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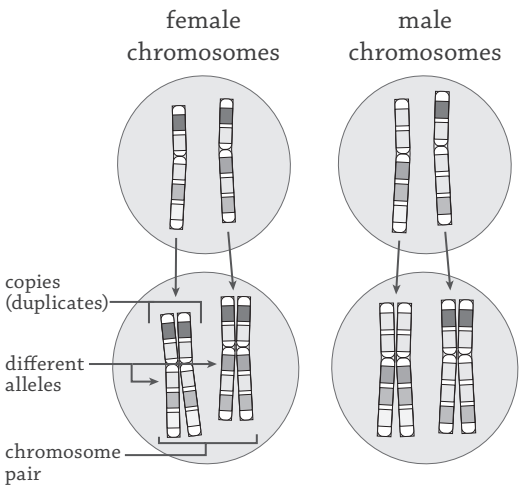
Build-a-Bird: The Pigeon Gene Shuffle

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.

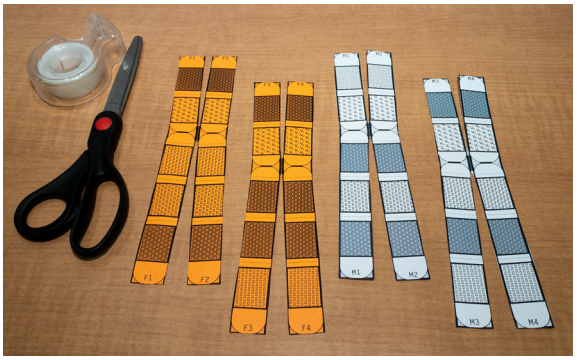
Which sperm joins with which egg is another roll of the dice. Offspring get a unique set of alleles from two parents, and a unique set of traits. With each generation, allele shuffling generates genetic diversity within a population.

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.



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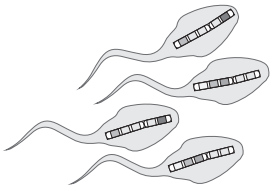
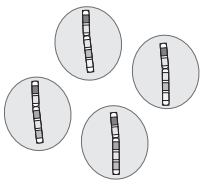
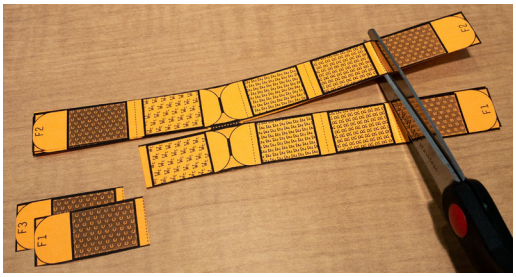
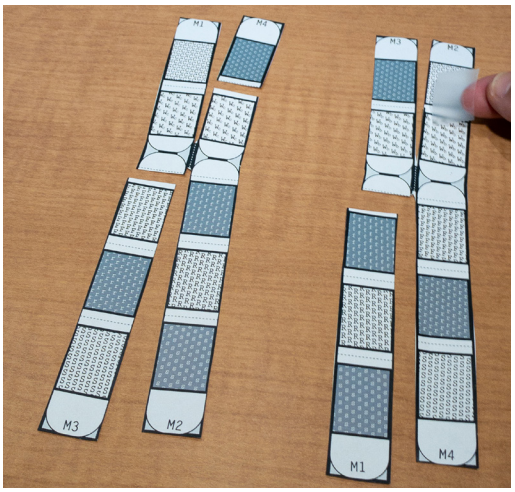
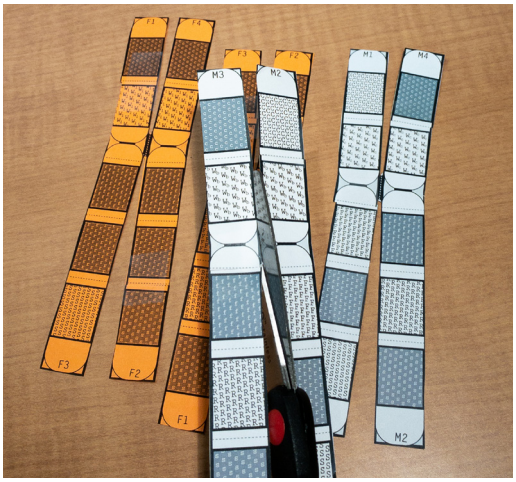
Crossing over: Chromosome pairs swap pieces of genetic material.

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.







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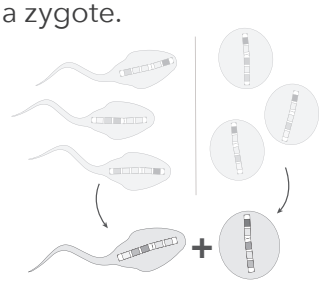
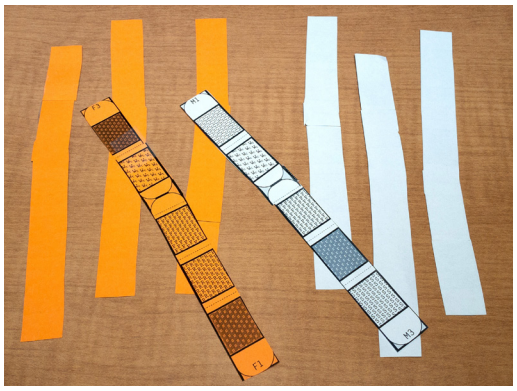
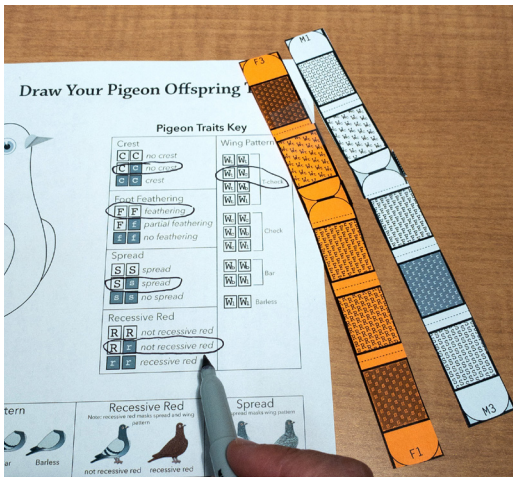
Fertilization: The female chromosome and male chromosome make a pair, creating a new combination of alleles different from both parents.

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?

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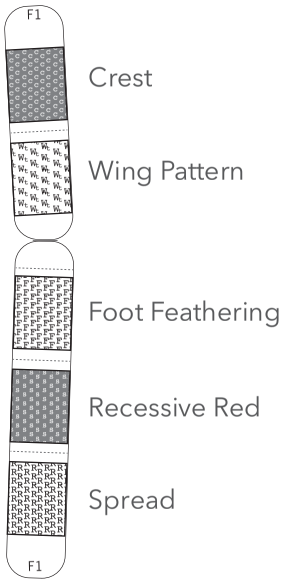
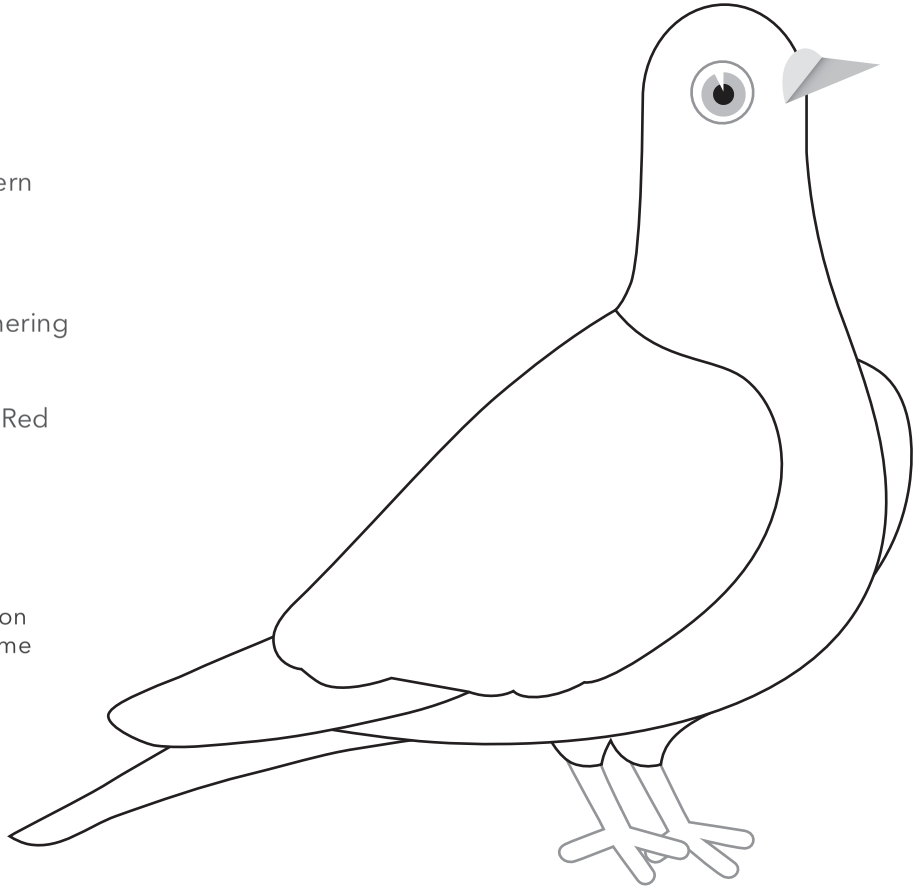
Draw Your Pigeon Offspring Traits



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*

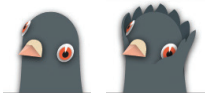
Recessive Red

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

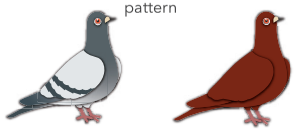


Foot Feathering

Wing Pattern

Recessive Red

Note: recessive red masks spread and wing pattern



Spread

Note: spread masks wing pattern