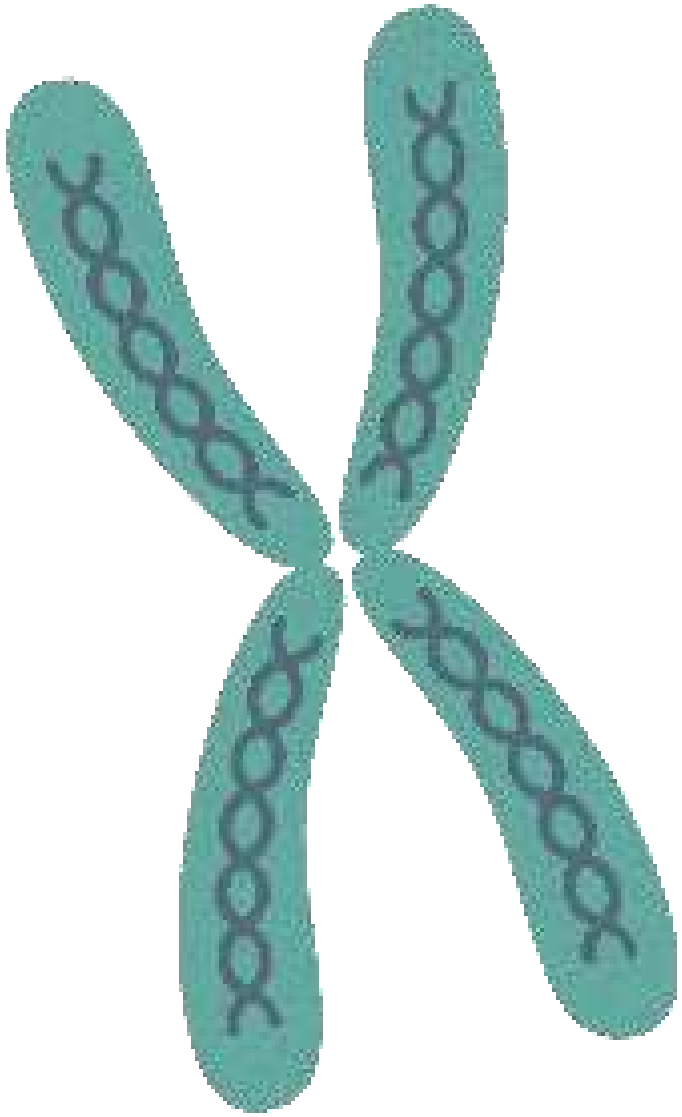

# Chromosome Shuffle

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**Game Overview** – a game that simulates the processes of chromosome reduction, independent assortment, and crossing-over during meiosis.

Through this game, students will gain a deeper understanding of how meiosis contributes to genetic diversity. **Background**: Cells Alive Simulation - Meiosis

**Game Materials:**

- **Chromosome Cards:** Two sets of chromosome cards in different colors (e.g., blue and red) to represent homologous pairs. Each set should have 4 pairs (8 cards total per color), with each pair labeled. Also sets of chromosomes that have undergone crossing over.
- **Crossing-Over Tokens:** Small markers or tokens to represent segments of chromosomes that will be exchanged during crossing-over.
- **Player Mats: 1 Mat** labeled Modeling: “Without Crossing Over," “With Crossing Over," "Independent Assortment - 1," and " Independent Assortment – 2.“
- **Game Instructions Sheet:** A sheet explaining the rules and steps of the game.

**Observation Sheets:** Worksheets for students to record their observations.

## Game Setup:

- **Divide the Class:** Split the students into small groups of 3-4 players.
- **Distribute Materials:** Each group receives chromosome cards, crossing-over tokens, player mats, and observation sheets.
- **Assign Roles:** Each group should assign roles such as "Shuffler," "Recorder," and "Model Builder."
    1. The **Shuffler** will handle the cards
    2. The **Recorder** will track observations
    3. The **Model Builder** will help create the visual models.

**Game Instructions:**

**Objective**: To simulate the processes of meiosis—chromosome reduction, independent assortment, and crossing-over—and observe how these processes lead to genetic diversity.

# Game Rules and Steps:

1. Start with **Homologous Pairs**: Place the chromosome cards in the "Original Pair" row of the player mat. Arrange them in homologous pairs, with one card from "Parent A" and the corresponding card from Card B next to each other.
2. **Chromosome Reduction**: The **Shuffler** will simulate the first meiotic division. Randomly separate the homologous pairs into two groups, each group representing a different cell. Place the cards in the "After Reduction" row. Note how the number of chromosomes is halved in each new cell. Write Diploid or Haploid in the blank.
3. **Observation**: The **Recorder** writes down which chromosomes ended up in each new cell, noting the reduction in chromosome number.
4. **Independent Assortment**: The **Shuffler** randomly pairs the chromosomes from the "After Reduction" row. This simulates the random assortment of chromosomes during meiosis.
5. **Observation**: The **Recorder** notes the new combinations of chromosomes in each cell, highlighting the variation created by independent assortment.

4. **Crossing-Over Simulation:** The Shuffler selects one or more pairs of homologous chromosomes. Use the crossing-over tokens to exchange segments between the homologous chromosomes, simulating crossing-over. Place the altered chromosome cards in the "After Crossing-Over" row.
5. **Observation: The Recorder** documents which segments were exchanged and how this changes the genetic information in each chromosome.
6. **Repeat the Process:** Groups should repeat steps 2-4 at least three times with different initial arrangements to see how these processes consistently create new genetic combinations.
7. **Create Visual Models:** The Model Builder uses the observations to create visual models (drawings or diagrams) that show outcomes without crossing over, 2 options for independent assortment, and crossing-over. Draw the chromosomes represented by the cards you and your team decide for each cell.
8. **Group Reflection:** After completing the game, each group should discuss how the processes observed lead to genetic diversity in the resulting cells. Write a short group reflection on how meiosis contributes to the variation seen in sexually reproducing populations.

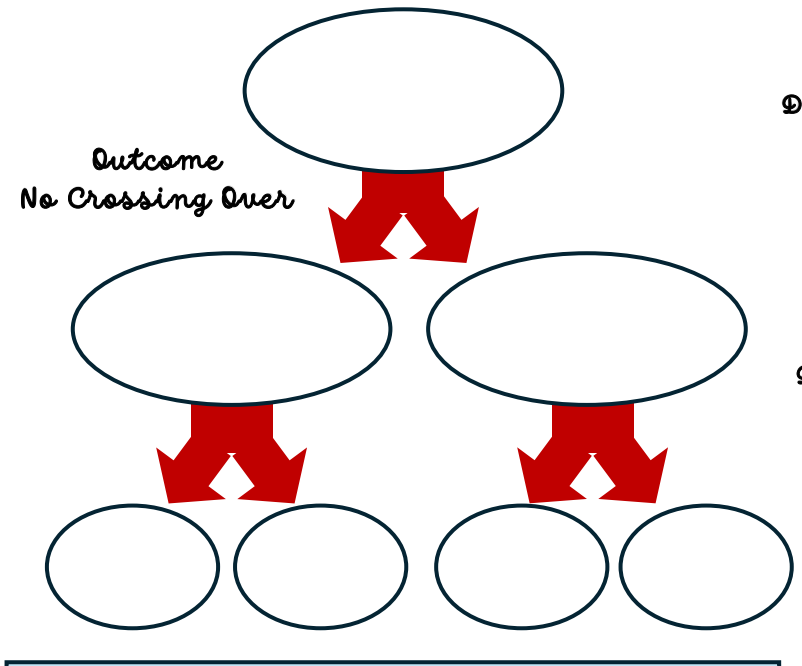
**Game Outcomes:** By the end of the game, students should be able to:

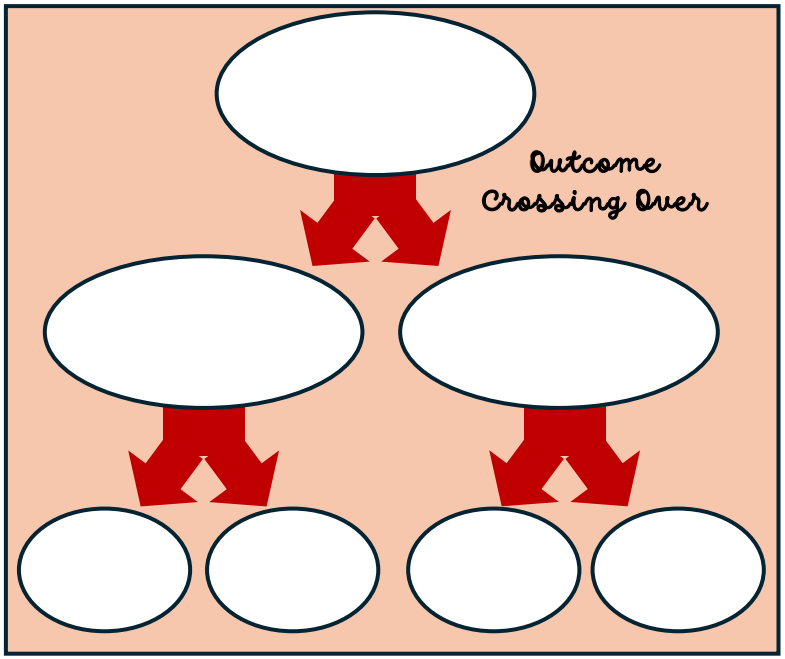
1. **Explain** the importance of chromosome reduction, independent assortment, and crossing-over in meiosis.
2. **Describe** how these processes contribute to genetic diversity.
3. **Create** accurate visual models representing each stage of meiosis.
4. **Reflect on** and articulate the significance of meiosis in genetic variation.

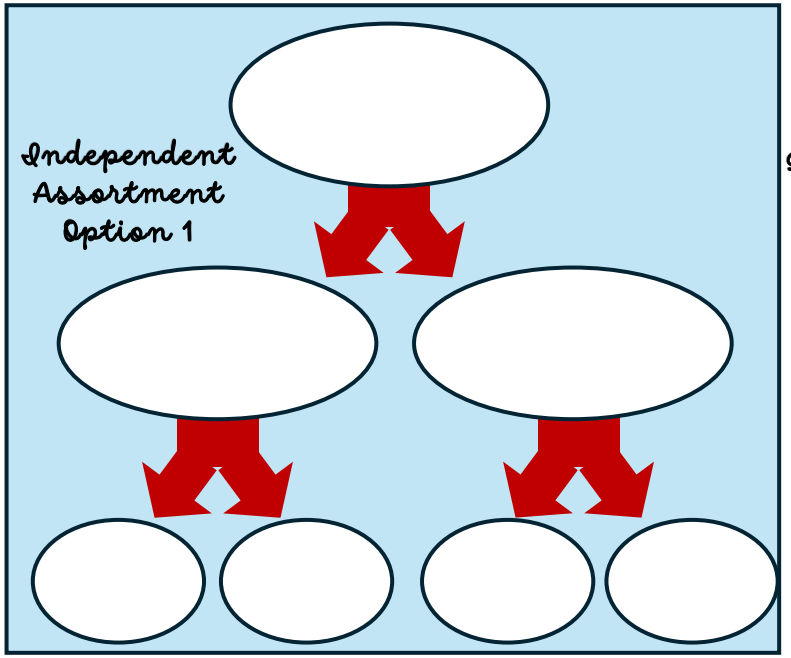
**Game Reflection:**

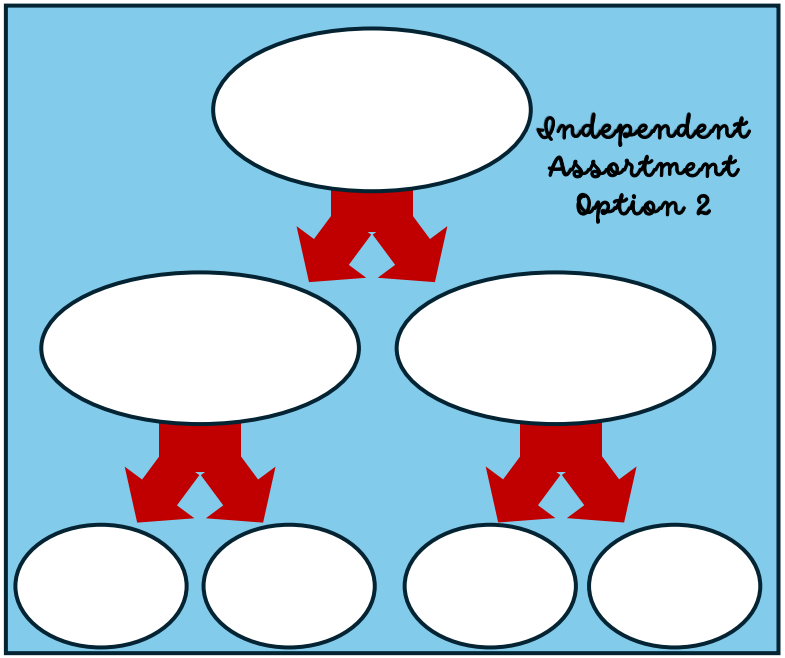
1. **Discuss** how genetic diversity might impact a population's ability to adapt to environmental changes.
2. **Consider** how errors during meiosis could lead to genetic disorders and explore the potential implications.

# Modeling

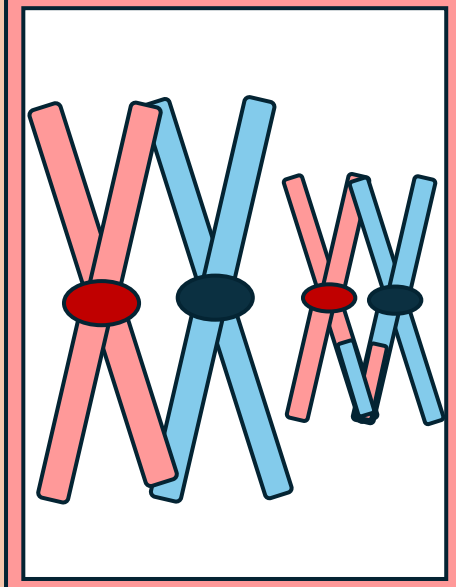

Outcome
No Crossing Over
Diploid or Haploid
Diploid or Haploid
Diploid or Haploid

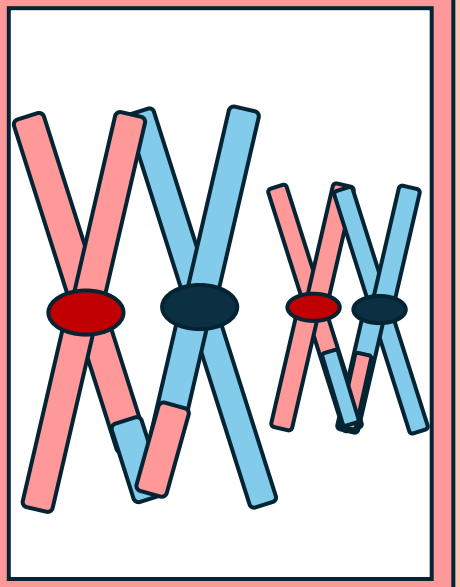

Outcome
Crossing Over

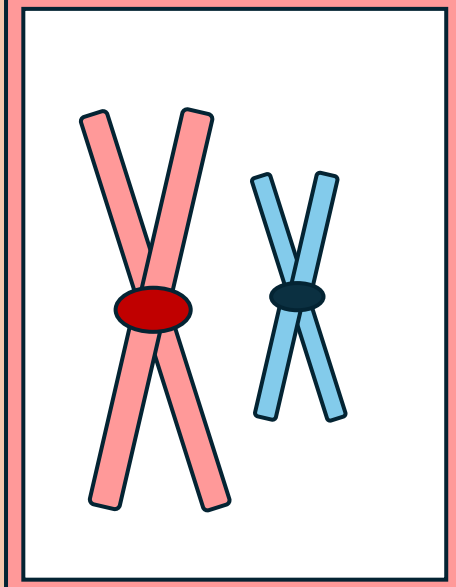

Independent
Assortment
Option 1
Diploid or Haploid
Diploid or Haploid
Diploid or Haploid

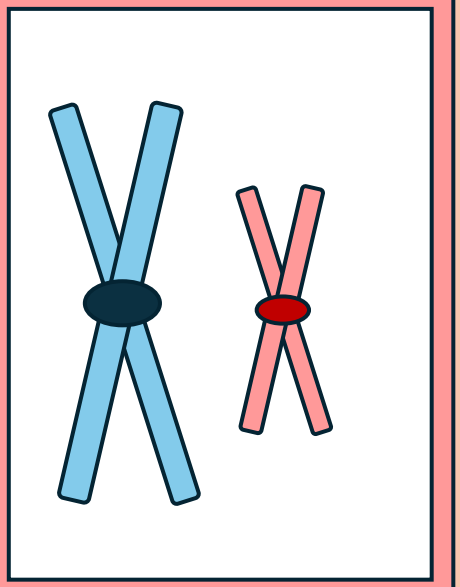

Independent
Assortment
Option 2

# A - Cards

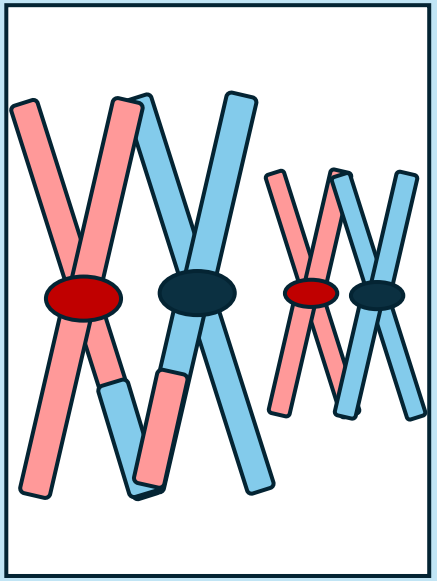


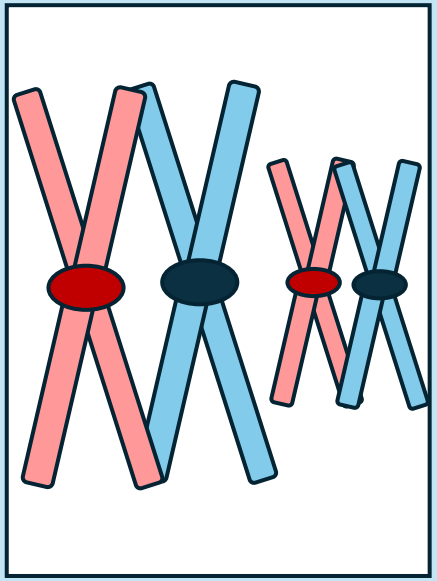


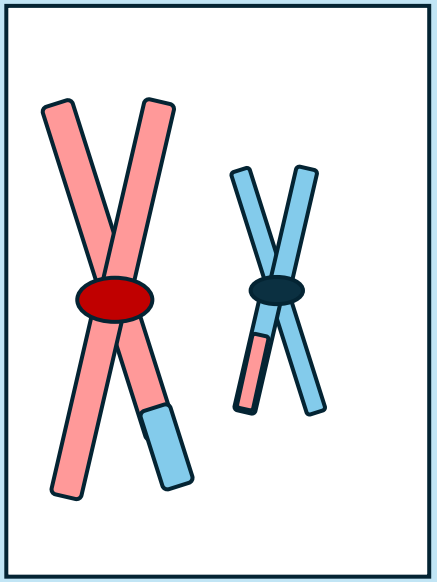


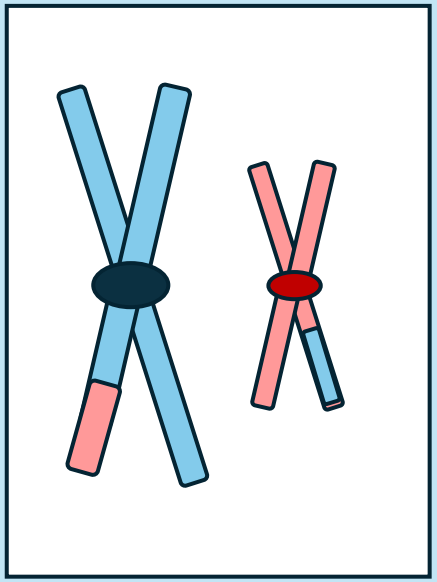


# B - Cards

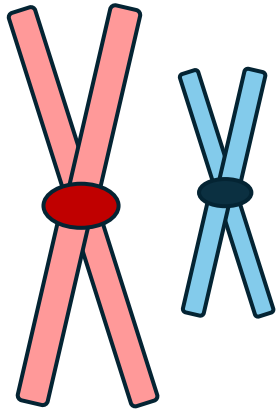


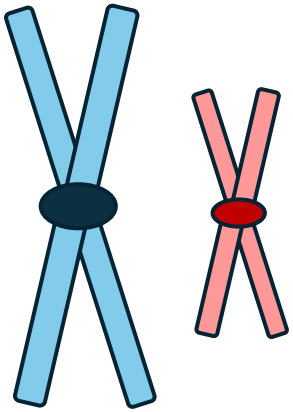


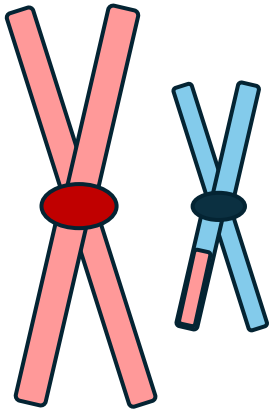


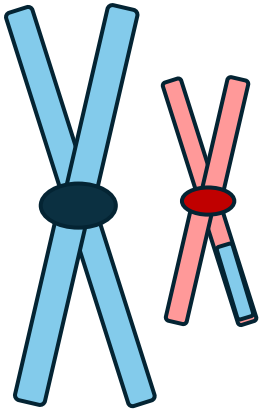


# A - Cards

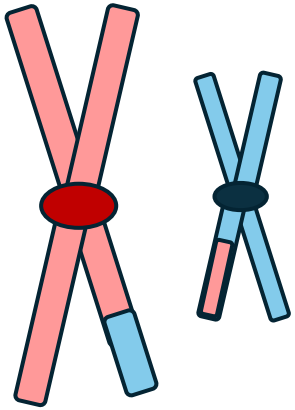


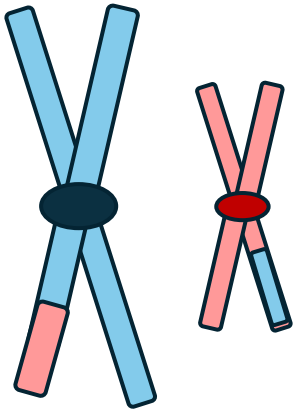


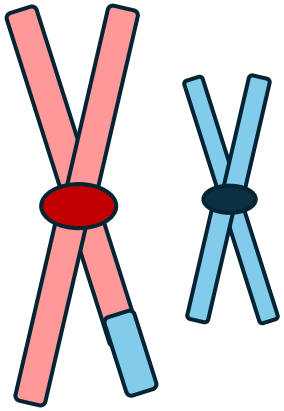


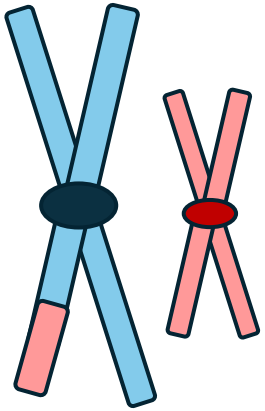


# B - Cards

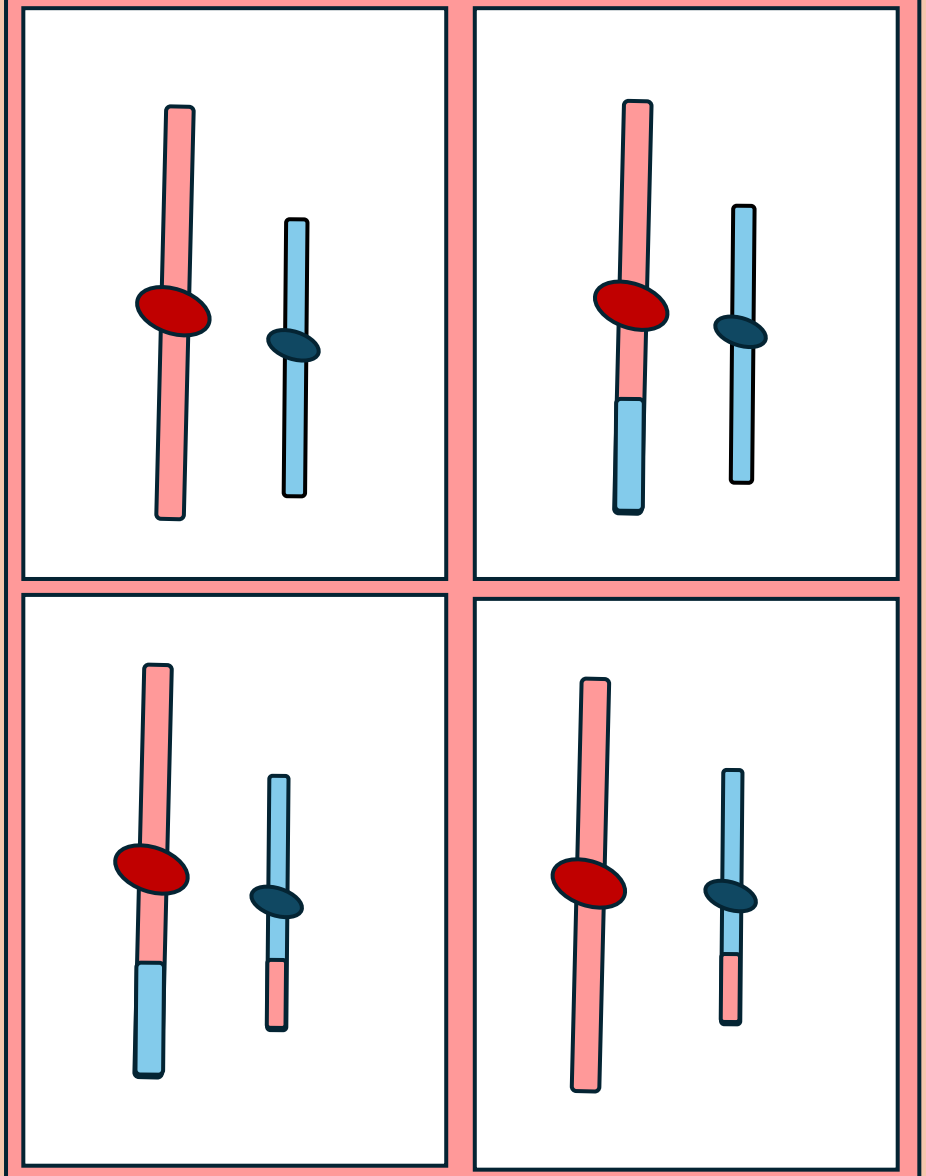




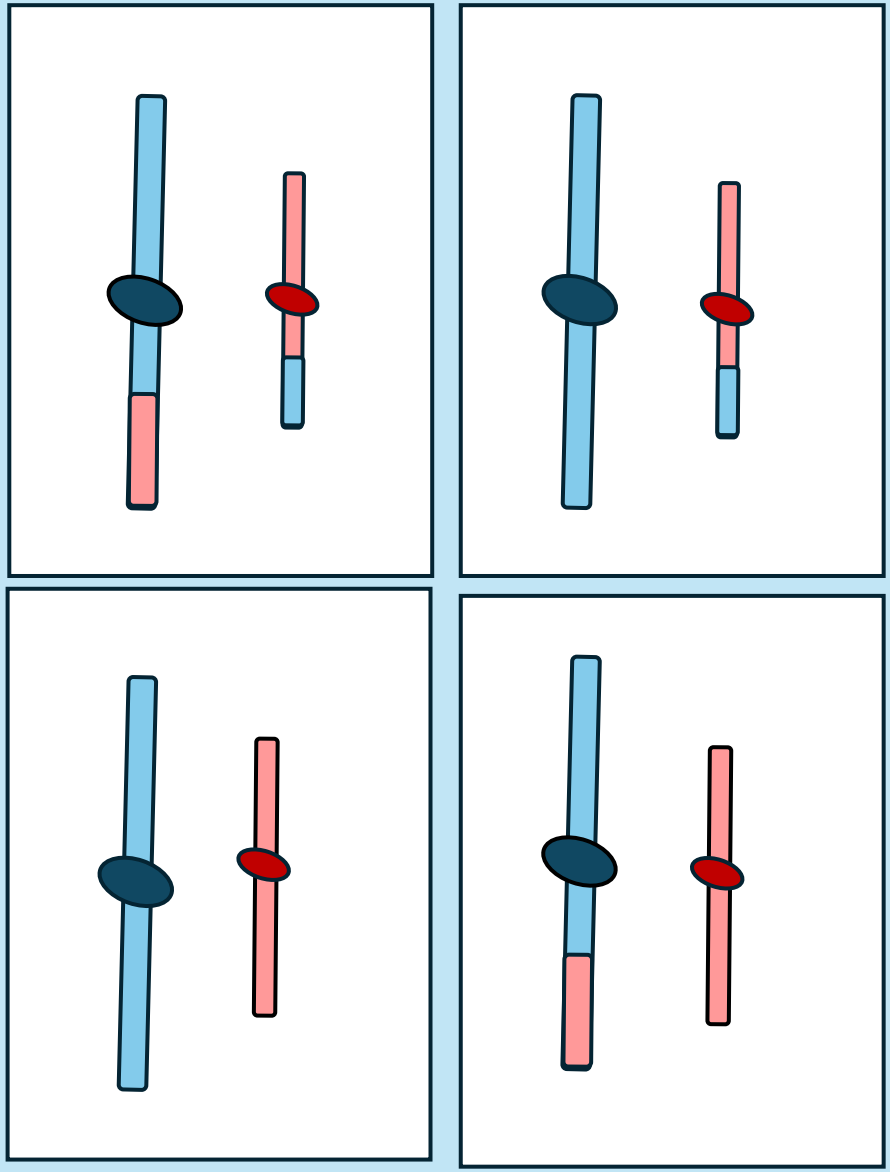




# Outcomes



# Outcomes



# Crossing Over



# Crossing Over


# Independent Assortment



# Independent Assortment


## Reflection

**Discuss how genetic diversity might impact a population's ability to adapt to environmental changes:**

- *"Genetic diversity is important for a population because it allows for..."*
- *"When a population has a wide range of genetic traits, it is more likely to..."*
- *"In the face of environmental changes, genetic diversity helps a population by..."*
- *"If all individuals in a population were genetically similar, they might struggle to..."*
- *"An example of how genetic diversity aids in adaptation is..."*
- *"The role of genetic diversity in natural selection is..."*

***Consider how errors during meiosis could lead to genetic disorders, and explore the potential implications:***

- *"Errors during meiosis, such as nondisjunction, can result in..."*
- *"When chromosomes do not separate properly during meiosis, it can cause..."*
- *"A well-known genetic disorder caused by meiotic errors is..."*
- *"The implications of a meiotic error in an organism can include..."*
- *"Genetic disorders resulting from meiosis can affect a population by..."*
- *"One way scientists study genetic disorders related to meiosis is by..."*