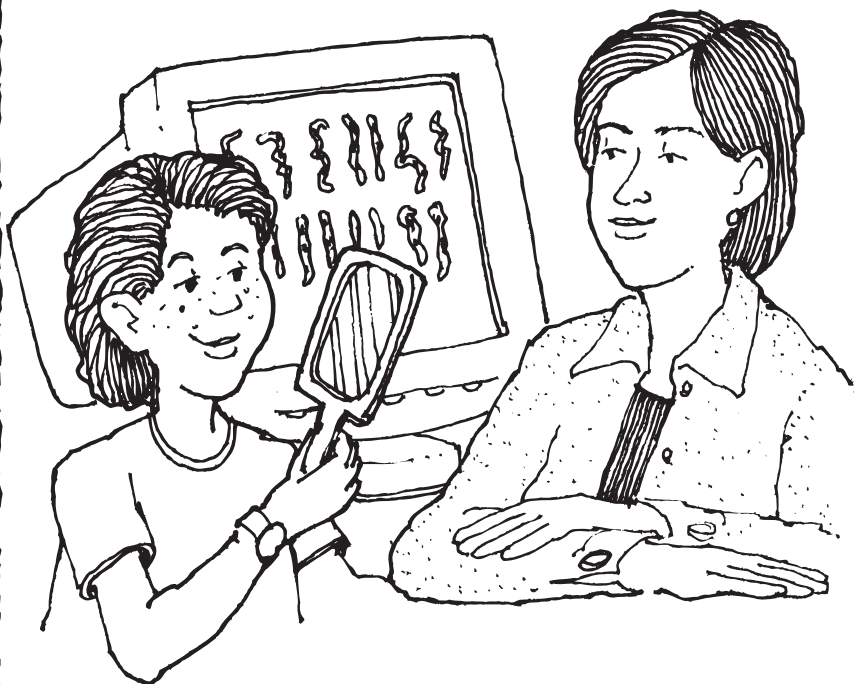


# GENETIC COUNSELOR



**ACTIVITY BOOK**



# Genetic Counselor Activity Book

.....

This book features five hands-on activities designed for 8- to 12-year-olds. Each activity includes one 30- to 45-minute project and extensions. Activities can be used in any order. Also included are objectives and learning outcomes, assessment questions, ideas for a presentation or exhibit and topics for further investigation. Wonderwise learning outcomes are based on national science education standards identified by McREL (Mid-continent Research for Education and Learning), the Nebraska Educational Standards, and the National Science Education Standards developed under the direction of the National Research Council. This book incorporates concepts of inquiry-based learning and the 4-H Youth Development experiential learning model.

**Each youth participant should receive a copy of the activities. Copies of this book can be downloaded from the Genetic Counselor CD-ROM.**

## **WONDERWISE** **Women in Science Learning Series**

Wonderwise introduces you to women who have made science their career. Each kit is a comprehensive instructional package that includes a video, CD-ROM, and activity book. With these materials, leaders and youth explore the world of women scientists and discover together the fun of learning about science. For more information about Wonderwise, including free samples, Web activities, resources, science education standards and ordering information, visit our Web site:

**wonderwise.unl.edu**



**Project Directors:** Judy Diamond and Gary Heusel **Developer:** Linda Allison **Design/Illustration:** Michael Davis, Linda Allison **Produced by:** University of Nebraska State Museum and the Nebraska Cooperative Extension 4-H Youth Programs. Thanks to Cathy Burson, Shawn Carlson and the F Street Community Center, Catherine P. Chia, Ph.D., Beth Conover, Sarah Disbrow, Kathy French, Sandra Frerichs, Brad Schaefer, Amy N. Spiegel, Peggy Sugars and 6th graders at Lake School. Mating Game was inspired by the "Make A Face" activity developed by Thomas Atkins and Joyce Roderick. Thanks to Megan Brown at the Genetics Project at the University of Washington for use of data from their Genetic Traits Database. Thanks to Larry Phelps from the University of Wisconsin for permission to use his karyotypes.

.....



**Funded by the Informal Science Education Program of the National Science Foundation**

# TABLE OF CONTENTS

## MEET CATHY /ACTIVITY ONE ..... 2

Watch a video about genetic counselor Cathy Burson and then explore your genetic features.

Learning Outcomes: Youth learn to use simple tools to gather scientific data and develop an understanding of a scientist's work.

## ALIKE AND DIFFERENT /ACTIVITY TWO ..... 7

Discover what's different and the same about you and your group.

Learning Outcomes: Youth learn to collect and interpret data, and develop an understanding of sampling populations.

## MATING GAME /ACTIVITY THREE ..... 14

Meet mom and pop Smiley Face genomes and mate some genes to make a new baby.

Learning Outcomes: Youth develop an understanding of gene expression and heredity.

## WHAT SORT? /ACTIVITY FOUR ..... 22

Meet a cheek cell, say hello to chromosomes, and complete a human chromosome chart.

Learning Outcomes: Youth develop an understanding of the cell, reproduction, and heredity.

## INSIDE DNA/ACTIVITY FIVE ..... 34

Build a model gene using gumdrops and licorice and learn some secrets of DNA.

Learning Outcomes: Youth develop an understanding of living systems and their most basic structures.

## PULLING IT ALL TOGETHER ..... 40

Create a story about a scientist who is a genetic counselor.

Learning Outcomes: Youth draw on what they have learned in the activities to construct their own understanding of what it means to be a scientist.

## NEW WONDERS ..... 41

Here are some ideas for projects or exhibits.

Learning Outcomes: Youth develop an understanding of science and technology in society and of science as a human endeavor.

# INFORMATION FOR LEADERS

## What You Will Need for Each Activity

Each youth participant should receive a copy of the activities. Listed below are the materials and preparations you will need for each activity. Most of the materials can be purchased locally. The more difficult-to-find items can be purchased from Wonderwise. The symbol © indicates that an item can be ordered from the Wonderwise Web site or GPN, the Wonderwise distributor. To purchase supplies, kits, videos, or CD-ROMs contact:

GPN (Great Plains National)  
P.O. Box 80669 ▪ Lincoln, NE ▪ 68501-0669  
Phone: 1-800-228-4630 ▪ FAX: 1-800-306-2330  
e-mail: gpn@unl.edu ▪ Web site: gpn.unl.edu

<b>Activity 1</b> Meet Cathy	<b>Activity 2</b> Alike and Different	<b>Activity 3</b> Mating Game	<b>Activity 4</b> What Sort?	<b>Activity 5</b> Inside DNA
<p><b>For the entire group:</b></p> <ul style="list-style-type: none"> <li>© 16-min. video <i>Cathy Burson, Genetic Counselor</i></li> <li>video player and television</li> </ul> <p><b>For each person:</b></p> <ul style="list-style-type: none"> <li>pencil</li> </ul>	<p><b>For each team of 2:</b></p> <ul style="list-style-type: none"> <li>2 pencils</li> <li>mirror</li> </ul>	<p><b>For each team of 2:</b></p> <ul style="list-style-type: none"> <li>scissors</li> <li>pencil</li> <li>crayons, markers, or colored pencils (yellow, orange, and blue)</li> <li>tape or glue</li> </ul> <hr/> <ul style="list-style-type: none"> <li>1 copy of <i>Smiley Mother's Genes</i> (p. 16) on colored paper</li> <li>1 copy of <i>Smiley Father's Genes</i> (p. 17) on different colored paper</li> </ul>	<p><b>For each person:</b></p> <p><b>Part one</b></p> <ul style="list-style-type: none"> <li>tape</li> <li>scissors</li> <li>colored pencil</li> <li>thread 2 meters long (6 feet)</li> <li>pencil</li> </ul> <p><b>For each team of 3:</b></p> <p><b>Part two</b></p> <ul style="list-style-type: none"> <li>scissors</li> <li>tape</li> <li>pencil</li> </ul> <hr/> <ul style="list-style-type: none"> <li>1 copy of <i>Baby's Chromosomes</i> (p. 28)</li> </ul>	<p><b>For each team of 2:</b></p> <p><b>Part one</b></p> <ul style="list-style-type: none"> <li>6 black licorice pieces, 1 cm (½ in)</li> <li>6 red licorice pieces, 2 cm (1 in)</li> <li>6 gumdrops (any 3 color pairs: for example, purple always pairs with green and white always pairs with yellow)</li> <li>six 16 cm (6 in) pieces of bead sculpture wire (plastic coated wire) or pipe cleaners</li> <li>6 toothpicks</li> <li>scissors</li> <li>cm ruler</li> </ul> <p><b>Part two</b></p> <ul style="list-style-type: none"> <li>another complete set of licorice, gumdrops, wire, and toothpicks</li> <li>colored pencils or crayons (that match the gumdrop colors)</li> </ul>

# MEET CATHY

ACTIVITY  
ONE

Watch the 16-minute video of Cathy Burson, genetic counselor, at work in a hospital clinic. Then find a partner and explore some of your genetic features.



## Before You Begin

Length:  
Part I - 30 mins.  
Part II - 30 mins.

## What You Need

### For the entire group:

© 16-min. video *Cathy Burson, Genetic Counselor*

- video player and television

### For each person:

- pencil

**What We Know.** Meet Cathy Burson, genetic counselor. Cathy works in a hospital clinic, where she sees people of all ages.

Adults and kids visit her with different kinds of health problems that might be passed on from one generation to the next. You probably know that we inherit features such as our hair or eye color from our parents. Some health problems are also inherited.

Features are passed to us through our **genes**. Not like the blue jeans that you wear, these genes are found inside your body's cells. Just like a broken engine part, if a gene is broken, it can create problems for the whole body.

Part of Cathy's work is figuring out if a gene is

causing a problem. Another part of her work is counseling her patients about treatments. Sometimes she sees adults to find out if their genes might cause problems for their baby if they decide to have one.

Cathy enjoys her job because it is part detective work, part people work, and part science. It is a new field where discoveries are made every day. To do her job well she constantly needs to learn new things and how to use new tools.

One of Cathy's tools is a picture of a person's genes taken with a microscope and colored dyes. Another tool is a chart of a family and the diseases that are present from one generation to the next.

# MEET CATHY

ACTIVITY  
ONE

## Part One: Meet Cathy

- 1 Watch the 16-minute video about genetic counselor Cathy Burson. Discuss what it is like to help people find out about their genes.

### Think It Over



List some activities that make up the work of a genetic counselor:

1.

2.

3.

## Part Two: People Up Close

Learn some of the features of another person. A feature is a part of your body or behavior that comes from your genes. Are you ready to explore some of your personal features?

- 1** Find a partner. One person will play the role of a genetic counselor; the other will act as the patient. The counselor will use the Genetic Survey (p. 5). Put the patient's name on the survey.
- 2** Check the patient's personal features listed on the Genetic Survey. Also fill in the **Special Features** box. List things like being allergic to cats, having a brown eye and a blue eye, or being able to write with either hand.
- 3** Now review the features on the Genetic Survey. Which features does your partner share with her mom or dad? Record these features in the **Family Survey** box (see p.5).
- 4** Switch roles. Repeat steps 1 to 3 using your partner's Genetic Survey.




# MEET CATHY

ACTIVITY  
ONE

## GENETIC SURVEY

Patient's Name: \_\_\_\_\_

Check or complete the box if the patient has that feature:

Male <input type="checkbox"/>	Eye color _____	Hair color _____
Female <input type="checkbox"/>		
Hair type      Wavy <input type="checkbox"/> Very Curly <input type="checkbox"/> Straight <input type="checkbox"/>	Handedness      Right <input type="checkbox"/> Left <input type="checkbox"/>	Height              Short <input type="checkbox"/> Medium <input type="checkbox"/> Tall <input type="checkbox"/>
Dimples  <input type="checkbox"/>	Freckles  <input type="checkbox"/>	Allergies <input type="checkbox"/>
Cleft in chin  <input type="checkbox"/>	Long second toe (at least as long as the big toe)  <input type="checkbox"/>	Need glasses  <input type="checkbox"/>
Talents & Abilities	Good at music <input type="checkbox"/>	<b>Special Features</b> _____ _____ _____ _____ _____
Can wiggle ears <input type="checkbox"/>	Good at art <input type="checkbox"/>	
Can touch tongue to nose <input type="checkbox"/>	Good at sports <input type="checkbox"/>	
Can bend thumb to touch wrist <input type="checkbox"/> 	Good at science <input type="checkbox"/>	
	Good at _____ <input type="checkbox"/>	
	Good at _____ <input type="checkbox"/>	

### Family Survey

Which of these features might be inherited from your father or your mother?



# MEET CATHY

ACTIVITY  
ONE

**Think It Over**



List five features that come from your genes.

1.

2.

3.

4.

5.

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

**You are like everybody else on earth, and you are like nobody else. Today you are invited to investigate some of the features that make you alike and different.**



## Before You Begin

Length:  
Part I - 10 mins.  
Part II - 30 to 40 mins.

## What You Need

For each team:

- 2 pencils
- mirror

**What We Know.** You are made of millions of tiny units called cells that are invisible to the naked eye. Inside each cell is a long strand of material called DNA. The DNA in each cell contains the instructions for making an entire human being. You could say that DNA is the recipe for making you. You may not know how tall you'll be when you grow up, but your DNA does.

The instructions are carried on sections of the DNA called genes. Genes control not only how tall you'll grow, but also other things in your

personal makeup like the curl of your hair or the shape of your toes or the wideness of your smile. Your particular combination of genes is unique. No other person in the world has your exact recipe (unless you have an identical twin).

The astonishing fact, however, is that 99 percent of your DNA recipe is exactly the same as every other human's. In fact, humans share most of the DNA recipe with other creatures on earth like leopards, lizards, ladybugs, and lice.

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

## Part One: How Alike Are You?

The human genetic recipe inside each of your cells is about the same in every human being. Take a few minutes to consider how alike you are.

- 1 Pick a partner.
- 2 Together with your partner list all the ways that you and your partner are the same.



### SAMENESS SURVEY

Note your physical features like number of fingers, toes, and eyes. Also consider abilities and the things you need to survive. For example...

We both breathe air.

We both have eyebrows.

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

**Think It Over**



Which features on your list are shared by all humans?

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

## Part Two: How Different Are You?

Thousands of genes make up the recipe that is you. There is plenty of room in the recipe for differences among people. Consider just how different you are by checking out a few of your more visible features.

- 1 Work with a partner.
- 2 Use the Differences Survey on page 11 to record your partner's features. To record each feature, circle the word at the bottom of each box that describes your partner. Hint: Have your partner use a mirror to doublecheck his or her own features.
- 3 Trade roles. It is your partner's turn to do the survey on you.



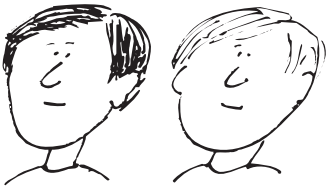

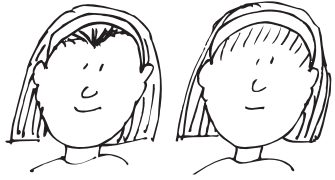
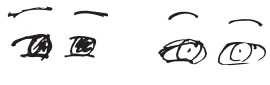


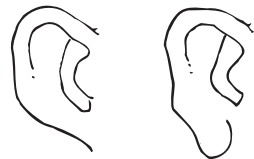
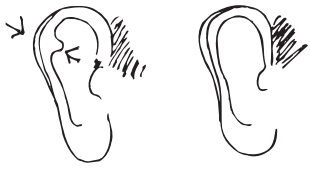
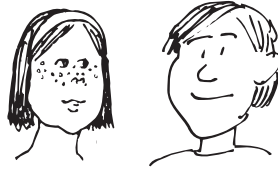
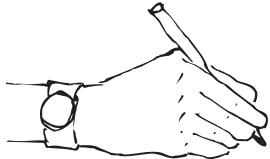
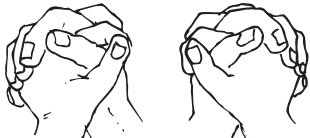

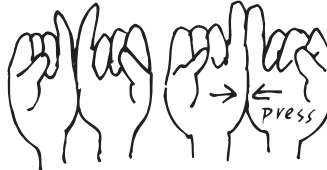


# ALIKE AND DIFFERENT

ACTIVITY  
TWO

## DIFFERENCES SURVEY

Partner's Name: \_\_\_\_\_

Survey your partner. Circle one word at the bottom of each box.

<b>Hair Color</b>  Dark      Light	<b>Hair Waves</b>  Straight      Curly	<b>Widow's Peak</b> Hairline dips vs. straight  Yes      No
<b>Eye Color</b> Black or brown vs. blue, green, hazel or gray  Dark      Light	<b>Dimples</b>  Yes      No	<b>Nose Shape</b>  Turned Up      Straight
<b>Ear Lobes</b> Lobes connected or not?  Yes      No	<b>Ear Points</b>  Yes      No	<b>Freckles</b>  Yes      No
<b>Handed</b> Which hand do you write with?  Left      Right	<b>Thumbed</b> Clasp hands. Which thumb lands on top?  Left      Right	<b>Finger Hair</b> Hair on middle knuckle?  Yes      No
<b>Bent Little Finger</b>  Yes      No	<b>Tongue Folding</b> Can you fold the tip back?  Yes      No	<b>Tongue Rolling</b> Roll it into U shape?  Yes      No

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

## Part Two: How Different Are You (cont'd)

- 4** Gather into one group. Using your Differences Surveys, count how many your group has...

Ear lobes connected?    # Yes \_\_\_\_\_ # No \_\_\_\_\_

Ability to roll tongue into a U shape?    # Yes \_\_\_\_\_ # No \_\_\_\_\_

- 5** Put your group totals into the Summary Table below to see how your group compares to kids from other places.

### SUMMARY TABLE

Ear Lobes Connected?	Yes	No
Your group's total		
Other kids' totals	103	239
Tongue in a U Shape?	Yes	No
Your group's total		
Other kids' totals	276	86

- 6** When one feature occurs much more often than another, it is called **dominant**. Look at the other kids' totals on the Summary Table.

Which is dominant, connected ear lobes or not connected? \_\_\_\_\_

Which is dominant, rolling tongue in a U shape or not? \_\_\_\_\_

# ALIKE AND DIFFERENT

ACTIVITY  
TWO

**Think It Over**



Do you think that more people in your  
community are left or right handed?

Why?



# MATING GAME

ACTIVITY  
THREE

**Smiley Faces are simple creatures with a simple set of genes. Mix and sort Smiley's genes to create your own Smiley Face baby.**



## Before You Begin

**Teams of 2**

Length:  
45 minutes

## What You Need

**For each team of 2:**

- scissors
- pencil
- crayons, markers, or colored pencils (yellow, orange, and blue)
- tape or glue

▪ 1 copy of *Smiley Mother's Genes* (p. 16) on colored paper

▪ 1 copy of *Smiley Father's Genes* (p. 17) on different colored paper

**What We Know.** You might have noticed that some human features seem to be more common (like brown eyes and right handedness) while others are more rare (red hair and lefties). There is a reason for this.

You inherited two sets of genes, one from your mother and one from your father. How does your body choose which genes to use? Certain features usually win out or dominate over others. Suppose your father has blue eyes and your mother has brown eyes. Brown eyes are dominant, so the

chances are you'll have brown eyes like your mother.

There are thousands of genes (instructions) in the recipe that makes you. These genes work in combination to make the vast variety of tall, short, smart, dark, blond, curly humans possible.

Today you will mate some genes that decide facial features. Then you will create the face of your own "baby" and explore the range of different faces these genes can make.

# MATING GAME

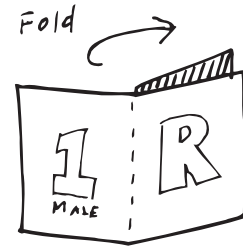
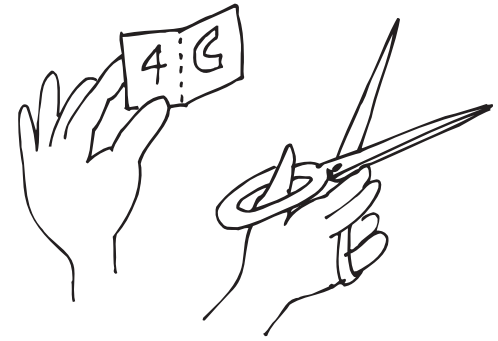
ACTIVITY  
THREE

## Make a Smiley Face Baby

Today you will work with a Smiley Face, a simple creature who has only a few genes. Get ready to become the proud parents of Smiley Face baby.

### Mix and Mate

- 1** Find a partner. Get one Smiley Mother's Genes (p. 16) and one Smiley Father's Genes (p. 17).
- 2** Cut out all the cards (you should have 24 gene cards).
- 3** Fold each gene card in half so that the letters and numbers show on the **outside**. Toss all the cards together in a pile. Really mix them up.
- 4** Sort the gene cards by number into six piles. Group the ones, twos, etc. together.
- 5** Choose two gene cards from each pile: One from the mother and one from the father. These are **gene pairs**. Now you have six pairs altogether. Put all the other gene cards aside.



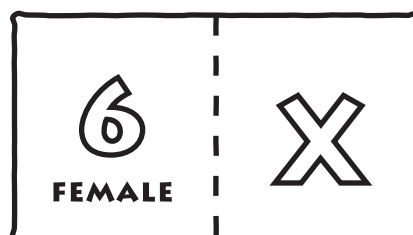
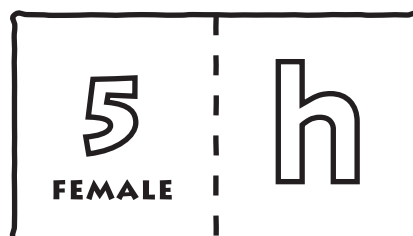
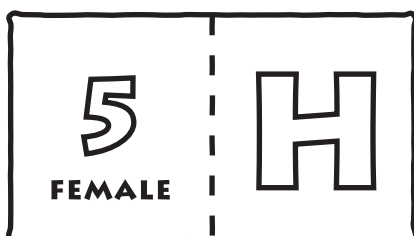
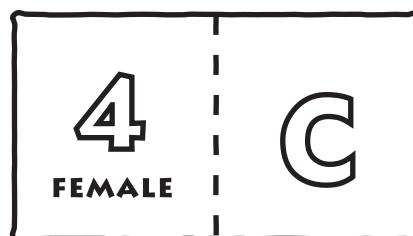
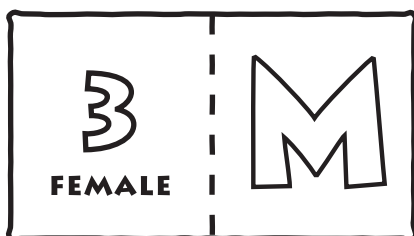
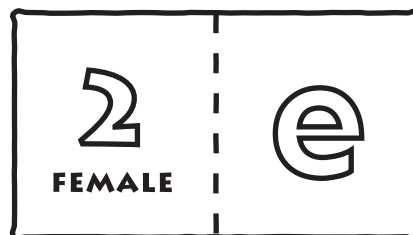
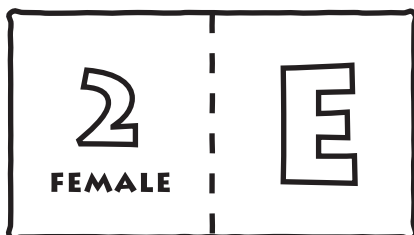
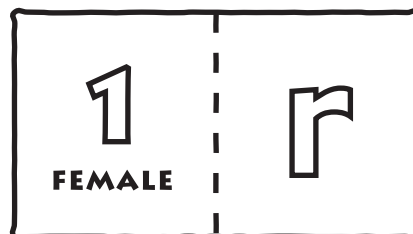
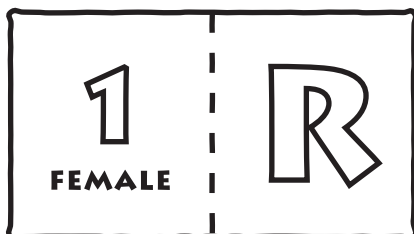
**Good work. You now have all the genes you need to create your Smiley Face baby.**



# MATING GAME

ACTIVITY  
THREE

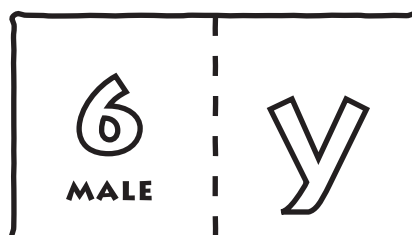
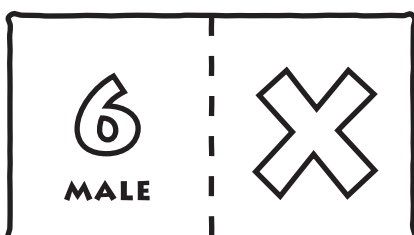
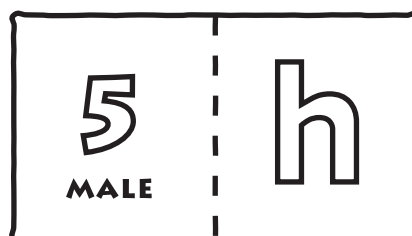
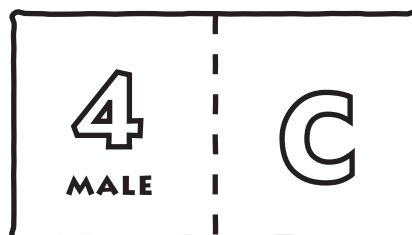
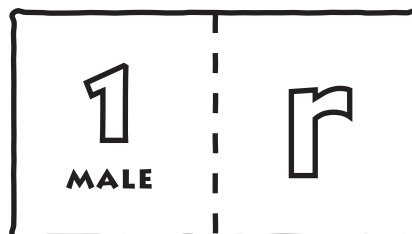
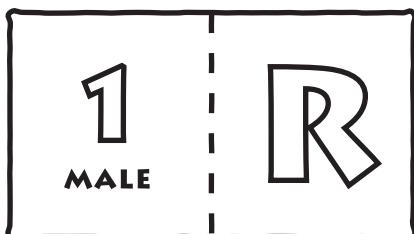
## SMILEY MOTHER'S GENES



# MATING GAME

ACTIVITY  
THREE

## SMILEY FATHER'S GENES



# MATING GAME

ACTIVITY  
THREE

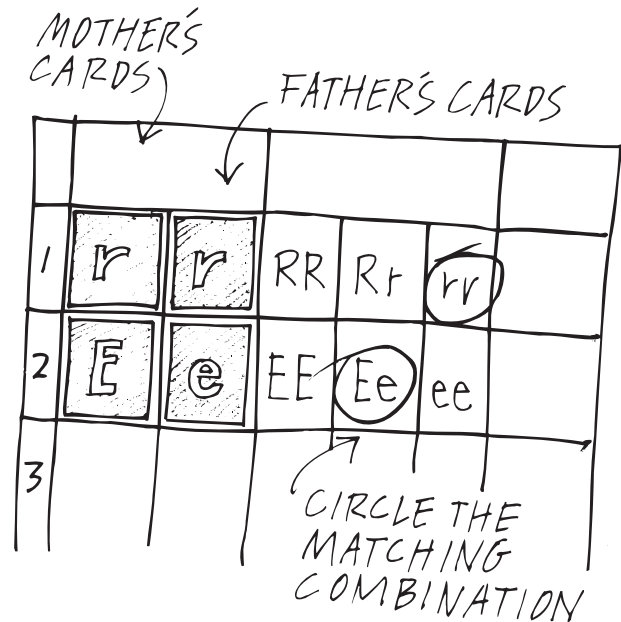
## Make a Smiley Face Baby (cont'd)

### Make the Face

**6** Use the Mating Game Results on p. 19. Tape the gene pairs to the Mating Game Results in the gene pair slots under mother and father.

**7** Read the information (letter codes) from each gene pair card. Circle the gene pair code in one of the next boxes that matches your gene cards.

**8** Record the word that describes your Smiley Face baby's feature in the Genetic Results box.



**Hint: For face shape if you have**  
RR write "round" in the last column  
Rr write "round" in the last column  
rr write "square" in the last column

**9** Good work. Ready to meet your baby face to face? Go to Your Offspring's Face on p. 20, and in the left column, circle the features expressed by your genes. Refer to your Mating Game Results form.

**10** Now you are ready to draw. Start with the face shape. Draw each feature on the list according to your baby's genes. Work your way down the list. Add something to your picture to show if your baby is a girl or a boy. Name your Smiley Face baby.

**11** Make a prediction: Do you think your Smiley Face baby will look like everyone else's? \_\_\_\_\_

**12** Now post all of the pictures of the Smiley Face babies together where everyone can see them. Compare the faces of the other newborn Smileys. Was your prediction correct? \_\_\_\_\_

# MATING GAME

ACTIVITY  
THREE

## MATING GAME RESULTS

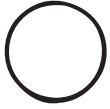
	GENE PAIRS Tape the cards in place.		Circle the gene combination that matches your cards.			GENETIC RESULTS Record the word that describes your baby.
	Mother's genes	Father's genes				
1.			Round RR	Round Rr	Square rr	1. Face Shape
2.			Tiny EE	Tiny Ee	Big ee	2. Eyes
3.			Wide MM	Wide Mm	Narrow mm	3. Mouth
4.			Yellow CC	Orange Cc	Blue cc	4. Skin Color
5.			None HH	None Hh	Thick hh	5. Hair
6.			Female XX	Male Xy		6. Sex

# MATING GAME

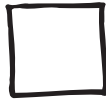
ACTIVITY  
THREE

## YOUR OFFSPRING'S FACE

### 1. Face Shape



Round



Square

### 2. Eyes



Tiny



Big

### 3. Mouth



Wide



Narrow

### 4. Skin Color



Yellow



Orange



Blue

### 5. Hair

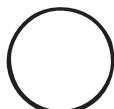


Bald

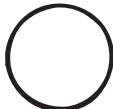


Thick

### 6. Sex



Male



Female

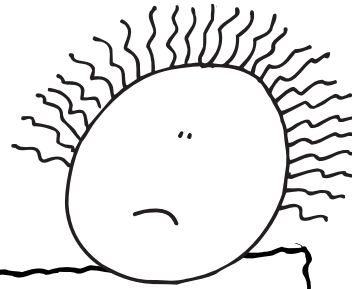
Use your genetic information to draw your offspring's face. Add something to show if your baby is a girl or a boy.

Name your offspring \_\_\_\_\_

# MATING GAME

ACTIVITY  
THREE

## Think It Over



If your Smiley Face baby was born female with thick hair and tiny eyes, your baby has a good chance of developing an upsidedown smile. How would you feel if your baby had Upsidedown Smile Syndrome?

If you could change the genes so no Smiley Face baby would ever be born with Upsidedown Smile Syndrome, would you do it?

Why or why not?



# WHAT SORT?

ACTIVITY  
FOUR

**Meet the chromosomes. These tiny bits of DNA may look like crumpled up tube socks, but they carry all the instructions necessary to make an entire human. Chromosomes can tell a lot about the person they belong to. Learn how now.**



## Before You Begin

**Work alone and in teams of 3**

Length:

Part I - 25 mins.

Part II -30 mins.

## What You Need

**For each person:**

### Part one

- tape
- scissors
- colored pencil
- thread 2 meters long (6 feet)
- pencil

**For each team of 3:**

### Part two

- scissors
- tape
- pencil

▪ 1 copy of *Baby's Chromosomes* (p. 28)

**What We Know.** Genes are sections of the DNA recipe that makes you. What do genes look like? They look small. How small? You must magnify genes a million times to get a look at them. You would see genes are arranged on strands of DNA like beads on a string. Thousands of gene strands are packed into a cell nucleus (the control center of the cell).

How can we study our genes when they are so tiny? We study the bundles they come in. When gene strands clump together they are called chromosomes. Chromosomes can be stained with dye to make them easier to see. Stained chromosomes look a lot like fuzzy striped caterpillars. Each stripe or band on a chromosome indicates hundreds of genes.

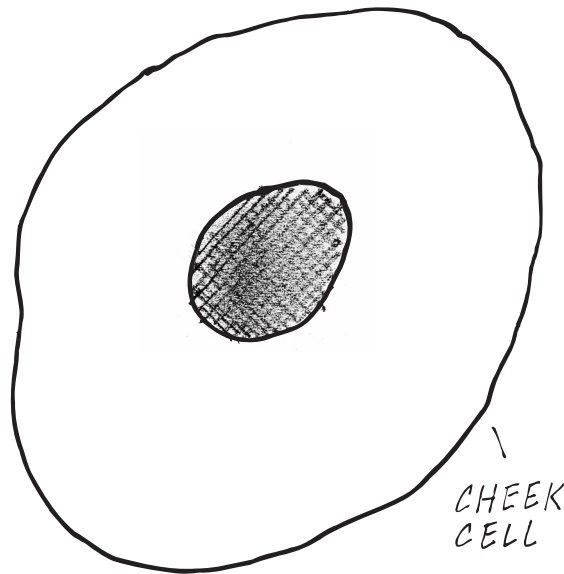
We can learn about our genetic makeup by looking closely at our chromosomes. Expectant mothers sometimes take a chromosome test to see whether their unborn baby will have a genetic problem.

To look at our chromosomes, genetic scientists first take a complete set of 46 chromosomes from a cell. Each of us gets half our chromosomes from our mother and half from our father, so we have 23 pairs of chromosomes. When the chromosomes are sorted into matching pairs it is easy to spot missing or extra chromosomes. An extra chromosome can mean that a baby has Down syndrome and will require extra care for growing and learning. You can also tell at a glance if the genes belong to a male or female.

Ready to sort?

## Part One: Hello Chromosome

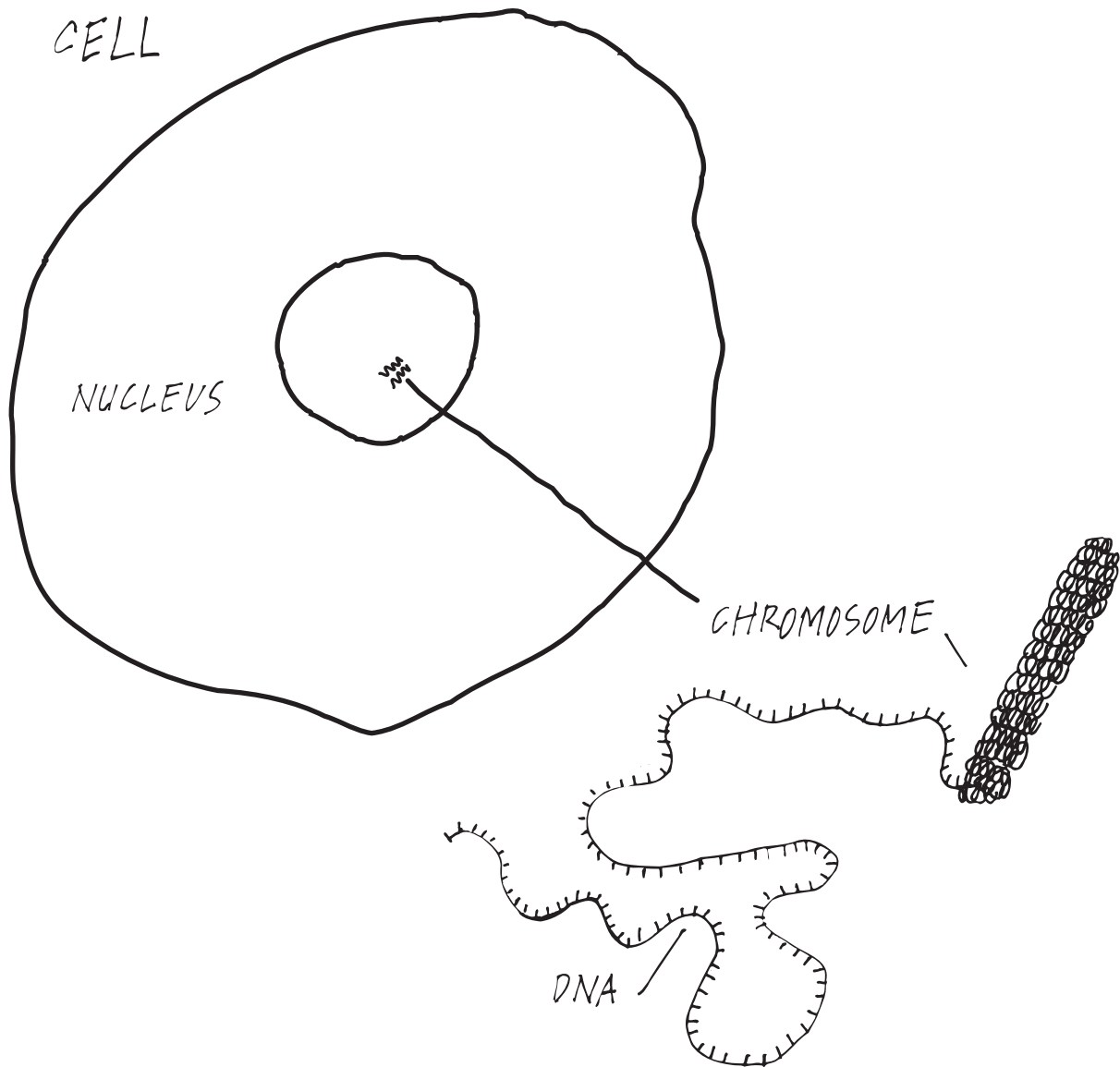
- 1** Scrape the inside of your mouth with your fingernail. You will notice a kind of white slime. This slime is cheek cells. Cheek cells are small. How small? Like most cells in your body, they are too small to see without magnification. They are small enough so that about ten of them would fit easily on the period at the end of this sentence.
- 2** See the picture of a cheek cell below. Label the **nucleus**, the dark center in the middle of the cell that controls cell operations. Genes are located on chromosomes inside the nucleus.



- 3** Chromosomes are made of thread-like material called DNA. How does real DNA fit into a microscopic cell? Not only is it coiled up, but it is so amazingly thin that about 5 million strands would fit through the eye of a needle. If you could unwind all the chromosomes in a cell and line up the threads end to end, the DNA would measure about 2 meters (6 feet). Think about how all that DNA can cram itself into such a tiny space.
- 4** Collect your thread and tape. The thread represents 2 meters (6 feet) of DNA. Tape the **middle** of the thread inside the nucleus in the picture above. DNA is found in the nucleus.
- 5** DNA threads have a coiled shape that helps them fit into a small space. Twist the ends until the thread fits inside the nucleus. Cram the thread inside. Then tape it in place.

## Part One: Hello Chromosome (cont'd)

- 6** When a cell gets ready to make a new cell, the DNA clumps into 23 pairs of chromosomes. There is only one pair of chromosomes in the cell nucleus below. Draw 22 more pairs of chromosomes inside the nucleus of the cell. Draw them to look like tiny bits of thread.



# WHAT SORT?

.....

ACTIVITY  
FOUR

**Think It Over**



Where in the cell do you find genes?

## Part Two: Reading Chromosomes

Today you will do the work of a genetic scientist. Genetic scientists sort chromosomes using a special chart called a karyotype (carry yo type). This chart makes it easy to compare one set of chromosomes to another.

Chromosomes from three babies have come to your lab for testing. Your assistants have prepared them with stain. They have begun to sort them but haven't finished. Match the rest of the chromosomes, and then analyze what you find. Ready to sort?

### Sort the Chromosomes

**1** Form your group of three and gather your materials. Each person in your group works with one Human Chromosome Chart (p. 27) and one set of Baby's Chromosomes A, B or C (p. 28). Fill in the bottom of the Human Chromosome Chart.

**2** Examine your Human Chromosome Chart. It has room for 23 pairs of chromosomes. Notice that chromosomes of similar size and band patterns are paired together. Circle the chromosomes that don't have a match.

**3** Take your set of Baby's Chromosomes and cut out each chromosome along the dotted lines. Be careful to keep your set separate from anyone else's chromosomes. Sort the chromosomes by length, with the longest first.

**4** Match up your baby's chromosomes to the single chromosomes to fill in the chart. First find the chromosomes that determine whether you have a female or a male. Put the X or Y chromosomes on the chart.

**5** Check with a teammate if you are not sure about a match. Continue matching your baby's chromosomes. Hint: Some babies may have extra chromosomes.

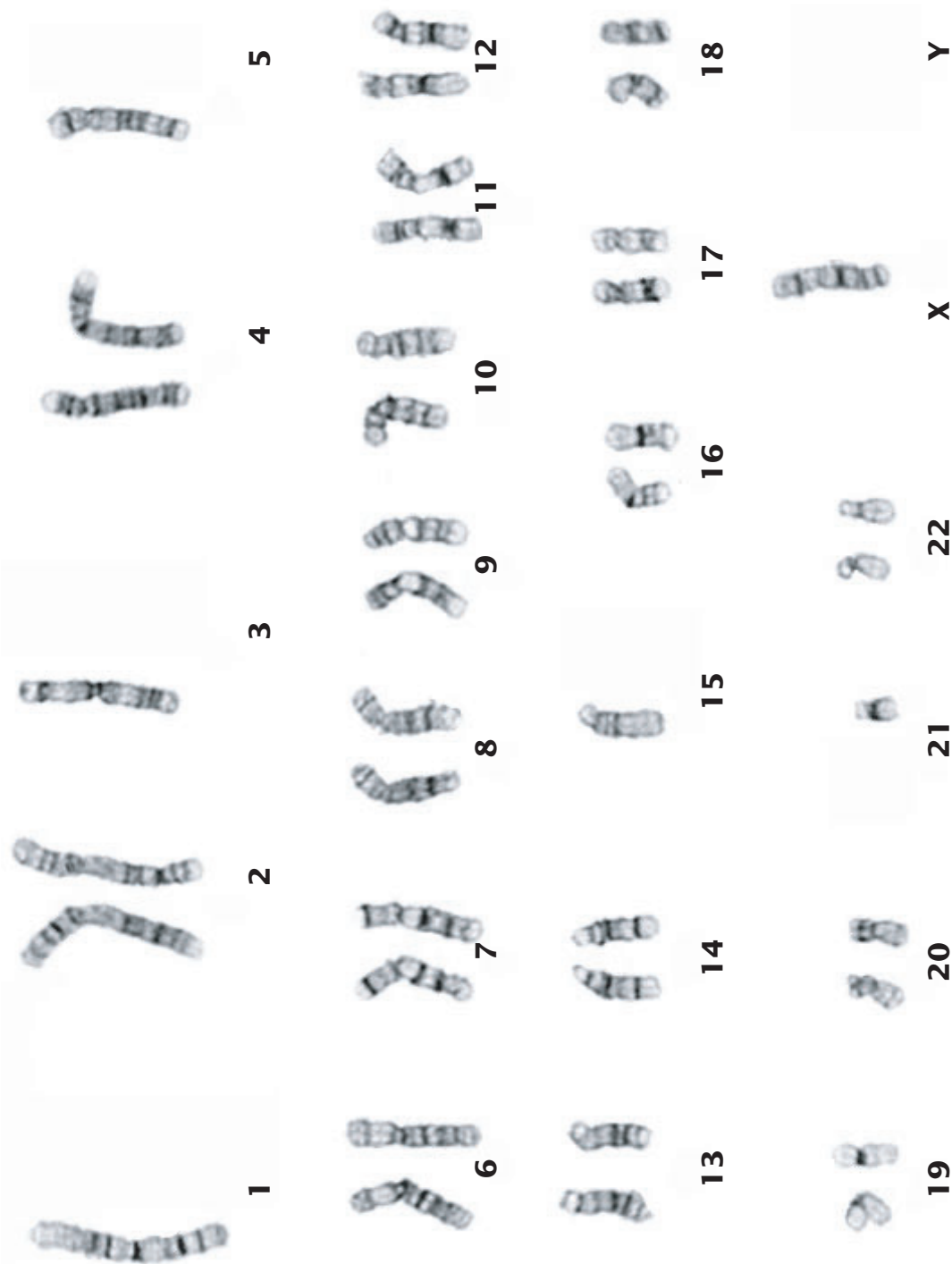
**6** Tape the chromosomes in position. Excellent job!



# WHAT SORT?

ACTIVITY  
FOUR

## HUMAN CHROMOSOME CHART



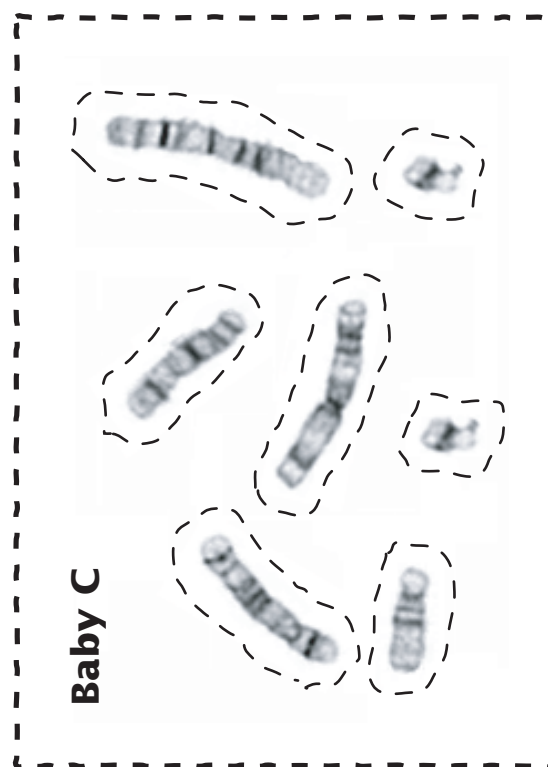
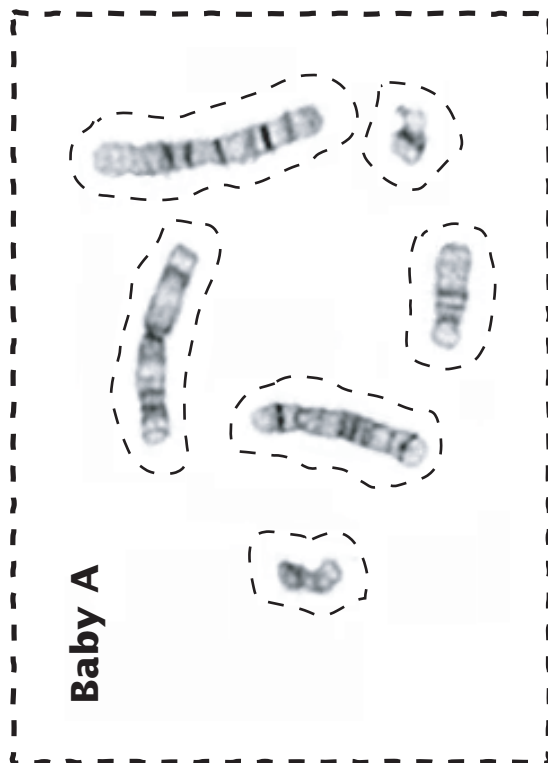
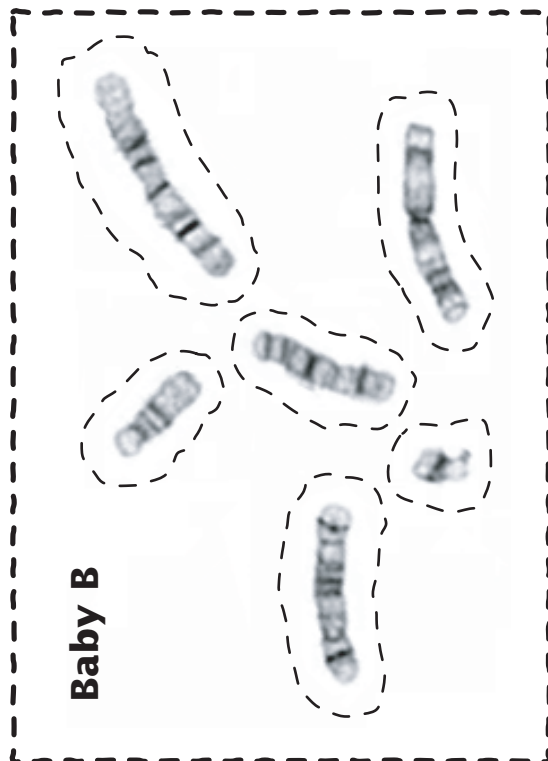
Your Name \_\_\_\_\_

Baby \_\_\_\_\_

# WHAT SORT?

ACTIVITY  
FOUR

## BABY'S CHROMOSOMES



## Part Two: Reading Chromosomes (cont'd)

### Read the Chromosomes

**7** Your Human Chromosome Chart is complete. Now it is time to read the results of your chromosome test. The information that decides male or female is located on the last chromosome pair (# 23).

XX (two long chromosomes show a female)

XY (a long and a short indicate a male.)

Does your test show a girl or a boy? \_\_\_\_\_

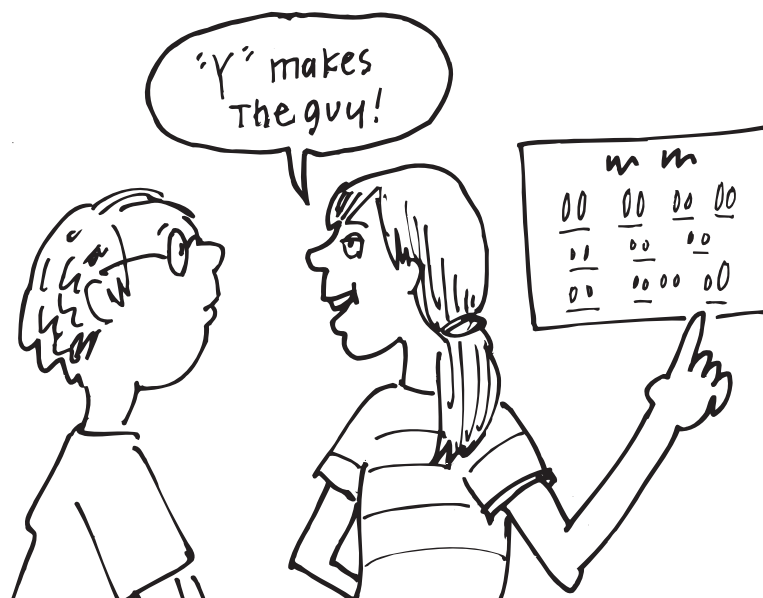
**8** Normal babies have 46 chromosomes.

How many chromosomes do you count on your chart? \_\_\_\_\_

Does your baby have an extra chromosome? Yes \_\_\_\_ No \_\_\_\_

An extra chromosome 21 indicates Down syndrome.

**9** Compare your Human Chromosome Chart to the complete charts on pages 30-32. Your chart should match one of those. If it does not, recheck the placement of your chromosomes.

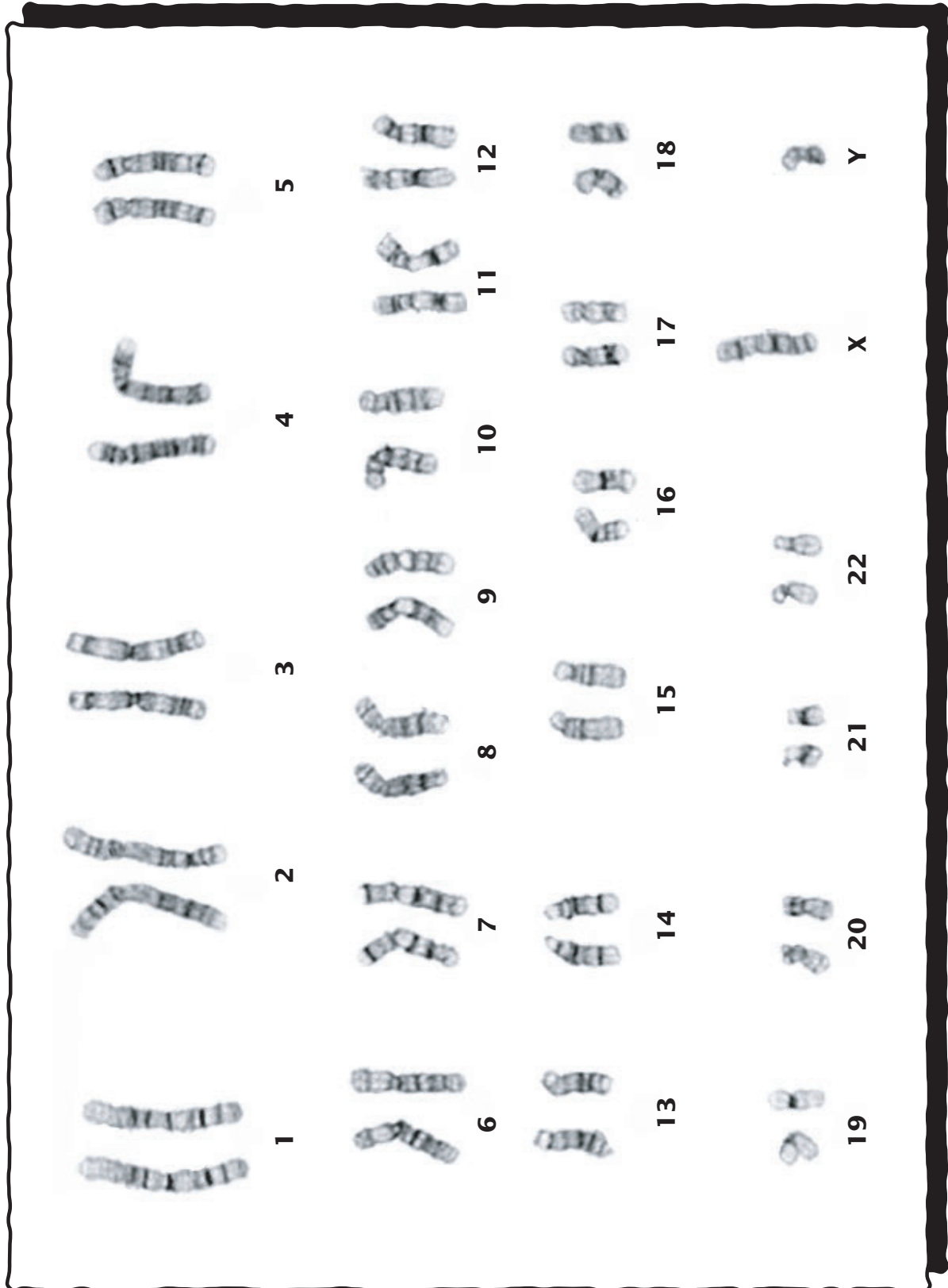




# WHAT SORT?

ACTIVITY  
FOUR

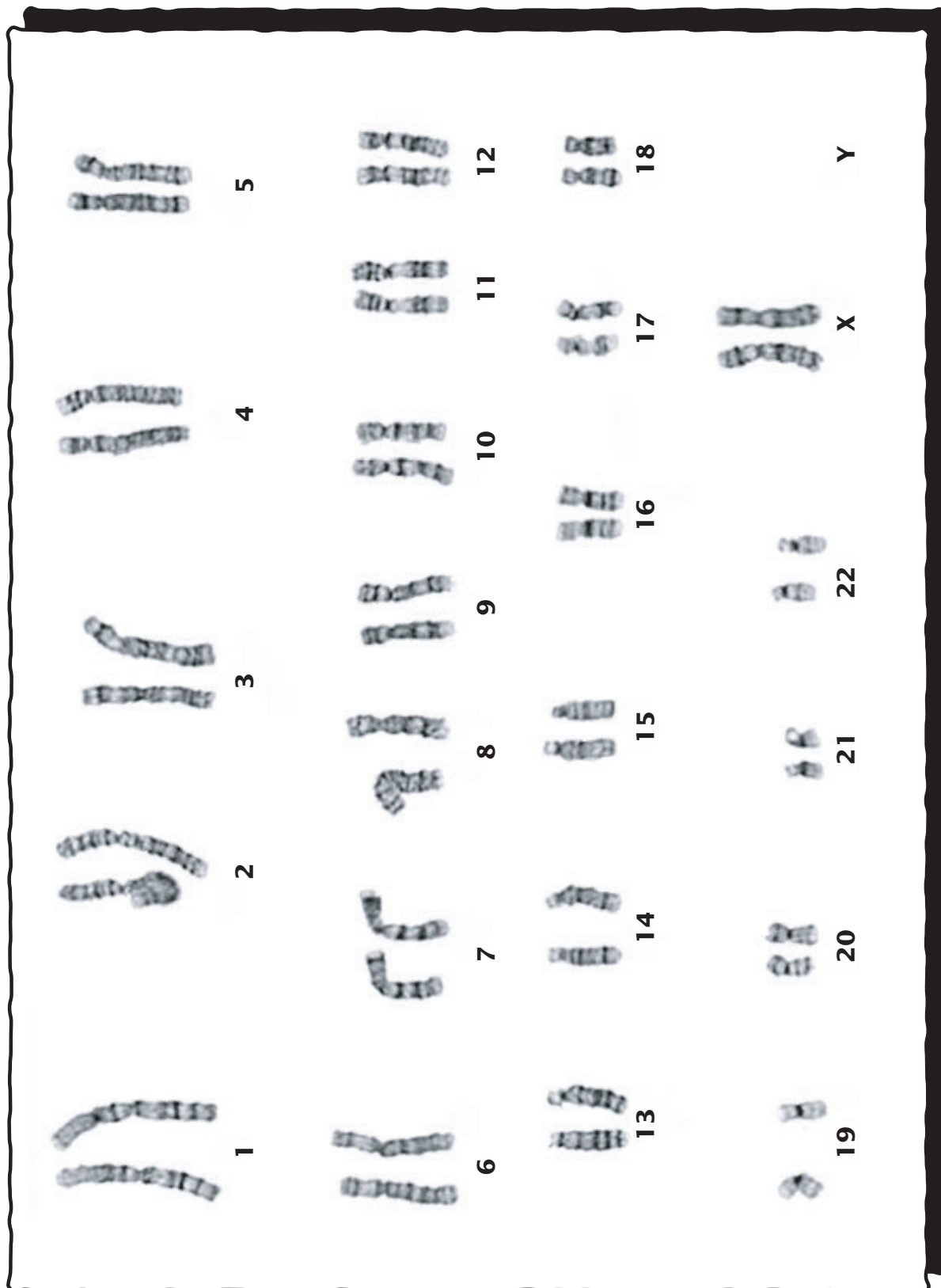
## NORMAL MALE CHROMOSOMES



# WHAT SORT?

ACTIVITY  
FOUR

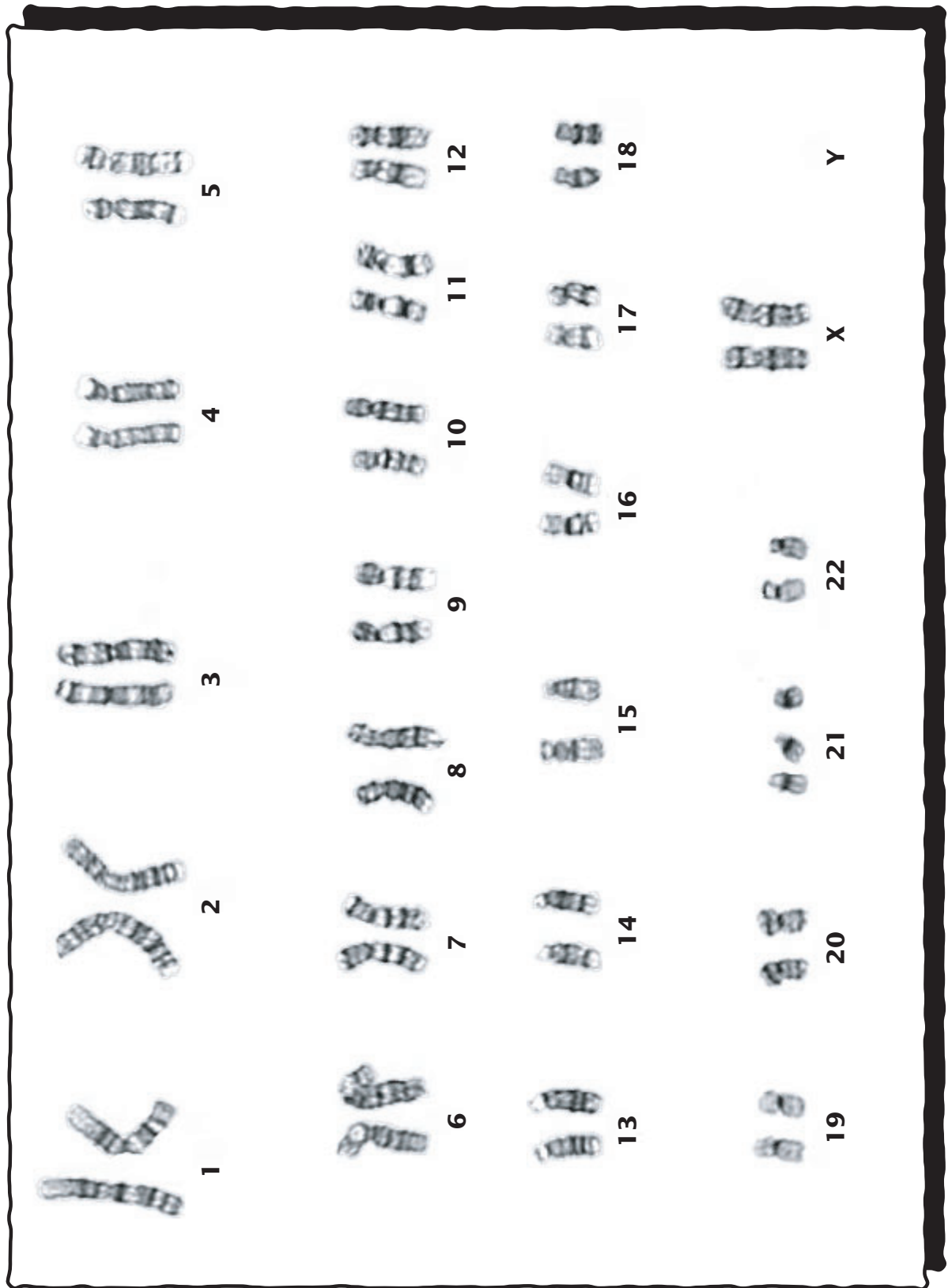
## NORMAL FEMALE CHROMOSOMES



# WHAT SORT?

ACTIVITY  
FOUR

## DOWN SYNDROME FEMALE CHROMOSOMES



# WHAT SORT?

---

ACTIVITY  
FOUR

## Think It Over



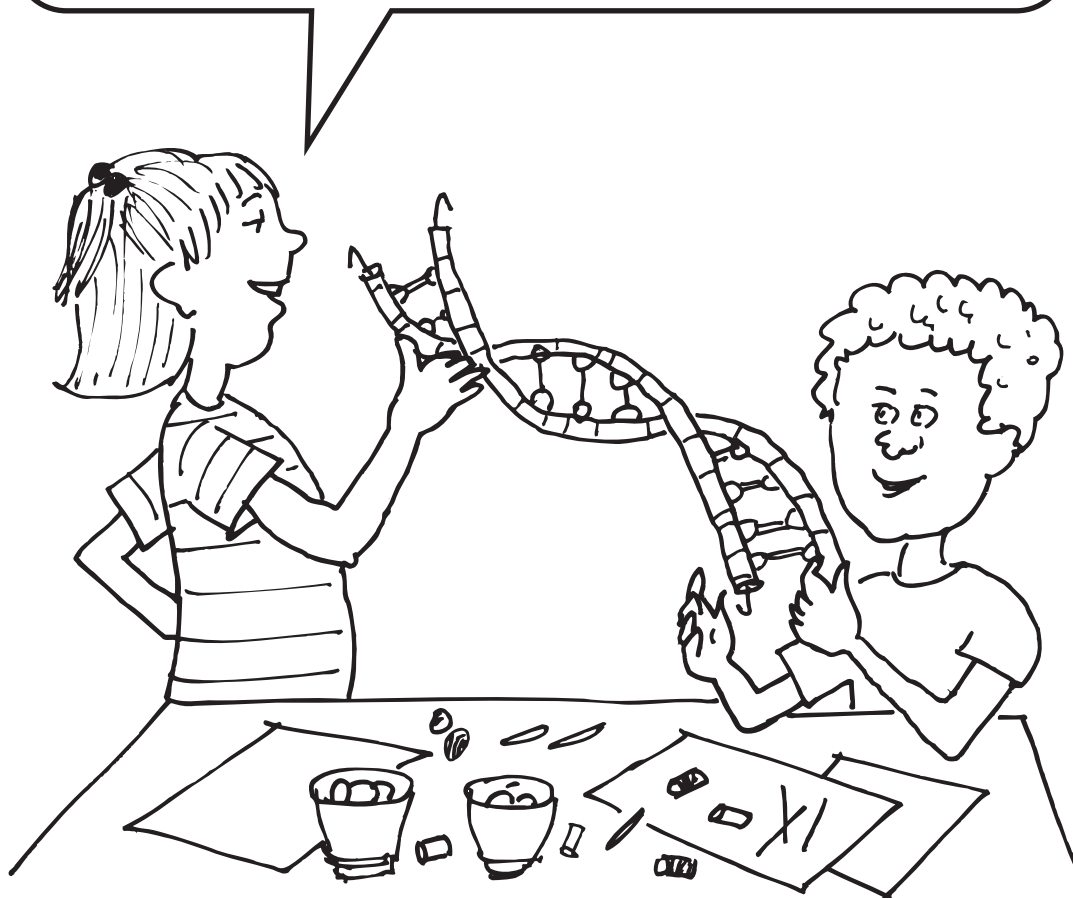
Your mom and dad tell you that a new baby is on the way. It is possible to test the baby's genes to find out if you will have a brother or a sister. Do you want to know?

Why or why not?

# INSIDE DNA

ACTIVITY  
FIVE

**DNA has a very interesting shape that gives it some special talents. Make a candy model of DNA and learn some of its inside secrets.**



## Before You Begin

**Work in teams of 2**  
**Length:**

Part I - 20 mins.

Part II - 30 mins.

## What You Need For each team of 2:

### Part one

- 6 black licorice pieces 1 cm ( $\frac{1}{2}$  in)
- 6 red licorice pieces, 2 cm (1 in)
- 6 gumdrops (any 3 color pairs: for example purple always pairs with green, and white always pairs with yellow)
- six 16 cm (6 in) pieces of bead sculpture wire (plastic coated wire) or pipe cleaners
- 6 toothpicks
- scissors
- cm ruler

### Part two

- another complete set of licorice, gumdrops, wire, and toothpicks
- colored pencils or crayons (that match the gumdrop colors)

**What We Know.** DNA is the thread-like material that makes up our genes and chromosomes. DNA has the amazing ability to carry in a code all the instructions needed to make a human being.

The DNA code has a very small alphabet — only 4 letters. The four letters stand for four chemicals whose names begin with A, T, C, or G. Altogether, there are 3 billion of these letters (chemicals) arranged in different orders along the DNA thread

inside each of us. Like beginning readers, scientists can read all 3 billion letters, but they are still trying to figure out what these letters mean for us.

The shape of DNA gives it another special ability — making a copy of itself. DNA is copied when a cell divides to make new cells. Your body is constantly making new cells as you grow. Every new cell gets a copy of your DNA code, so it can tell the cell how to work and to make new cells.

## Part One: Build DNA

Your genes are made of a substance called DNA, **d**ioxyribo**n**ucleic **a**cid (dee oxee rye bow new clay ick acid). Ready to build a model section of DNA?

**1** Find a partner and gather your licorice (red & black), gumdrops, wire, and toothpicks. Put together the DNA backbones. The backbones are actually made from two chemicals: sugars and phosphates. You need three sugars (red licorice) and three phosphates (black licorice).

**2** Alternate red and black licorice on a piece of wire. It should look like the picture to the right. Make another just like it. Hint: Bend the tips of the wire back to hold everything in place.

**3** Between the DNA backbones are base pairs (gumdrops). Make three base pairs. Join each pair of gumdrops with two toothpicks. They should look like the picture to the right.

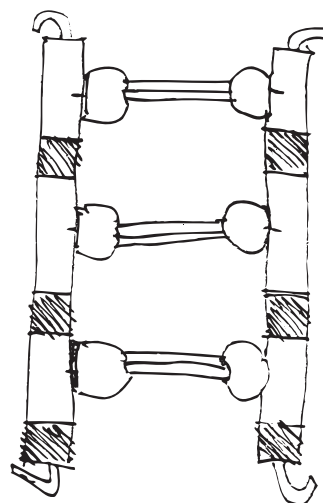
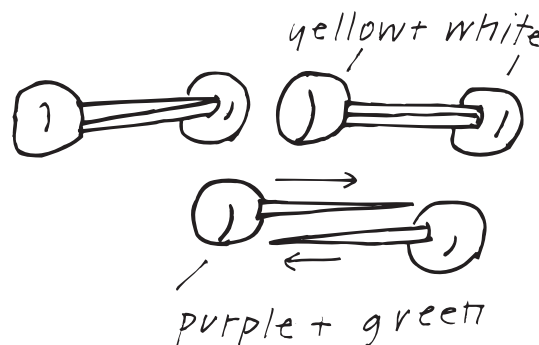
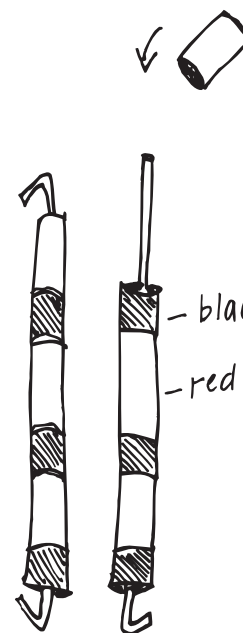
MAKE SURE: purple goes with green  
white goes with yellow

**4** Make the DNA ladder by connecting the backbones with the toothpicks. Toothpick only to the red (sugar) sections.

**5** Doublecheck your DNA to make sure there is not a mutation. Mutations are mistakes in the DNA structure.

- Red alternates with black.
- Only purple and green can pair.
- Only white and yellow can pair.
- Toothpicks only connect to reds.

**6** When everything is correct, tighten the toothpick bonds so your model will stay together.



## Think It Over

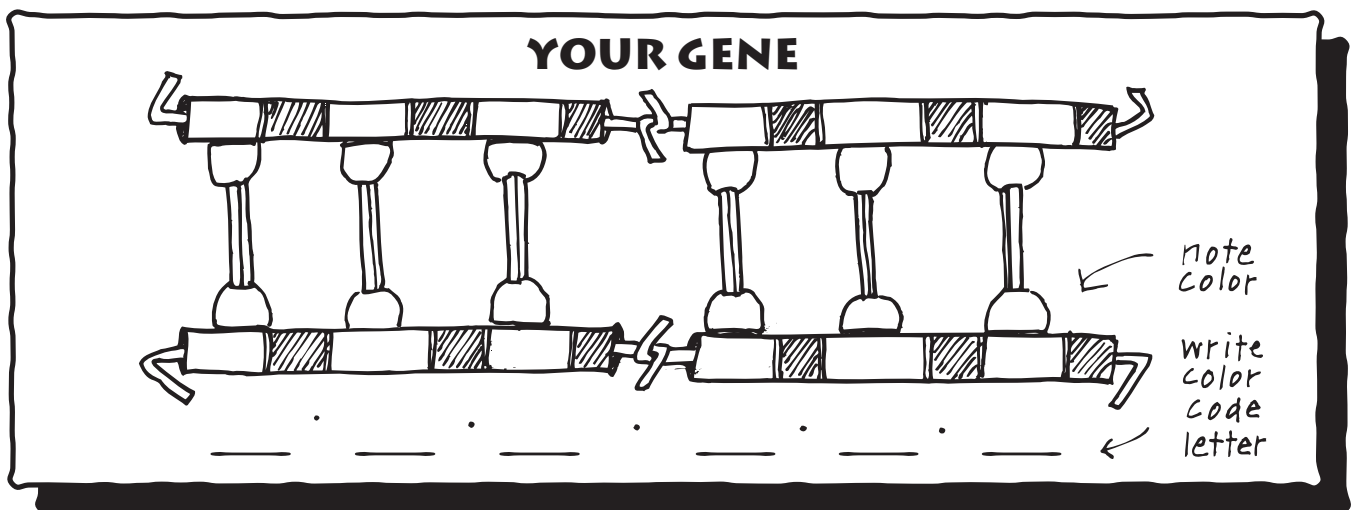


Your DNA model is made of candy.  
What is real DNA made of?

## Part Two: Make a Gene and Copy It

Different sections of your DNA control different features like eye color or the ability to roll your tongue. These sections are called genes.

- 1** Find another team. Connect your DNA section with the other team's section to make a gene. Do this by hooking the wire ends together.
- 2** Use colored pencils to color the drawing below to match your gene.



- 3** Genes are described by a special code of letters. Using the table below, find the code that describes your gene. Write in the code for the bottom gumdrops only.

Gumdrop Color	Code	Real Name
Green	T	Thymine
Purple	A	Adenine
White	C	Cytosine
Yellow	G	Guanine



- 4** Twist the genes to create a spiral shape to your DNA.



## Part Two: Make a Gene and Copy It (cont'd)

### Copying the DNA Code

**5** DNA copies itself by splitting down the middle and making another half of itself. Divide your DNA strand in half by carefully pulling apart the two sides.

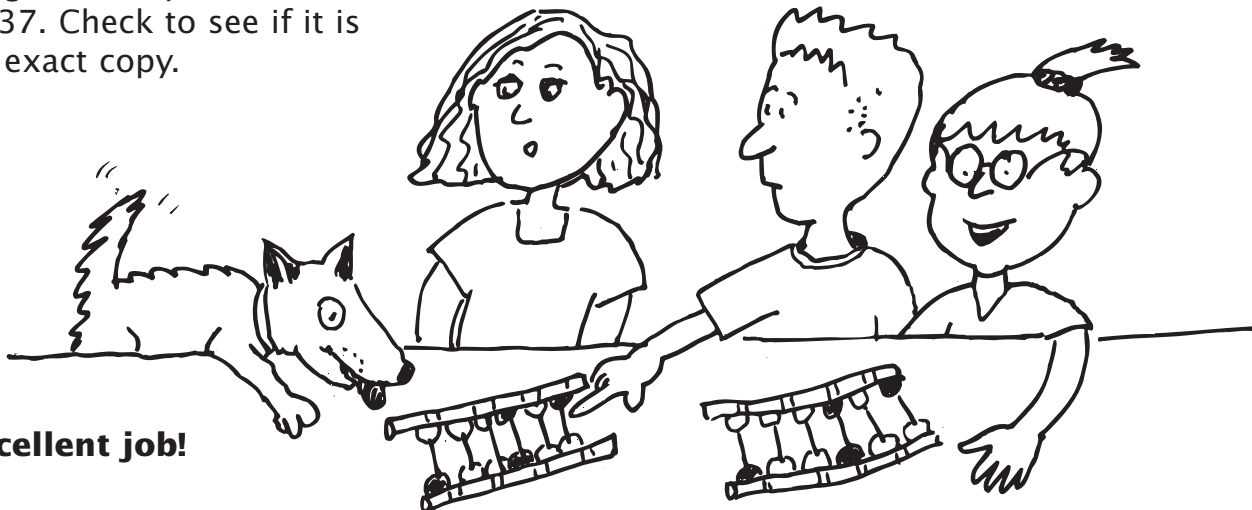
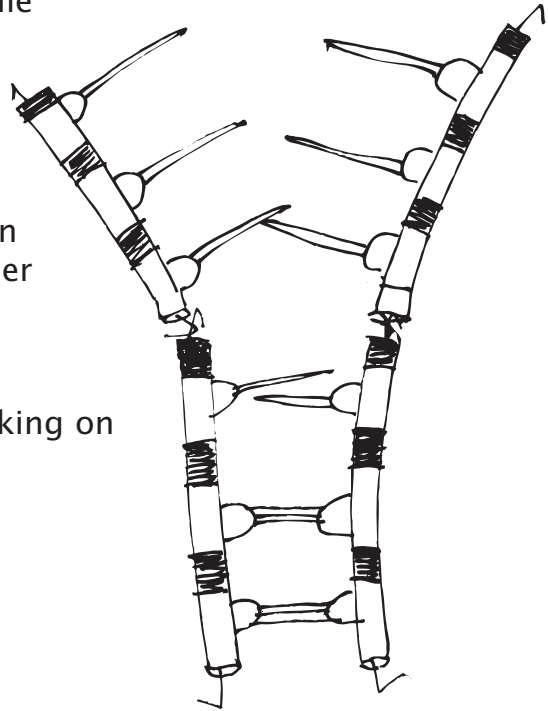
**6** Divide into two teams. Your team's challenge is to make a complete DNA section just like the original DNA pattern. Collect another set of licorice, (red, black) gumdrops, wire, and toothpicks to make a DNA copy.

Each team works with one DNA half. (Hint: working on a flat surface makes this job easier.)

Use the following rules and your DNA replication will be a success:

- Red alternates with black.
- Only purple and green can pair.
- Only white and yellow can pair.
- Toothpicks only connect to reds.

**7** When your team is done, compare your DNA copy to your original gene that you colored on p. 37. Check to see if it is an exact copy.



**Excellent job!**

## Think It Over



Were there any differences between your original DNA model and the DNA copy?

If you found differences, what might this mean to the owner of this DNA?

# PULLING IT ALL TOGETHER

.....

**Create a story  
about a scientist who  
works as a genetic  
counselor.**



# NEW WONDERS

---

**Here are some ideas you might like to use for projects or exhibits.**



## **1. KITCHEN DNA**

DNA may be extremely tiny but with a bit of care you can get some to appear right in your kitchen. All you need is an onion, some simple ingredients and about 30 minutes. Instructions for preparing DNA are available on the Web. A key word search using DNA and kitchen or DNA and onion should get you a recipe.

## **2. TALENT SEARCH**

Some people can wiggle their ears. Some can do splits. Some can lick the tip of their nose. Some of these weird tricks are the result of practice. Some are the result of an inherited ability. Do you have any unusual talents? How about your family and friends? When you find enough weird talents, put together a demonstration. Call the show, "Astonishing Tricks and Amazing Talents."

## **3. BARKING UP THE FAMILY TREE**

Your genes are a mix of your mother's and father's genes. Their genes came from their mothers and fathers (your two sets of grandparents). Their genes came from their mothers and fathers (your four sets of great-grandparents). Ask older family members what features have been passed on from your relatives. It is fun to collect the names of your ancestors and chart them in a family tree. If you don't know how to draw a family tree, you can learn how at the library or on the Web. Search for a "family tree" or "pedigree chart."

## **4. CRIME STORIES**

DNA is being used to solve crimes and is often in the news. Collect stories from the newspaper, TV, or the Web. Use the stories you collect from media as inspiration for writing your own story that uses DNA to solve a mystery or crime.