____, _____, _____, and _____.

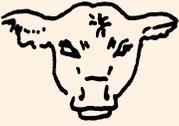
2. _____ alleles are only expressed when the two alleles are the same.
3. When alleles are different they are _____.
4. The genetic constitution of an organism is called the _____.
5. Cellular division resulting in exact duplicate cells is _____.
6. Within each cell there is a _____ that contains genetic material.
7. The long molecule that carries the genetic material is _____ or _____.
8. DNA is organized into tightly coiled strands known as _____.
9. Segments of the chromosomes that contain the traits of the organism are _____.

A Plant Cell



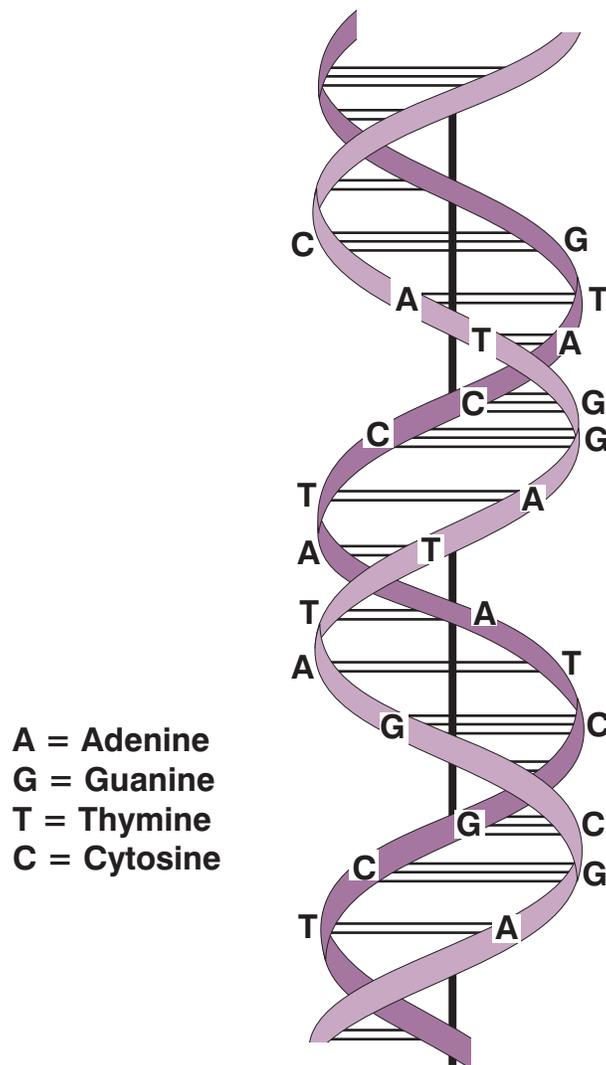
A Diagram for Determining the Probable Results from a Dominant and Recessive Character

		Male	
		P	P
Female	p	Pp  (Polled - Impure)	Pp  (Polled - Impure)
	p	Pp  (Polled - Impure)	Pp  (Polled - Impure)

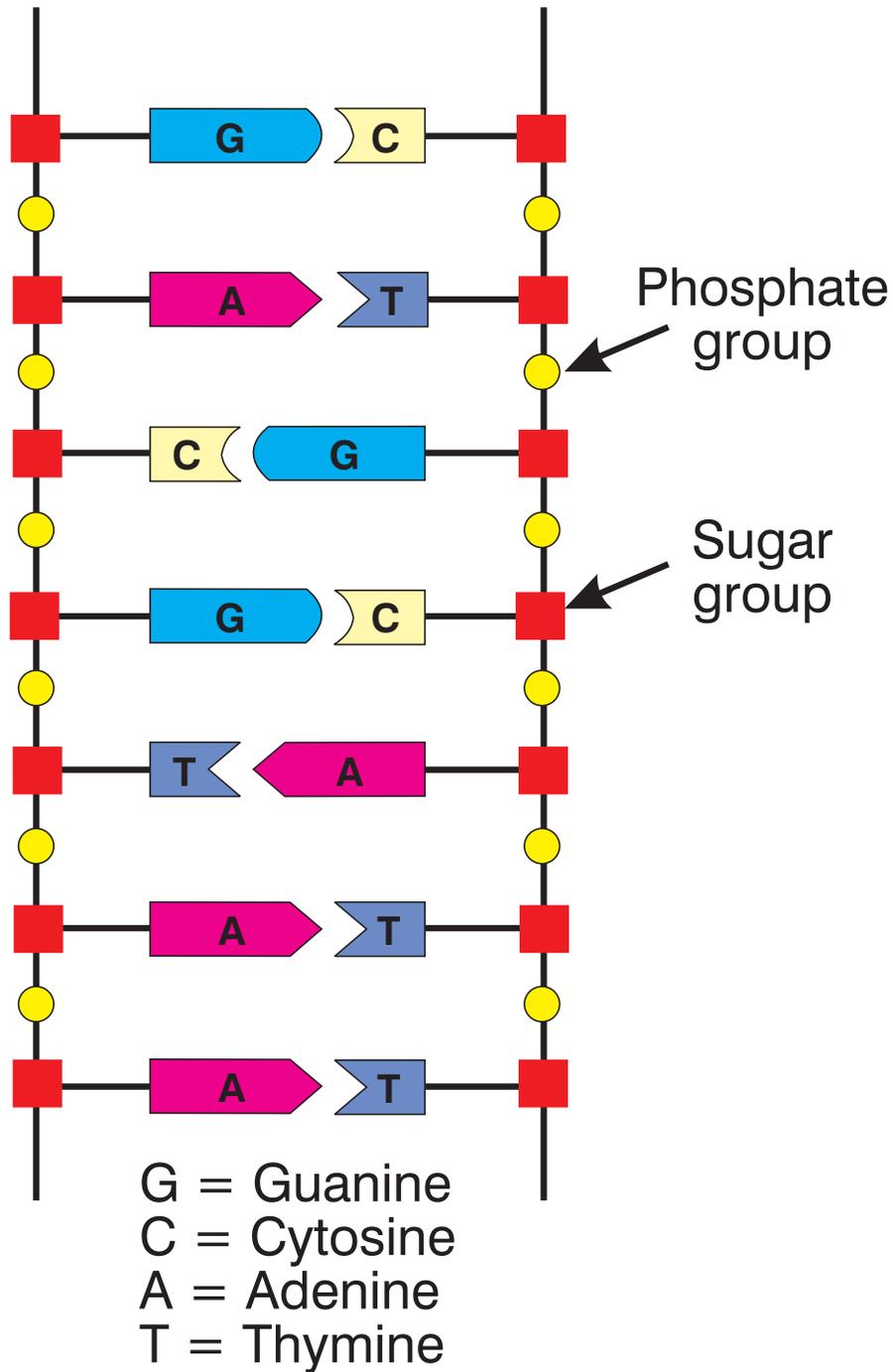
		Male	
		P	p
Female	P	PP  (Polled - Pure)	Pp  (Polled - Impure)
	p	Pp  (Polled - Impure)	pp  (Horned - Pure)

Structure of DNA

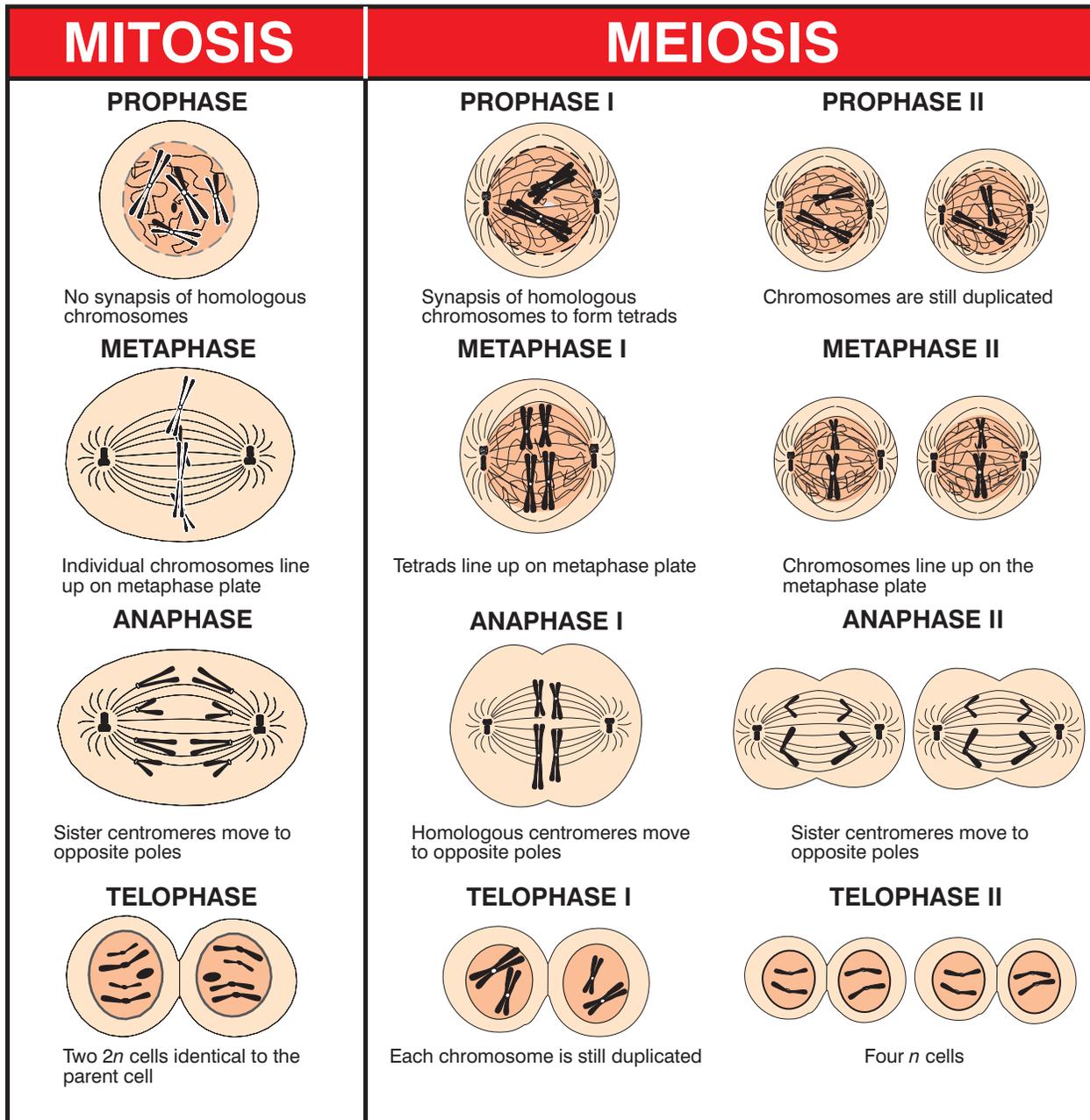
- Chromosomes contain long strands of DNA
- DNA consists of two strands of nucleotides, joined by hydrogen bonds and twisted into a double helix
- Every DNA nucleotide contains a sugar, a phosphate group, and a base
- Adenine only lines with Thymine; Guanine only lines with Cytosine



Nucleotides Bond to Form Double Helix



Mitosis and Meiosis



Lab Sheet

Transmission of Characteristics

Fill out the chart above for the possible characteristics from the following mating: The bull is homozygous for black (BB) and the cow is homozygous for black (BB). Indicate whether the offspring will be homozygous (pure) or heterozygous (impure).

Fill out the above chart for the possible characteristics from the following mating: The bull is homozygous for black (BB) and the cow is heterozygous for black (Bb). Indicate whether the offspring will be homozygous (pure) or heterozygous (impure).

Fill out the above chart for the possible characteristics from the following mating: The bull is heterozygous for black (Bb) and the cow is heterozygous for black (Bb). Indicate whether the offspring will be homozygous (pure) or heterozygous (impure).

Lab Sheet

Inheritance of Physical Characteristics

Tongue Rolling

Many people can turn the sides of their tongues so that, near the tip, the sides nearly touch on top (Figure 1). When everyone in the class has tried to do this, record the results in Table 1. Also record the data of other class sections and determine the percentages of “rollers” and “nonrollers.” Percentages, however, will not tell you whether the ability to roll the tongue is inherited or, if it is inherited, whether a dominant or recessive gene is involved. To learn this, determine how many members of your family have this trait and record your findings in Figure 3. Write the symbol (+) in the circle or square to indicate an individual who can roll his or her tongue and the symbol (–) for one who cannot do this.

Using *T* to represent the dominant character and *t* the recessive character, indicate the genotype (that is, *TT*, *Tt*, *tt*) of each member of your family.

To aid you in deciding on the method of inheritance, it may be helpful to examine the inheritance of hair color in human beings, as illustrated in Figure 2. For example, it is possible for two parents who do not have red hair to have a child who does. However, because there are genes at two loci producing red hair in humans, two red-haired parents could have children who do not have red hair. This is not common, however, because the second locus is rather rare in the population.

Using the information you have collected, indicate whether the ability to roll the tongue is inherited as a dominant or recessive gene.

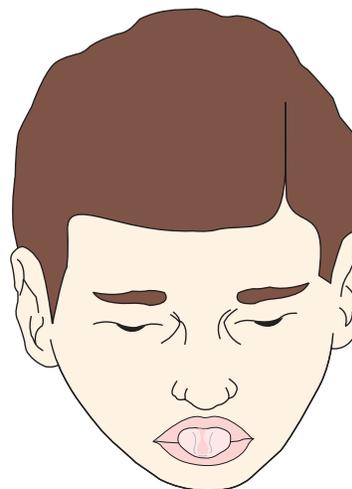


Figure 1 Tongue rolling

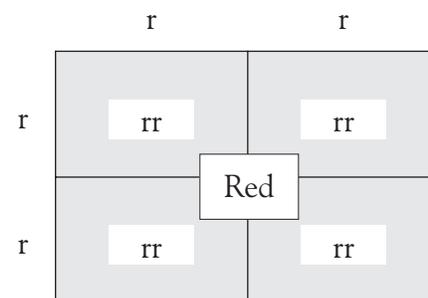
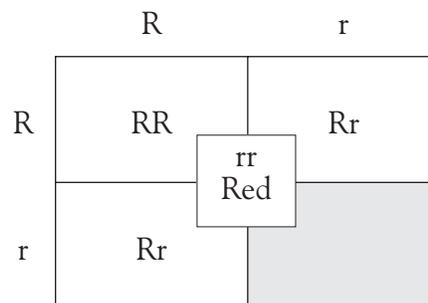
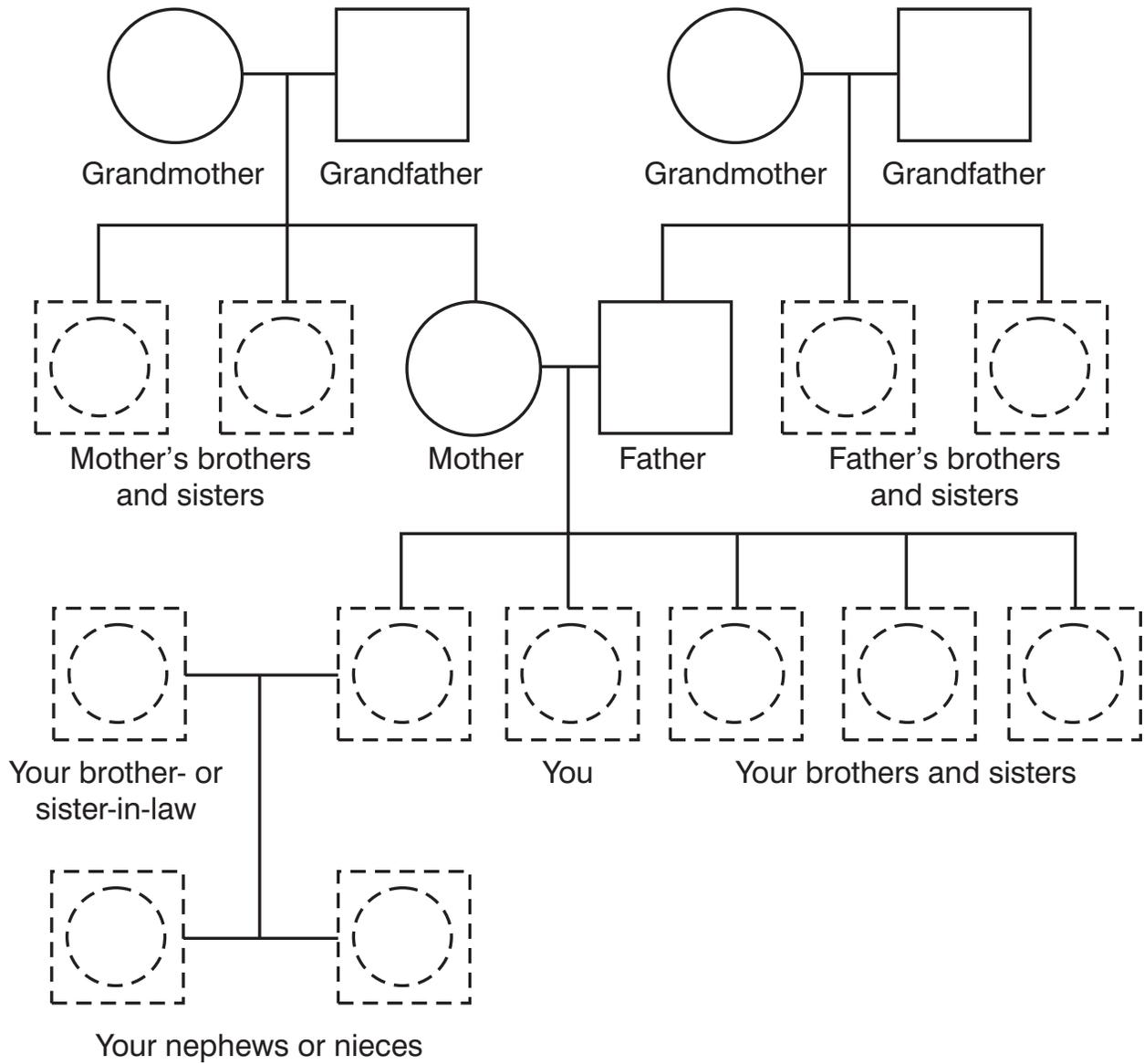


Figure 2 Inheritance of hair color



Connect dashes to make solid-line squares for males and solid-line circles for females as follows:



Table I Analysis of the ability to roll the tongue

Class section number	# of students	# of tongue rollers	# of nonrollers	% rollers	% nonrollers
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					