Build a Bird Science Project

INSTRUCTIONS:
1. Write an exploratory question based on watching the following:

What is Inheritance?
What Are Chromosomes?
Allele Shuffling (video)

2. Build the Chromosomes (See Student Instructions for Chromosomes on Page 3 and the Cut Outs you will need to have printed from Page 4)

3. Answer the following questions:

- Where the alleles came from in the first place?

- How allele "shuffling" during sexual reproduction contributes to genetic and phenotypic variation in offspring?

- What is the amount of genetic and phenotypic variation you see in the offspring from just two pigeons?

4. Go to this page: https://learn.genetics.utah.edu/content/pigeons/ to learn more about pigeons for this next activity. Write your notes on the next page...

NOTES ABOUT PIGEONS

NAME _____ DATE _____

Build a Chromosome

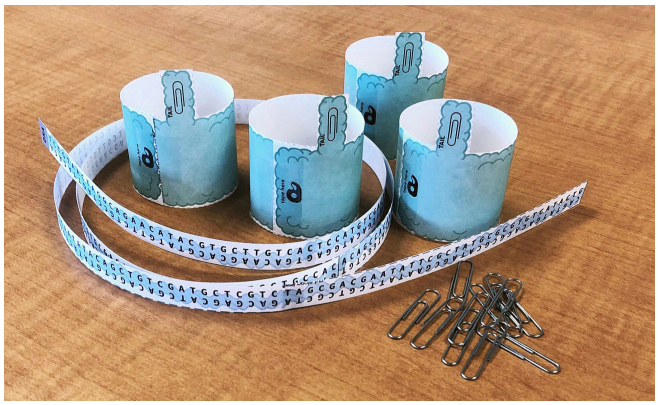
Student Instructions

Background

Each chromosome is made of a long strand of DNA wound around spool-like molecules called histones. This keeps a cell's DNA organized, untangled, and accessible to gene reading machinery.

You will build paper models of chromosomes to explore how DNA is organized in dividing and non-dividing cells.

Prepare Your Materials



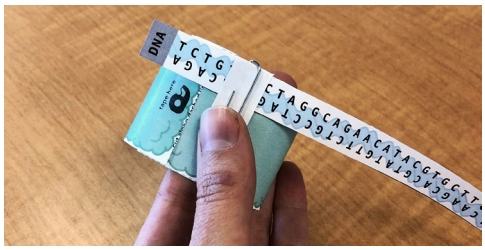
- Cut out the histones. Tape the ends together to make 4 separate "spools."
- Cut out the DNA strips. Tape the gray ends together to form one long ribbon.
- Gather 12 paper clips.

NON-DIVIDING CELL

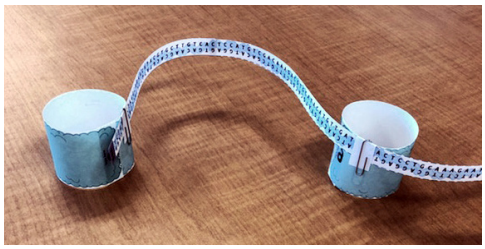
In a cell that is not dividing, DNA is coiled loosely around histones. The histones keep DNA organized so it fits into the nucleus, and gene reading machinery can access the appropriate pieces.

Relaxed Chromosome

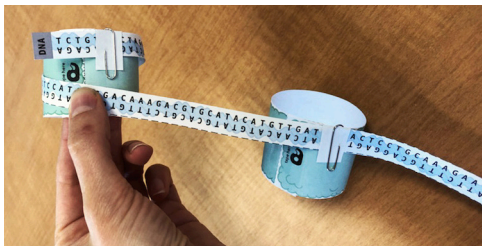
1. Locate one of your prepared histone spools and your DNA ribbon. Place one end of the DNA ribbon onto a histone. Fold the histone tail over the DNA to help hold it in place. Secure it with a paper clip.



2. Attach the remaining histones along the DNA ribbon. Place them at a distance of 2 DNA strips apart (about 16 cm).



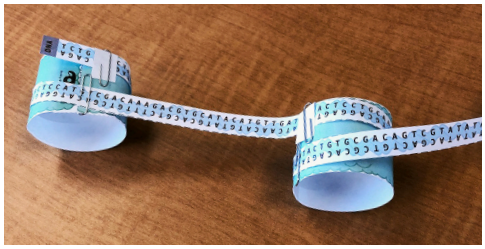
3. Hold the first histone upright in one hand. Wind the DNA ribbon around it one time. There should be space between the first histone and the next one. If they are touching, unwind the DNA ribbon a little bit to put some space between the histones.



NAME _____ DATE _____

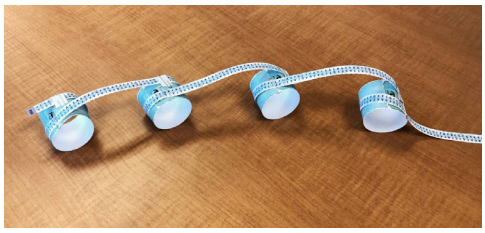
4. Secure the DNA ribbon with a paper clip. Make sure neighboring histones do not touch one another.

5. Trying not to fold or bend the DNA ribbon, wind it once around the next histone. Again, be sure that no part of neighboring histones are touching. Secure the DNA ribbon with a paper clip.



6. Repeat until the DNA ribbon has been wound around all of the histones. The histones and DNA should be spooled loosely, with some space between the histones.

Save your Relaxed Chromosome model. You will need it for the next part of this activity.



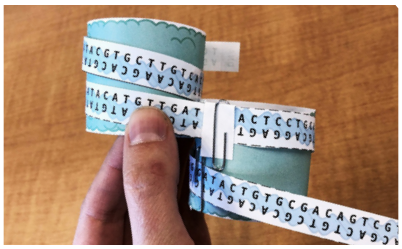
DIVIDING CELL

When a cell divides (or gets ready to divide), DNA is coiled tightly around histones. The chromosomes are very condensed compared to a non-dividing cell, and gene reading machinery does not have access to the DNA. After cell division, chromosomes return to their relaxed state.

Condensed Chromosome:

7. Locate the Relaxed Chromosome model you built in the first part of this activity.

8. Hold the first histone upright in one hand. Continue to wind the DNA ribbon around it approximately one more time, or until you bump into the next histone.



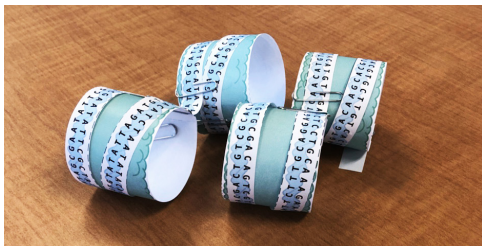
9. Secure the DNA ribbon with a paper clip. Make sure the neighboring histones are touching one another.

In a real cell, a length of DNA wraps around a histone about 1.7 times. Histone tails stabilize the structure, like they do in your model.

NAME _____ DATE _____

10. Trying not to fold or bend the DNA ribbon, wind it around the next histone. Again, make sure the neighboring histones are touching, and secure the DNA ribbon with a paper clip.

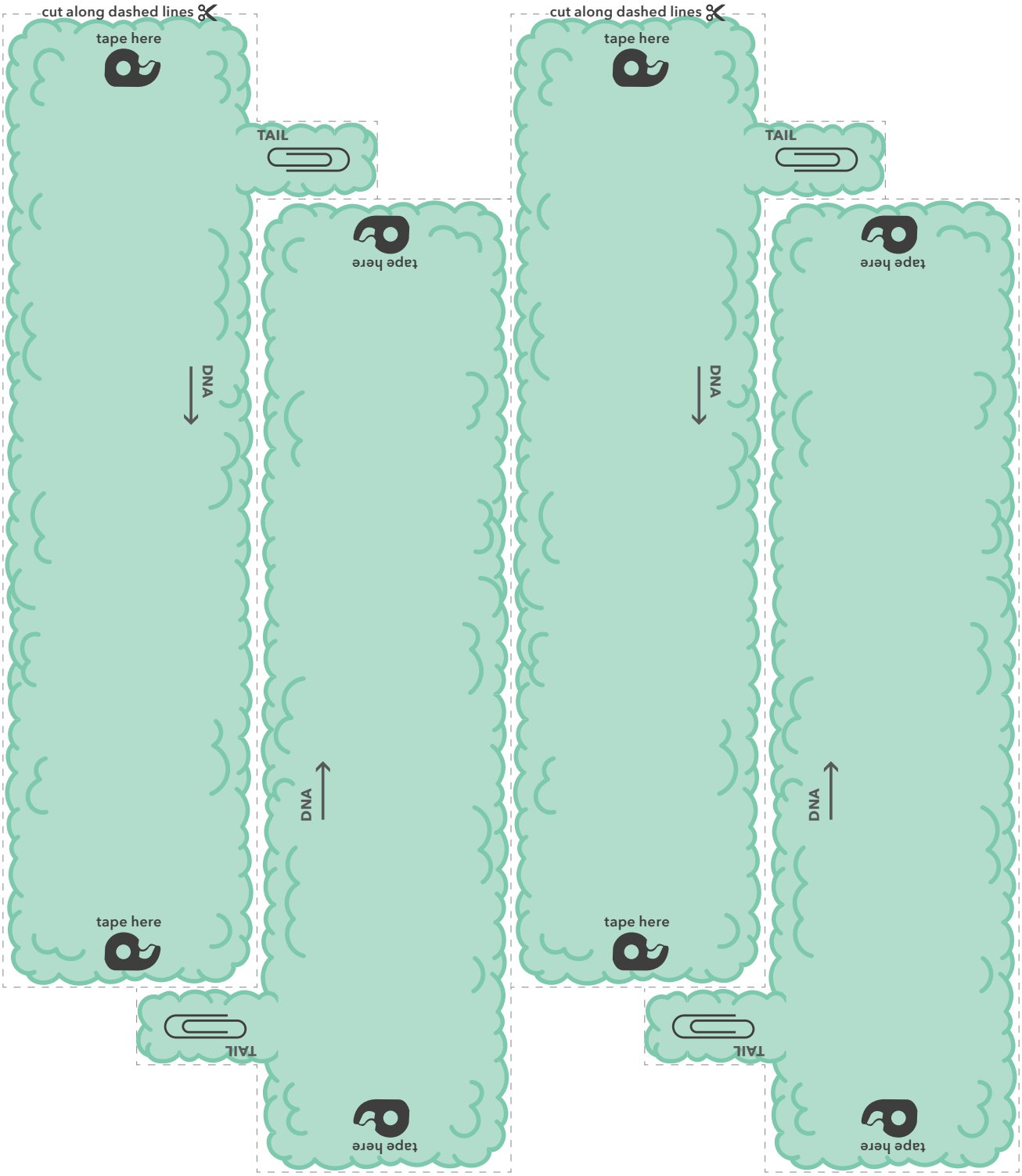
11. Repeat until all of the DNA ribbon has been wound around all of the histones. The histones should begin to stack on top of one another as you wind.



Build a Chromosome: Cut-outs

Histone Spools

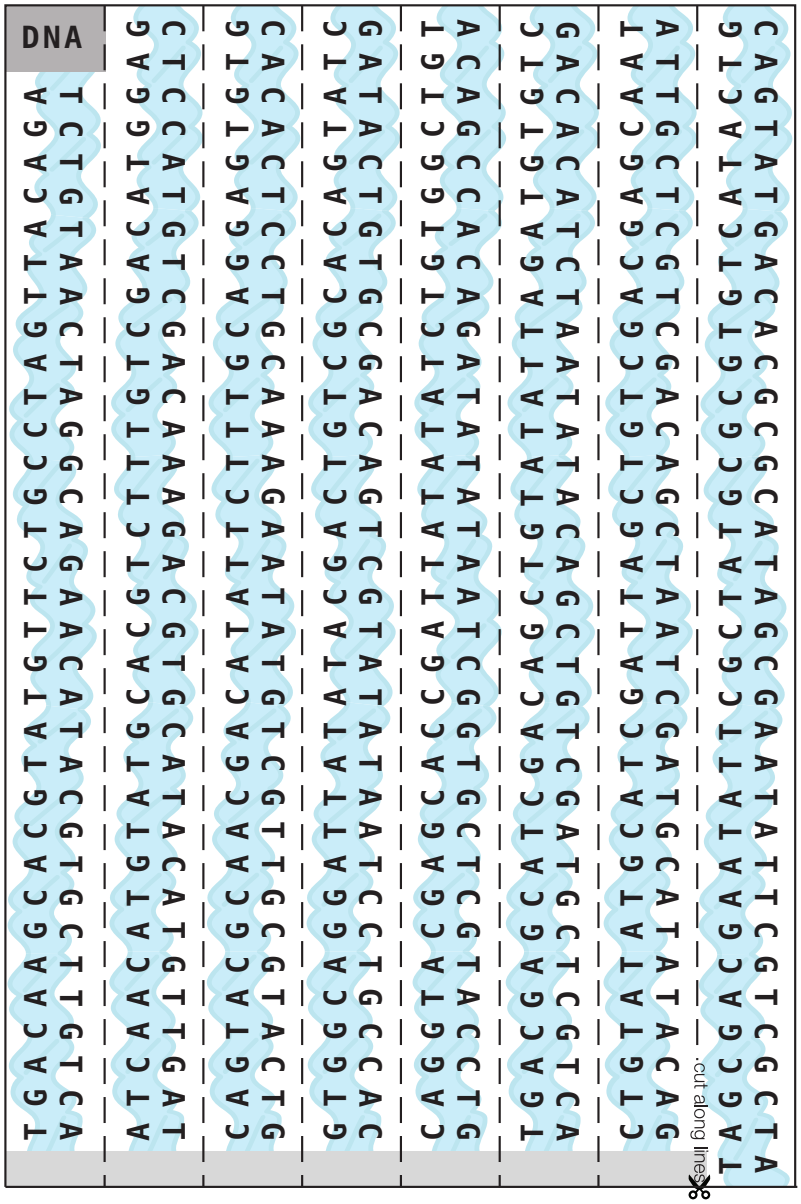
Tape the ends of each histone together to form separate spools.



Updated June 29, 2018

DNA Strips

Tape the ends of the DNA strips together to form one long DNA ribbon.



NAME _____ DATE _____

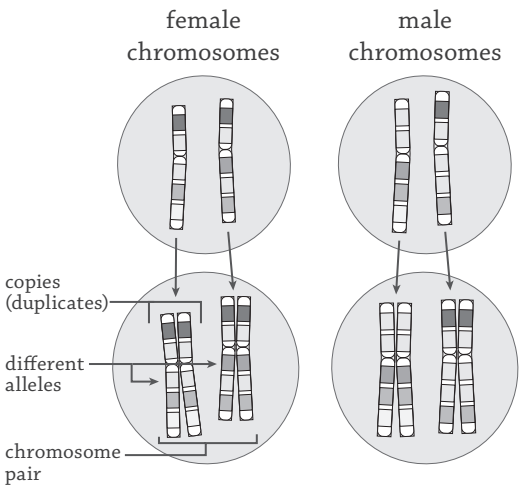
Build-a-Bird: The Pigeon Gene Shuffle

Student Instructions

Background

Animals that reproduce sexually make gametes; in most animals, that's eggs and sperm. Making gametes requires a special type of cell division, during which alleles are shuffled and recombined to make a nearly infinite number of allele combinations:

1. After the cell copies its DNA, the DNA coils up tightly, forming structures called chromosomes.
   - Each chromosome is made up of one very long DNA molecule.
   - A single chromosome can have hundreds or even thousands of genes.
   - Most sexually reproducing organisms have two copies of each chromosome.
2. Pairs of chromosomes swap large sections of DNA (called crossing-over or recombination). After crossing-over, each chromosome still has the same genes in the same order, but a new combination of alleles.
3. The cell divides to make gametes, each with only one copy of each chromosome. Each gamete has a different combination of alleles.



For this activity, the chromosomes have already been duplicated.

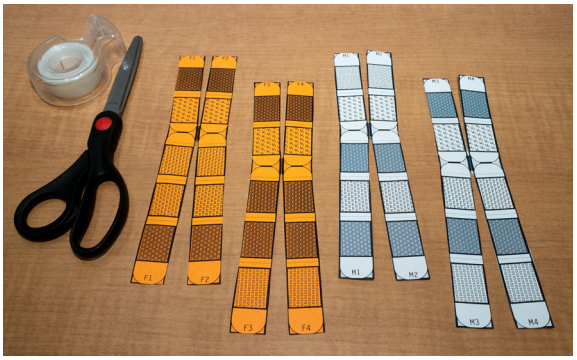
Which sperm joins with which egg is another roll of the dice. Offspring get a unique set of alleles from two parents, and a unique set of traits. With each generation, allele shuffling generates genetic diversity within a population.

In this activity you'll (1) recombine a pigeon chromosome, (2) make gametes, (3) combine gametes to make a pigeon offspring, and (4) determine what traits the offspring has—as you draw it.

You'll be working with real pigeon genes, but for the sake of simplicity, they've all been placed on one chromosome. In reality, pigeons have 80 chromosomes (40 pairs).

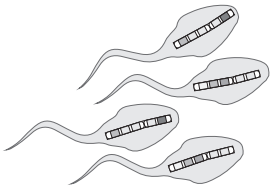
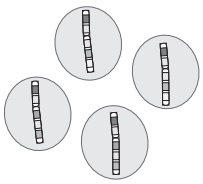
Prepare your materials

- Cut out the Male Pigeon Chromosomes and Female Pigeon Chromosomes. Cut only around the outside—NOT along the dashed lines between duplicated chromosome or between genes. Those lines will be important later.
- The activity begins with the cells having already gone through the process of DNA replication—so each chromosome is attached to its copy.

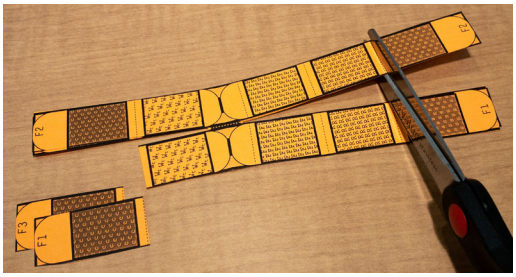


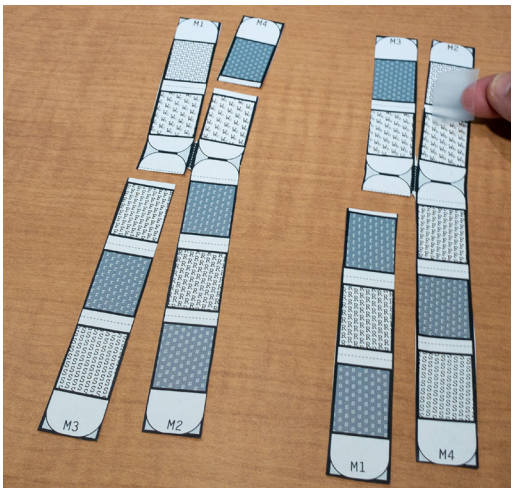
NAME _____ DATE _____

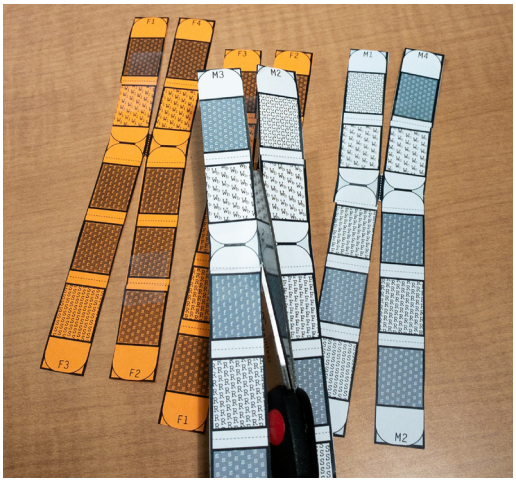
Crossing over: Chromosome pairs swap pieces of genetic material.

A cell does this:	Do this with your model:
1. The chromosome pairs line up next to each other and become intertwined.	Line up the female chromosomes, one on top of the other. Nearby, line up the male chromsomes.
2. Cellular machinery breaks the chromosomes at the exact same place, swaps the genetic material, and connects the pieces back together. The longer the chromosome, the more places it can cross over. Most chromosomes cross over in at least 1 or 2 places.	**a.** Recombine the female chromosomes. Cut the horizontal dashed lines (between genes) in one spot on the F1 & F3 chromosomes, and in a different spot on F2 & F4. Swap the pieces—F1 with F3, and F2 with F4. Tape the pieces in place. **b.** Now recombine the male chromosomes. Swap pieces between M1 and M3, then between M2 and M4. *Note: Do NOT cross over between female & male chromosomes.*
3. The cell divides to make four gametes, each with only one copy of every chromosome.  	Separate the chromosome copies: cut along the vertical dashed lines. Each chromosome now represents an individual sperm (male) or egg (female) cell.

Chromosomes that are crosssing over (arrows, left) are visible under the microscope.

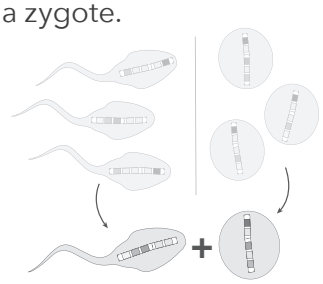


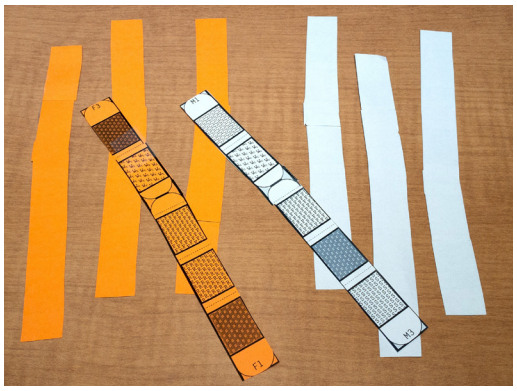


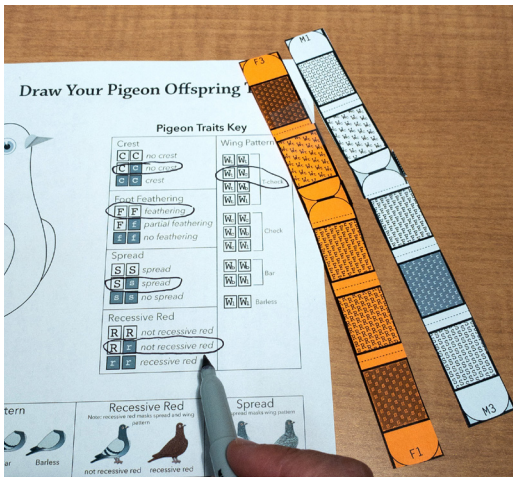


NAME _____ DATE _____

Fertilization: The female chromosome and male chromosome make a pair, creating a new combination of alleles different from both parents.

A cell does this:	Do this with your model:
4. One sperm cell and one egg cell fuse to form a zygote. 	Turn over the chromosomes so you can't see the genes, and shuffle them around. Choose one female chromosome and one male chromosome; this is your zygote.
5. As the zygote grows into a pigeon, it develops traits based on the combination of its alleles.	Turn your selected chromosomes right-side up and line them up side by side. Use the Pigeon Traits Key to decode the allele combinations for each of the five genes. Circle the trait variations for your offspring. Then draw them on the pigeon diagram. *Hint: Start with Spread and Recessive Red.*

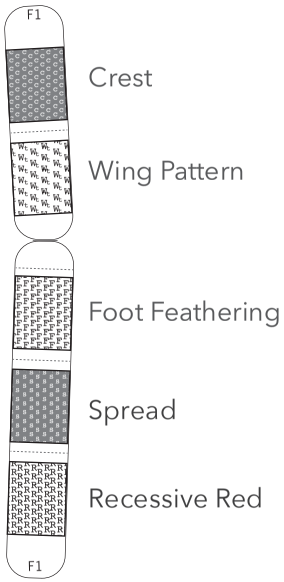




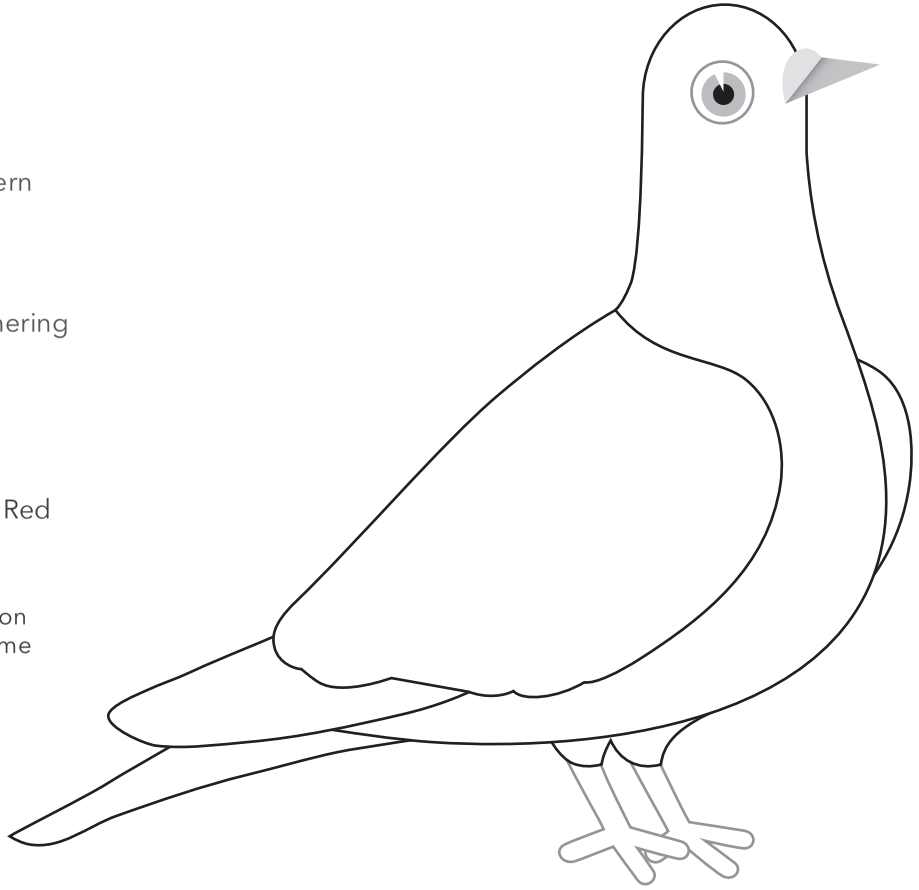
How does your offspring compare to others in your class?

NAME _____ DATE _____

Draw Your Pigeon Offspring Traits



Genes at each position along the chromosome



Pigeon Traits Key

Crest

C C	*no crest*
C c	*no crest*
c c	*crest*

Foot Feathering

F F	*feathering*
F f	*partial feathering*
f f	*no feathering*

Spread

S S	*spread*
S s	*spread*
s s	*no spread*

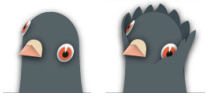
Recessive Red

R R	*not recessive red*
R r	*not recessive red*
r r	*recessive red*

Wing Pattern

W_t W_t	T-check
W_t W_c	T-check
W_t W_b	T-check
W_t W_1	T-check
W_c W_c	Check
W_c W_b	Check
W_c W_1	Check
W_b W_b	Bar
W_b W_1	Bar
W_1 W_1	Barless

Crest

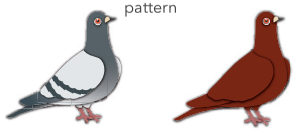


Foot Feathering

Wing Pattern

Recessive Red

Note: recessive red masks spread and wing pattern



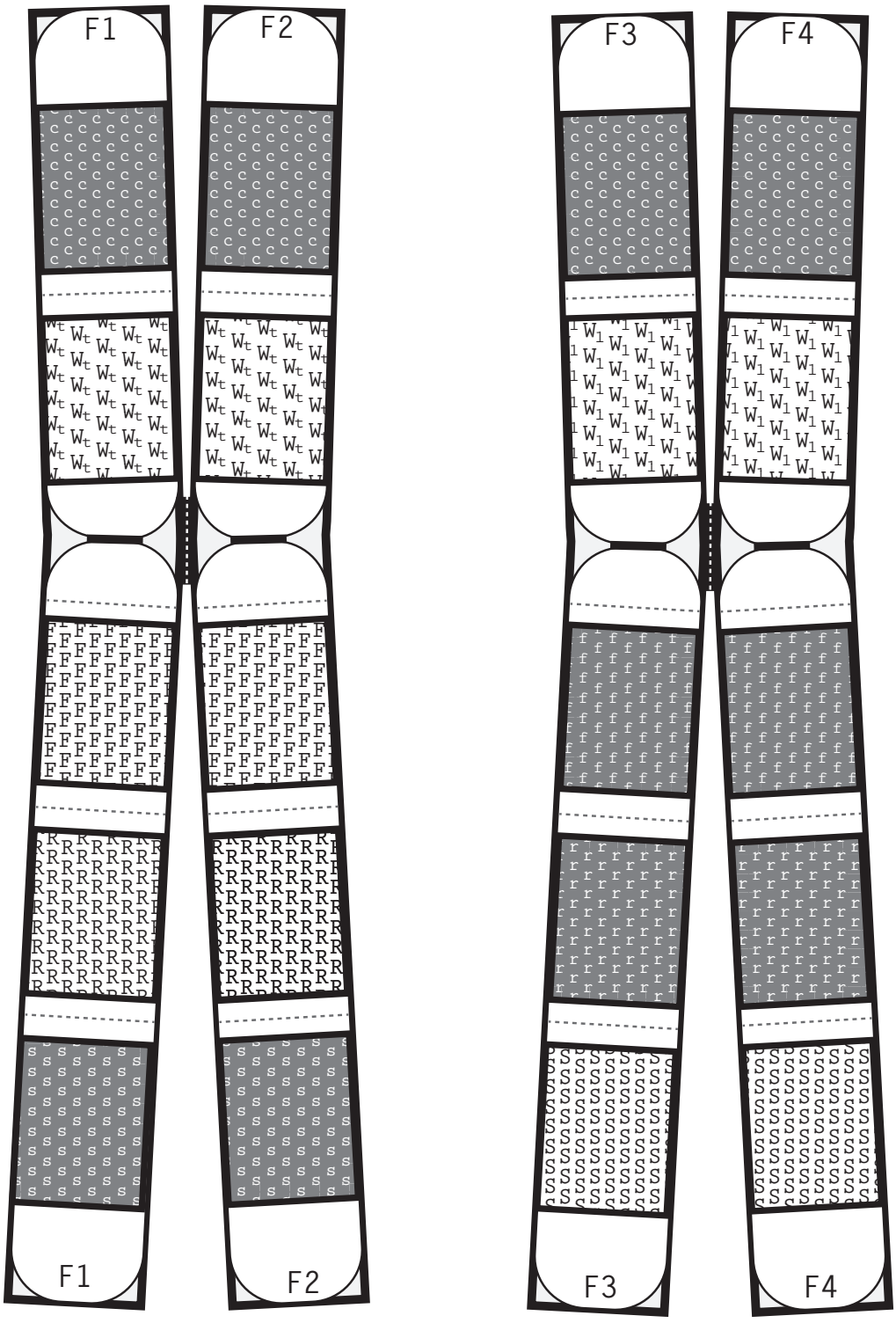
Spread

Note: spread masks wing pattern

NAME _____ DATE _____

Female Pigeon Chromosomes

(print on colored paper)



Male Pigeon Chromosomes

(print on white paper)