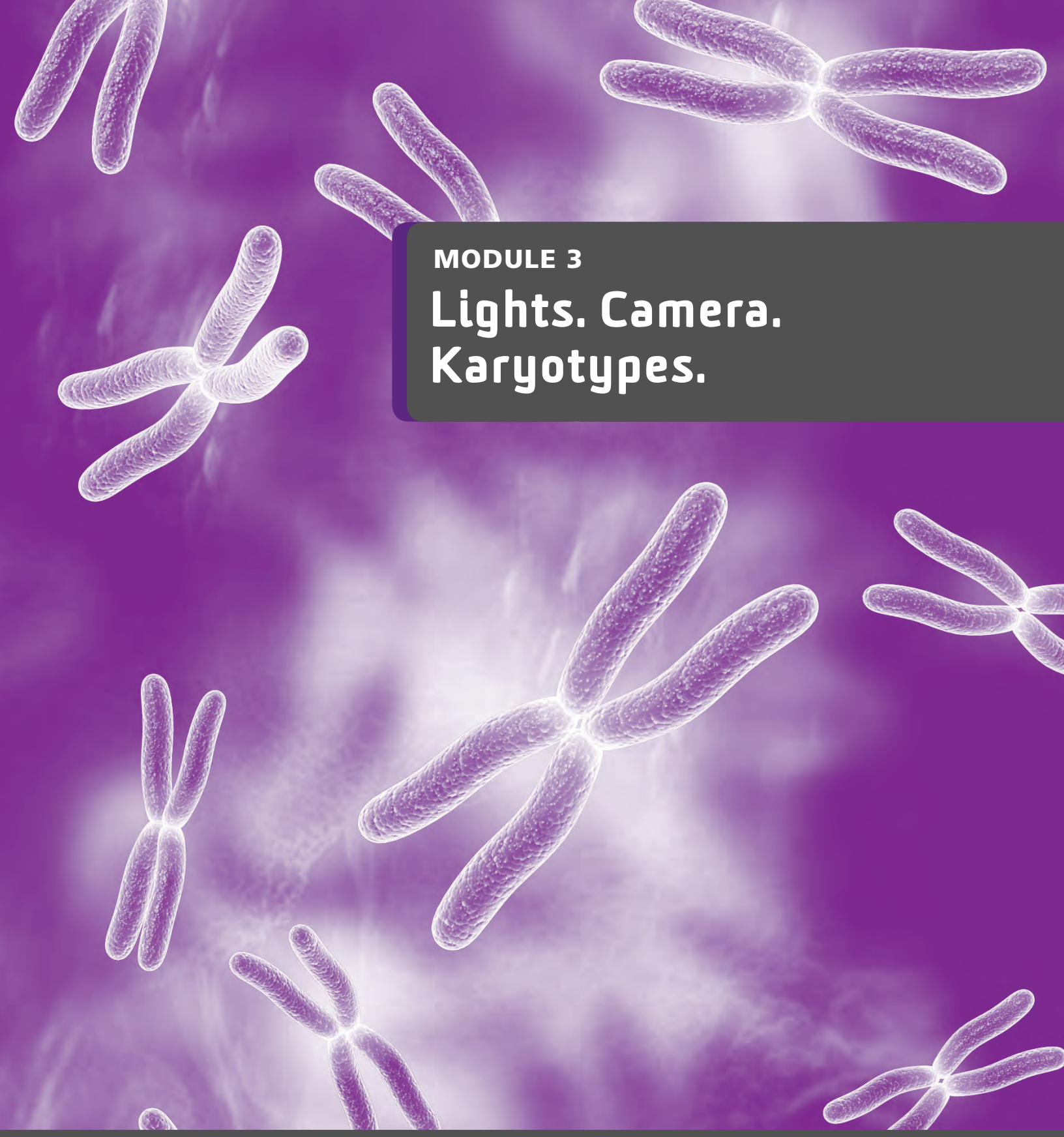

MODULE 3

Lights. Camera. Karyotypes.

FACILITATOR'S GUIDE

GENETICS FOR KIDS

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Table of contents

Lights. Camera. Karyotypes. | **Module 3**

1 Introduction

1 Learning objectives

1 Prior knowledge

1 Relevant standards of learning

2 Background

3 Vocabulary

3 Materials list

3 Procedure

6 Extension lesson

6 Teacher notes

6 Additional resources

7 Student handout

15 Student handout - Answer key

Lights. Camera. Karyotypes.

Introduction

Images of chromosome pairs are essential to understanding the function of living organisms. A karyotype is a picture of chromosome pairs. In a karyotype, chromosomes are configured in pairs and are arranged in order of size, from the largest to the smallest, with the sex chromosomes last. Each chromosome has a pattern of light and dark lines, or band patterns. The chromosomes are paired by matching their band patterns. Karyotypes have several critical uses and are helpful for doctors and scientists. For example, doctors can examine images of human chromosome pairs and detect defects that may lead to health complications. Veterinarians can examine pictures of animal chromosomes and assess qualities, such as fertility, which is the ability to produce offspring.

In this module, students will be introduced to karyotypes and their uses, and will learn how to read a karyotype and how to identify characteristics of the organism, based on the picture of chromosomes. The module also reinforces the basic concepts about chromosomes and the idea that genetic material is found in the cells of all living organisms.

Learning Objectives

- ✓ Recognize a karyotype
- ✓ Count the number of chromosomes shown in a karyotype
- ✓ Identify sex (male or female) from a human karyotype
- ✓ Identify uses of a karyotype in the scientific and medical communities

Prior Knowledge

To complete this module, students should already be able to:

- ✓ Recognize that chromosomes are found in the nucleus of cells
- ✓ Understand that chromosomes are made of genetic material that controls what the cell is made of and what the cell does

Relevant Standards of Learning

National Science Education Standards
Life Science, Content Standard C

Structure and function in living systems

- All organisms are composed of cells–the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.

Reproduction and heredity

- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes that are located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one gene, or by many genes. A single gene can influence more than one trait. A human cell contains many thousands of different genes.

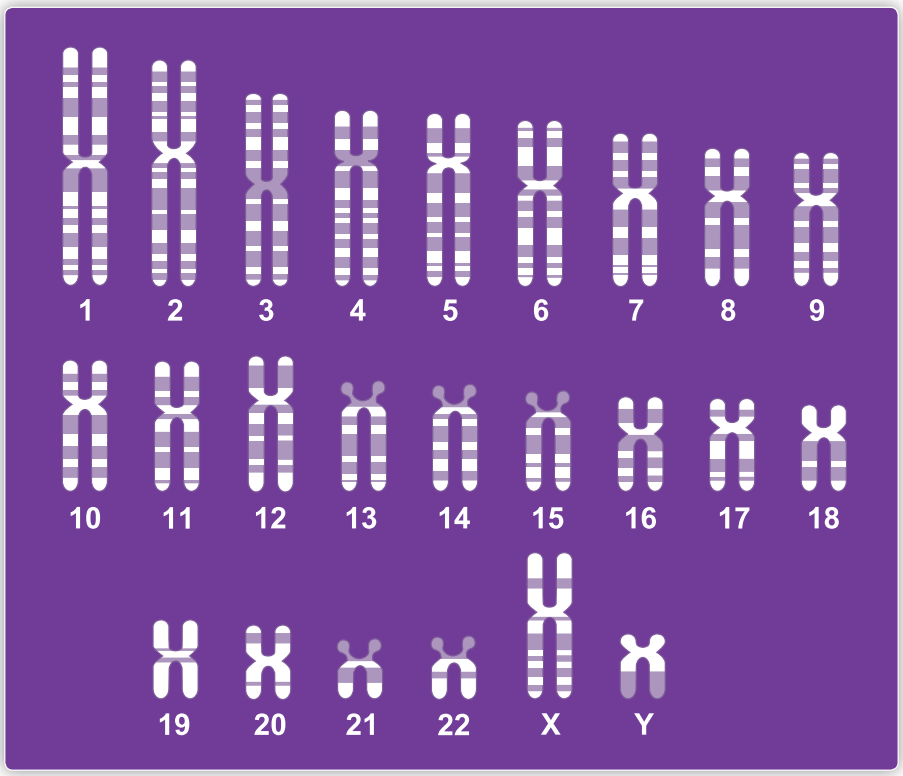
New York State Intermediate Science Standards (Grades 5 - 8)
Standard 4: The Living Environment

Major Understandings

- 2.1a: Hereditary information is contained in genes. Genes are composed of DNA that makes up the chromosomes of cells.
- 2.1e: In sexual reproduction typically half of the genes come from each parent. Sexually-produced offspring are not identical to either parent.

Background

A **karyotype** is a picture of chromosome pairs. Chromosomes are visible during **mitosis**, which is the process of cell division. In preparation for cell division, DNA coils tightly around proteins that exist in the nucleus of the cell. During mitosis, the DNA coils are shorter and fatter than normal and are visible when viewed through a microscope. DNA coils during mitosis are called chromosomes. In a karyotype, chromosomes are paired by matching their light and dark lines, or band patterns. These pairs are arranged from largest to smallest. Humans have 46 chromosomes, or 23 pairs of chromosomes. In each pair, one chromosome comes from the father and one chromosome comes from the mother. Pair 23, the last pair, determines sex (male or female). Human females have two X chromosomes, and males have one X and one Y chromosome. By looking at karyotypes, scientists can determine whether an organism is male or female, its **biological classification**, and whether it has certain health conditions.



Organisms may have **atypical** karyotypes (chromosome number). Atypical karyotypes mean that an organism may be missing chromosomes or may have extra chromosomes. In humans, this would mean that a person may have more than 46 chromosomes or less than 46 chromosomes. Atypical chromosome number in humans can cause a range of health complications. For example, one extra copy of chromosome 21 results in Down syndrome, a genetic birth defect that affects children's brain and body development. A person with Down syndrome has 47 chromosomes, and often has an abnormally shaped head and slower mental development than children with typical chromosome pairs. If a person is missing an X chromosome, that person will have Turner syndrome, which affects only girls. A person with Turner syndrome has only 45 chromosomes, and is sometimes born with swollen hands and feet and wider than normal necks.

Early karyotypes were produced by culturing, or growing, cells under controlled conditions. Scientists took microphotographs of chromosomes as they became visible during mitosis. The chromosomes were then cut from the photographs, rearranged by size, and adhered to another sheet of paper.

Today, computer imaging eliminates manual cutting and pasting. Early karyotypes did not show the light and dark lines on chromosomes (band patterns) that can be detected today with various staining techniques *(see Teacher Note 1)*. With the advances in medical imaging and staining techniques, the modern karyotype is a critical tool for doctors and scientists.

Vocabulary

1. **Atypical**: Not typical, irregular, and different from what is "normal."
2. **Biological classification**: The systematic grouping of organisms into categories on the basis of evolutionary or structural relationships between them.
3. **Chromosome**: A single molecule of DNA and its associated proteins, which condense and become visible during mitosis. Chromosomes determine traits including gender, hair color, and eye color.
4. **Homologous**: Similar and related in structure, function, or evolutionary origin.
5. **Karyotype**: A picture of the chromosomes present in an organism's cells.
6. **Mitosis**: The process during which a cell duplicates and splits into two identical cells, unless changes have occurred to the chromosomes during this process.
7. **Nonhomologous**: Not similar or related in structure, function, or evolutionary origin.

Materials List

Before you begin, ensure that you have all of the items necessary to complete the module.

- ✓ **Student Handout**
- ✓ **Scissors**

Procedure

Day of the Lesson

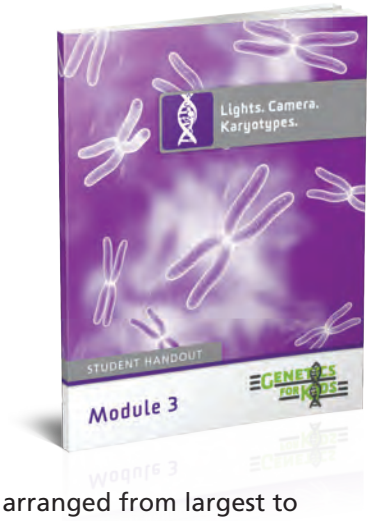
1. Seat students in pairs.

   Inform students that in today's module they will learn about karyotypes. A karyotype, a picture of an organism's chromosomes and can be used to detect health conditions and identify characteristics of an organism.

2. Distribute a **Student Handout** to each student.

3. Instruct students to read **Part I: Introduction**.

   Ask students to silently read **Part I: Introduction** on the **Student Handout**. Provide students with enough time to read the Introduction. Circulate around the room as students read; redirect student with questions and check for comprehension as needed.



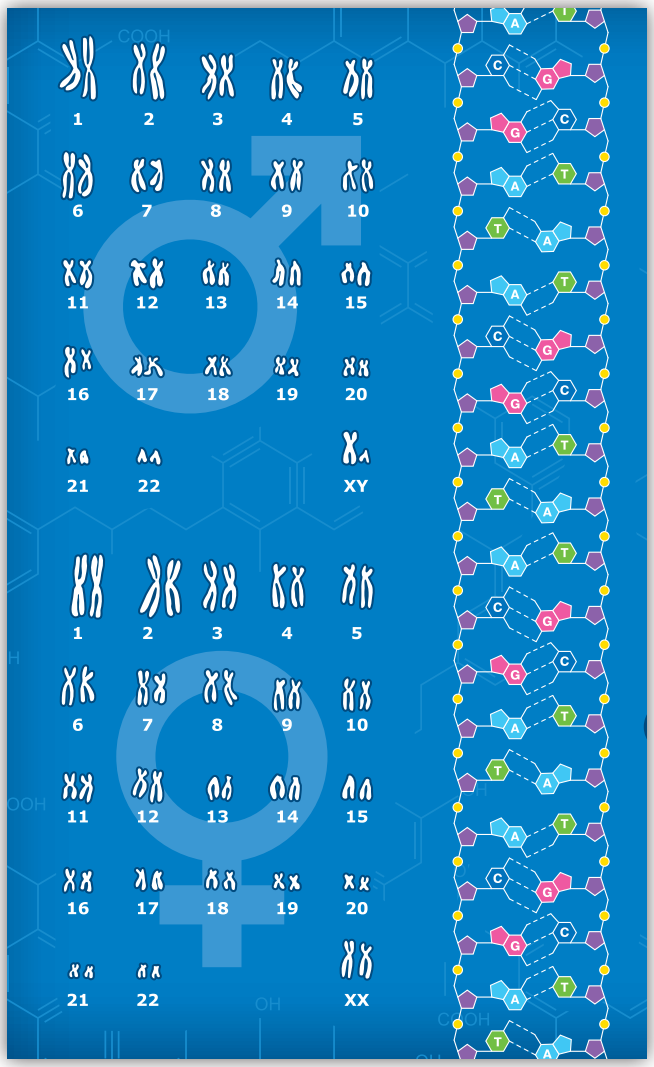
4. Emphasize key points from **Part I: Introduction**.

   When all students are finished reading, address any questions students may have about karyotypes. Emphasize the following key points:

   - A karyotype is a picture of an organism's chromosomes.
   - In a karyotype, individual chromosomes are paired by matching their dark and light lines, or banding patterns. Chromosome pairs are then arranged from largest to smallest. The sex chromosomes are always last *(see Teacher Notes 1 and 2)*.
   - The dotted lines on each chromosome separate the smallest part of the chromosome from the longest part of the chromosome. The smallest part of the chromosome always goes on top.
   - Humans have 46 chromosomes (23 pairs). Human chromosome pairs are numbered 1 through 23. The sex chromosomes are number 23. Human females have two X sex chromosomes, and human males have one X and one Y sex chromosome *(see Teacher Note 3)*.

- Some organisms have atypical chromosomes, meaning they are missing or have an extra chromosome. Atypical chromosomes may indicate that a person has a genetic disease. For example, one extra copy of chromosome 21 results in Down syndrome and a missing sex chromosome results in Turner syndrome.

- Karyotypes can be used by the scientific and medical community to identify diseases and identify the sex of an organism.



5. Check students' understanding of **Part I: Introduction**.

   After you have emphasized the key points of the **Introduction**, ask students the following questions:

   - What is a karyotype?
   - Why are chromosomes paired?
   - How many total chromosomes does a typical human have?
   - How many pairs of chromosomes does a typical human have?
   - What sex chromosomes does a male have?
   - What sex chromosomes does a female have?

   After discussing the above questions, allow students a few moments to record the answers in **Part II** of the "Check your understanding" box.

6. Introduce **Part III: Activities**. Tell students they will work with their partner to complete three activities.

7. Instruct students to complete ***Activity 1: Examining a human karyotype***.

   Ask students to look at the karyotype in ***Activity 1*** and answer the questions. Circulate around the room while students answer the questions for ***Activity 1***; redirect students with questions and check for comprehension, as needed.

   Give students enough time to examine the karyotype and answer the questions. Once all students have completed the questions, discuss the answers as a class.

8. Instruct students to complete ***Activity 2: Does chromosome number always mean organisms are related?***

   Ask students to read ***Activity 2*** on the **Student Handout** and complete the "Check your understanding" box. Provide students with enough time to read the content and answer the question. Circulate around the room as students read and remind students that some related organisms might have similar chromosome numbers. However, many nonrelated organisms also have a similar chromosome number. For example, the commercial potato and the great ape both have 48 chromosomes. Answer student questions and check for comprehension, as needed.

9. Instruct students to complete ***Activity 3: Using karyotypes for medical diagnoses.***

   Inform students that they will examine a human karyotype to determine whether the human has a typical or atypical karyotype. Instruct students to carefully inspect the human karyotype and answer the questions below the karyotype.

   Circulate around the room as students complete ***Activity 3***. Remind students that atypical chromosome number can indicate medical conditions, even if that health condition is not obvious by looking at the person.

10. Introduce ***Activity 4: Karyotype concentration.***

    Inform students that they will work with their partner to make homologous, or similar pairs of chromosomes for an opossum. Students will have a set of 11 cards from the father opossum and a set of 11 cards from the mother opossum. There is an image of a chromosome on each card. Place cards face down in rows. Each student should take turns flipping over a card from each opossum (father and mother). Chromosomes are a homologous pair if the banding (line) pattern on the chromosomes match.

    Inform students that when they are finished matching chromosome pairs, students should construct a karyotype for the opossum by ordering the pairs of chromosomes from largest to smallest. When students are finished, students should raise their hand so you can check the matches.

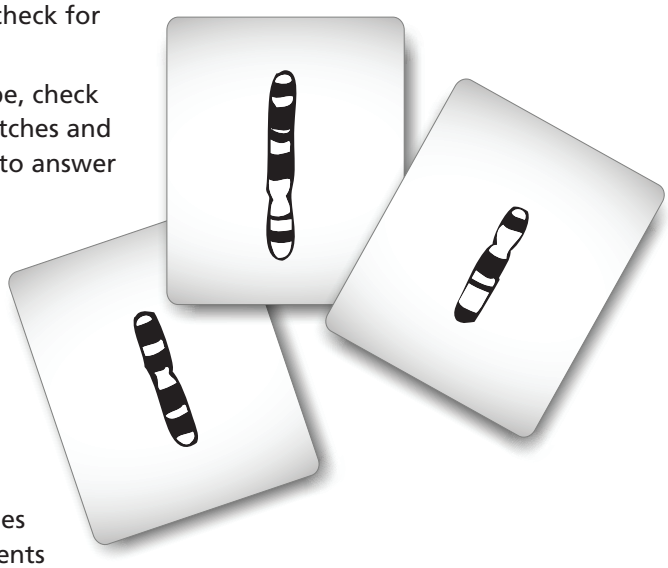
    Instruct students to carefully read the directions for ***Activity 4*** in their **Student Handout**.

11. Distribute one set of opossum chromosome cards to each pair of students. A set includes the chromosomes for the mother opossum and father opossum.

    Remind students to carefully follow the directions on the **Student Handout**.

    Circulate around the room while students match the chromosomes; redirect students with questions and check for comprehension as needed.

    When pairs of students have completed the karyotype, check the matches. When students have completed the matches and assembled a correct karyotype, instruct the students to answer the questions in the **Student Handout**.

    Students should determine that the opossum has 22 chromosomes and that the opossum pictured in the karyotype is a female. Students cannot determine if the karyotype is typical for an opossum because they have no reference karyotype for comparison. Once students have determined the sex of the opossum, provide them with the typical number of chromosomes for an opossum. Inform students that 22 is the typical number of chromosomes for the common opossum, so the karyotype the students create is a typical opossum karyotype.

12. Lead a closing class discussion about the module's activities.

    Discuss student observations about the opossum karyotype and answer any questions from the activities. Then discuss **Part IV: Conclusion questions**. Encourage students to give specific examples from the module's activities to answer the questions. Following the discussion, allow students enough time to record the answers on the **Student Handout**.

Extension Lesson

Variations of Karyotype Concentration

Students can research and construct similar matching games for karyotypes of organisms with different numbers of chromosomes.

Additional Research

The students can also investigate reasons for atypical chromosomes and how changes in chromosomes can affect health. Once students research the reasons for atypical chromosomes, they can investigate the effects of genetic disorders such as Down syndrome and Turner syndrome.

Teacher Notes

1. Males are more likely to have sex-linked traits, which is the result of genes carried on the X chromosome, because they only have one X chromosome. Sex-linked traits are the result of genes that are carried on the X chromosome. If a gene for a trait is carried on the X chromosome, males will exhibit the trait, even if it is recessive, because males only have one X chromosome. Hemophilia, for example, is a genetic disorder of the blood and is an X-linked, or sex-linked, mutation. Males need only one X chromosome with the mutation that causes hemophilia to develop the disease because they do not have a second X chromosome. Females, however, have two X chromosomes–they can have the hemophilia mutation on one X chromosome and still not develop hemophilia because they have a second X chromosome with a normal functioning gene. A female can be a hemophilia carrier, but to have the disease a female would require the hemophilia mutation on both copies of her X chromosome.

2. Sperm and egg cells are created through a special form of division called meiosis. Meiosis is different from mitosis because the end result of meiosis creates four cells with only half of the chromosomes of the parent cell.

3. Be aware that that not all organisms that sexually reproduce use an XX/XY chromosome structure to determine the sex of the offspring. For example, male birds are ZZ, while female birds are ZW.

Additional Resources

1. Howard Hughes Medical Institute, *Biointeractive*. This website links to an activity that compares different organisms' Karyotypes and characteristics. http://www.hhmi.org/biointeractive/gender/pdf/xsandoscardshires.pdf

2. Indiana University, Evolution and the Nature of Science Institutes, *Chromosome Fusion? Ppt.* This PowerPoint presentation is advanced for middle school students, but slides 1–8 provide helpful diagrams for teachers to better understand the relationship between gorilla, chimpanzee, and human chromosomes. http://www.indiana.edu/~ensiweb/pp.pres.html

3. University of Arizona, the Biology Project, *Karyotyping Activity*. This website offers an online Karyotyping activity in which students complete a karyotype and then read the karyotype to determine the patient's diagnosis. http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html

4. University of *Utah, Learn. Genetics*. Make a Karyotype on paper or online. http://learn.genetics.utah.edu/content/begin/traits/karyotype/karyotype_paper.pdf

Part I: Introduction

DNA is the hereditary material that contains instructions for the appearance and function of all parts of living organisms. In human beings, for example, DNA is responsible for the texture of your hair and the color of your eyes and skin among many other traits. **Mitosis** is the process of cell division in living organisms. During **mitosis**, DNA becomes tightly coiled. When DNA coils, the DNA becomes a chromosome. Chromosomes are short and fat because they are tightly coiled. Tightly coiling makes the chromosomes visible under a microscope.

Karyotypes are pictures of chromosome pairs. By looking at karyotypes, scientists can determine whether an organism is male or female, whether it has certain health conditions, and its **biological classification**.

In a karyotype, chromosomes are paired by matching their light and dark lines, or band patterns. Chromosomes that are paired together are called **homologous**, or similar, pairs. Homologous means similar. In a karyotype homologous pairs are arranged from largest to smallest. Humans have 46 chromosomes, so they have 23 pairs of chromosomes. One chromosome of each pair comes from the father and one chromosome comes from the mother. In that way, every organism has DNA from both of its parents. Pair 23, the last pair, determines sex (male or female). Human females have two X chromosomes (XX), and males have one X and one Y chromosome (XY).

Sometimes there are problems with chromosome pairs. Some organisms have **atypical** chromosomes. In these cases an organism may have an extra chromosome, or an organism may be missing a chromosome. Atypical chromosomes can result in genetic diseases. For example, one extra copy of chromosome 21 results in Down syndrome, which is a genetic birth defect that affects children's brain and body development. Children born with Down syndrome often have an abnormally shaped head and have slower mental development than children with typical chromosome pairs. People missing one of the sex chromosomes, pair 23, can have Turner syndrome. Turner syndrome affects girls who are missing one X chromosome, and are sometimes born with swollen hands and feet and wider than normal necks.

In today's activity, you will look at karyotypes to determine whether a person is male or female, and diagnosing a medical condition based on an atypical human karyotype. Then, you will play a game to practice matching chromosomes into pairs.

Part II: Vocabulary

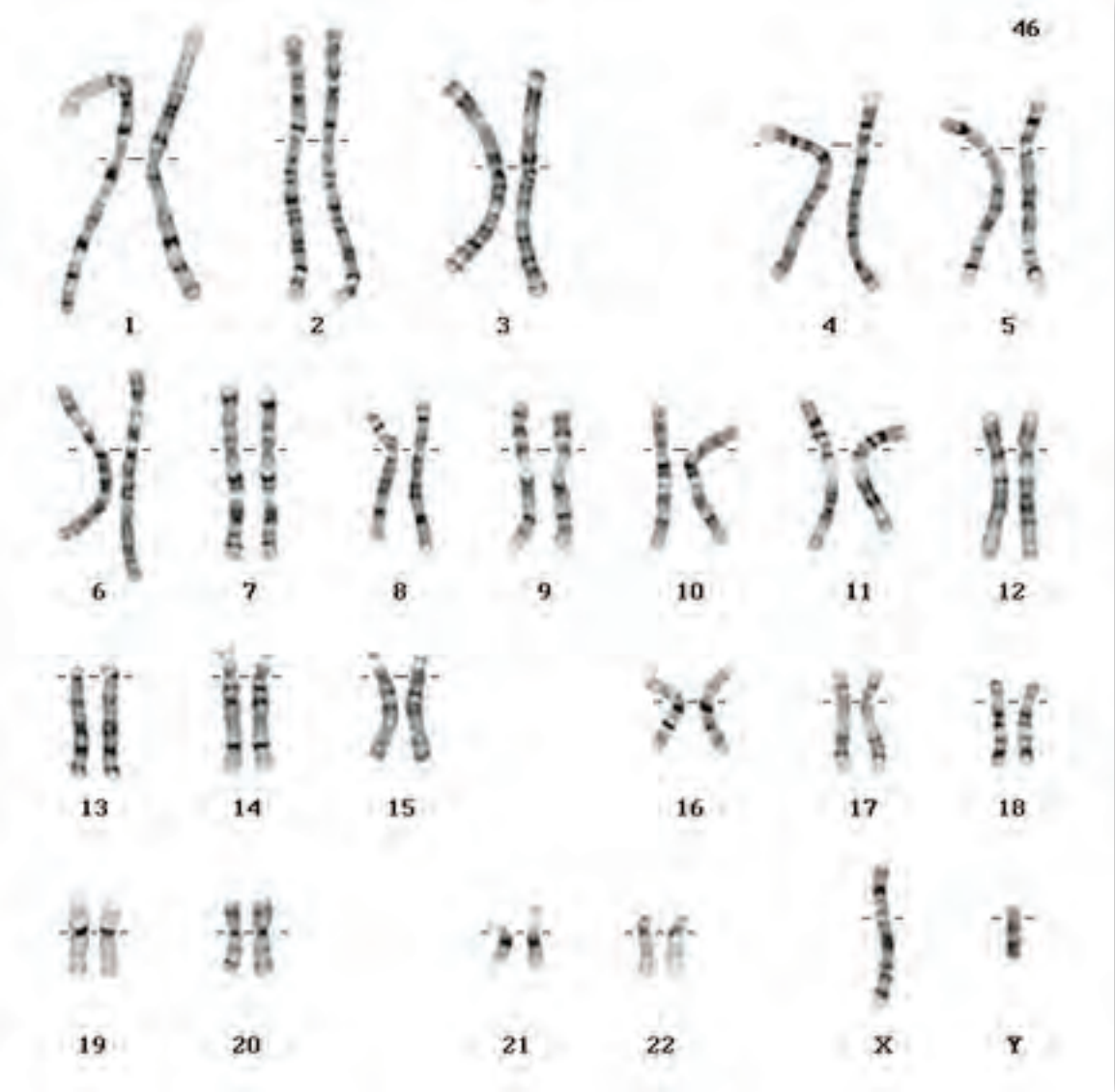
1. **Atypical**: Not typical, irregular, and different from what is "normal."
2. **Biological classification**: The systematic grouping of organisms into categories on the basis of evolutionary or structural relationships between them.
3. **Chromosome**: A single molecule of DNA and its associated proteins which condense and become visible during mitosis. Chromosomes determine traits, including gender, hair color, and eye color.
4. **Homologous**: Similar and related in structure, function, or evolutionary origin.
5. **Karyotype**: A picture of the chromosomes present in an organism's cells.
6. **Mitosis**: The process during which a cell duplicates and splits into two identical cells, unless changes have occurred to the chromosomes during this process.
7. **Nonhomologous**: Not similar or related in structure, function, or evolutionary origin.

Check your understanding:

- The typical human has _____ total chromosomes and ____ pairs of chromosomes.
- Male humans have one _____ and one _____ sex chromosome.
- Female humans have one _____ and one _____ sex chromosome.

Part III: Activities

Activity 1: Examining a human karyotype



Answer the following questions about the above karyotype:

How many chromosomes does this organism have? (Do not forget the sex chromosomes).

How many pairs of chromosomes does this organism have? (Do not forget the sex chromosomes).

Is the person a male or female? How do you know?

Does this person have the typical number of chromosomes for a human? How can you tell?

_____

_____

What would a picture of a person's chromosomes be used for?

_____

_____

_____

Activity 2: Does chromosome number always mean organisms are related?

Some organisms with different numbers of chromosomes have important similarities in the way their DNA is organized. For example, fruit flies have 8 chromosomes, while humans have 46 chromosomes. Scientists frequently use fruit flies in experiments because DNA in fruit fly chromosomes is arranged in a similar manner to DNA in human chromosomes. Scientists can use fruit flies to predict how humans may respond to a disease or medical treatment without conducting tests on humans.

On the other hand, the great apes (chimpanzees and gorillas) have 48 chromosomes. Humans are classified with great apes. However, a commercial potato also has 48 chromosomes. Potatoes and great apes are not classified together. Do you think a potato has many similarities to gorillas or chimpanzees?

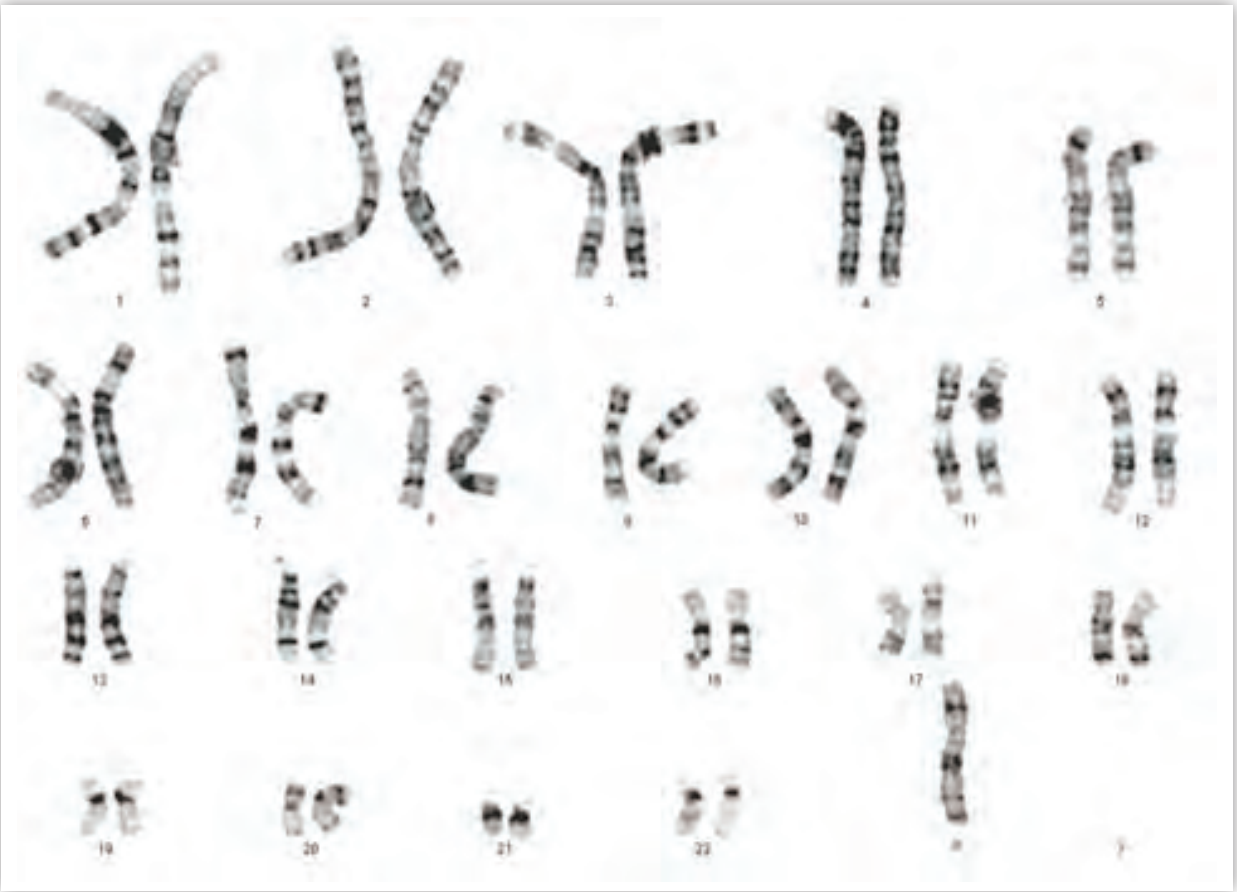
Just because organisms have the same or similar numbers of chromosomes **does not necessarily** mean that the organisms are closely related or that they can be classified together.

Check your understanding:

Circle the correct answer and give at least two examples to prove your point: Organisms with the same number of chromosomes can *(always, sometimes, never)* be classified together.

Activity 3: Using karyotypes for medical diagnoses

Look carefully at the following karyotype. Using what you have learned about human karyotypes, what information does this karyotype give you?



1. Is this a typical human karyotype? Why or why not?

2. Do you think this person is a male or a female? Explain your answer.

3. How would looking at this karyotype affect the medical care this person receives?

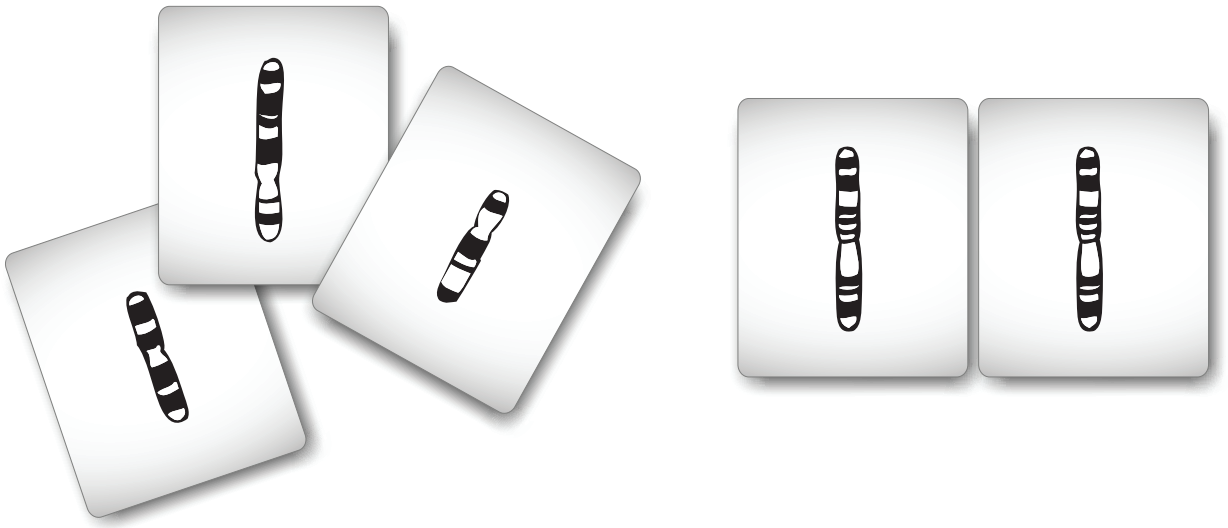
Activity 4: Karyotype concentration

You will receive two set of the chromosomes cards, one for a mother and one for a father. These chromosomes are based on the chromosomes in the nuclei of cells of the common opossum. The opossum inherited half of its chromosomes from its mother and half of its chromosomes from its father.

To play the game (2 people)

1. Lay all the cards face down in multiple rows.
2. The youngest person chooses two cards to flip over.
   - If the two cards are matching chromosomes (the word for this is homologous), then he or she says "HOMOLOGOUS" and removes those two cards from the table. Homologous chromosomes have similar banding or lines.
     - ➥ Player then takes another turn.
   - If the two cards are not matching chromosomes, the player says "NON-HOMOLOGOUS" and turns the cards back over.
     - ➥ It is the next person's turn to try to make a match.
3. The game is over when all the chromosomes have been matched. Whoever has the most cards wins the game.
4. Once the game is over, work with your partner to construct a karyotype with the matched chromosomes. Put the largest chromosomes first, second largest second, and so on until the smallest chromosome pair. Your teacher will check off your matches.

What information can you tell from the karyotype of the opossum?



Part IV: Conclusion questions

1. What has today's lesson shown us? What have you learned?

2. What is a karyotype and what information does it provide?

3. Why would doctors and scientists want to look at chromosomes?

Part V: Notes

Part I: Introduction

DNA is the hereditary material that contains instructions for the appearance and function of all parts of living organisms. In human beings, for example, DNA is responsible for the texture of your hair and the color of your eyes and skin among many other traits. **Mitosis** is the process of cell division in living organisms. During **mitosis**, DNA becomes tightly coiled. When DNA coils, the DNA becomes a chromosome. Chromosomes are short and fat because they are tightly coiled. Tightly coiling makes the chromosomes visible under a microscope.

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Sometimes there are problems with chromosome pairs. Some organisms have **atypical** chromosomes. In these cases an organism may have an extra chromosome, or an organism may be missing a chromosome. Atypical chromosomes can result in genetic diseases. For example, one extra copy of chromosome 21 results in Down syndrome, which is a genetic birth defect that affects children's brain and body development. Children born with Down syndrome often have an abnormally shaped head and have slower mental development than children with typical chromosome pairs. People missing one of the sex chromosomes, pair 23, can have Turner syndrome. Turner syndrome affects girls who are missing one X chromosome, and are sometimes born with swollen hands and feet and wider than normal necks.

In today's activity, you will look at karyotypes to determine whether a person is male or female, and diagnosing a medical condition based on an atypical human karyotype. Then, you will play a game to practice matching chromosomes into pairs.

Part II: Vocabulary

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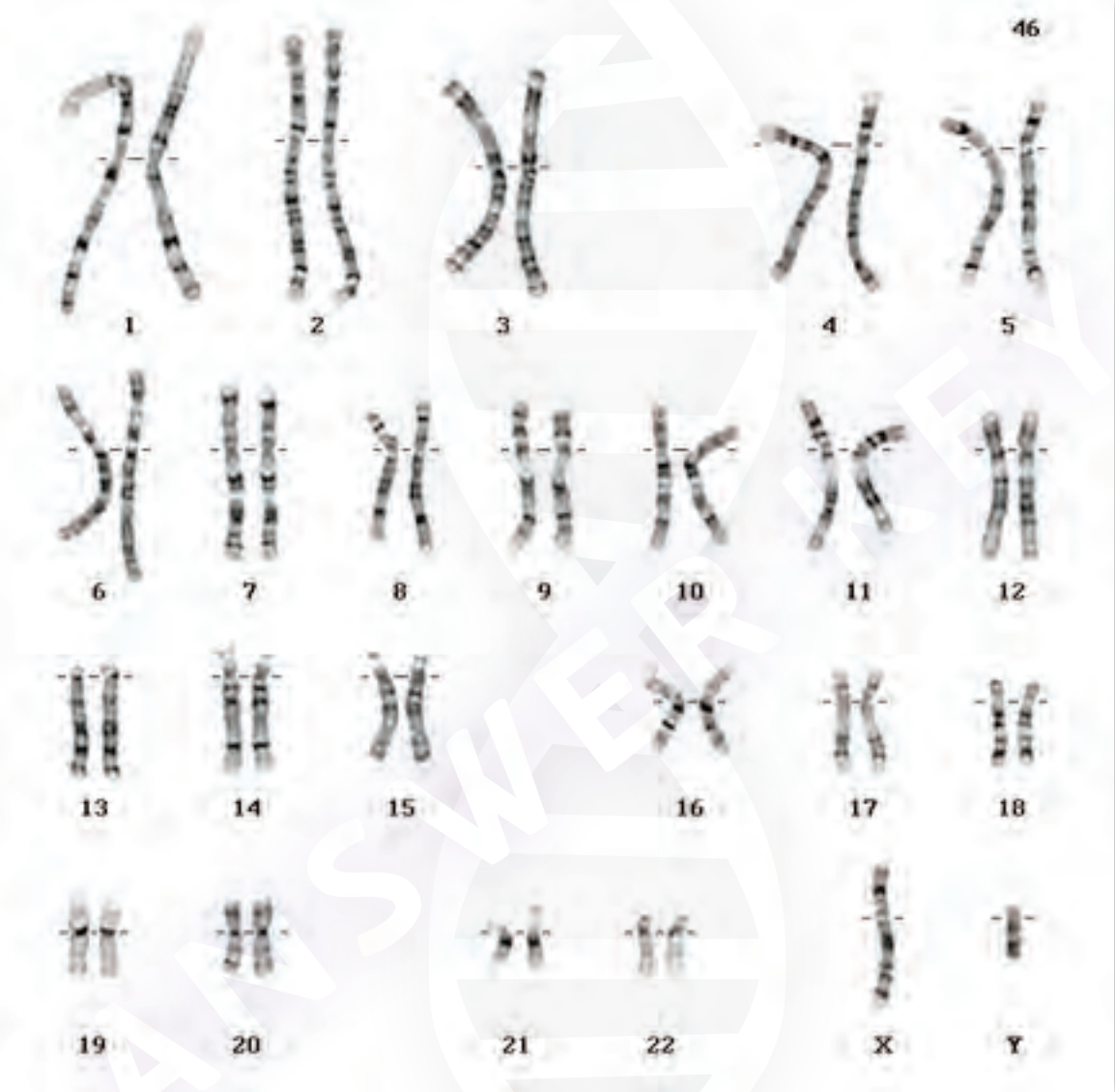
7. **Nonhomologous**: Not similar or related in structure, function, or evolutionary origin.

Check your understanding:

- The typical human has **46** total chromosomes and **23** pairs of chromosomes.
- Male humans have one **X** and one **Y** sex chromosome.
- Female humans have one **X** and one **X** sex chromosome.

Part III: Activities

Activity 1: Examining a human karyotype



Answer the following questions about the above karyotype:

How many chromosomes does this organism have? (Do not forget the sex chromosomes.)

46

How many pairs of chromosomes does this organism have? (Do not forget the sex chromosomes.)

23

Is the person a male or female? How do you know?

This person is male because the person has one X and one Y sex chromosome.

Does this person have the typical number of chromosomes for a human? How can you tell?

The typical number of chromosomes for a human is 46. This person has 46 chromosomes, so this person has a typical number of chromosomes.

What would a picture of a person's chromosomes be used for?

Karyotypes can be used to determine sex of a person, health conditions, and biological classification.

Activity 2: Does chromosome number always mean organisms are related?

Some organisms with different numbers of chromosomes have important similarities in the way their DNA is organized. For example, fruit flies have 8 chromosomes, while humans have 46 chromosomes. Scientists frequently use fruit flies in experiments because DNA in fruit fly chromosomes is arranged in a similar manner to DNA in human chromosomes. Scientists can use fruit flies to predict how humans may respond to a disease or medical treatment without conducting tests on humans.

On the other hand, the great apes (chimpanzees and gorillas) have 48 chromosomes. Humans are classified with great apes. However, a commercial potato also has 48 chromosomes. Potatoes and great apes are not classified together. Do you think a potato has many similarities to gorillas or chimpanzees?

Just because organisms have the same or similar numbers of chromosomes **does not necessarily** mean that the organisms are closely related or that they can be classified together.

Check your understanding:

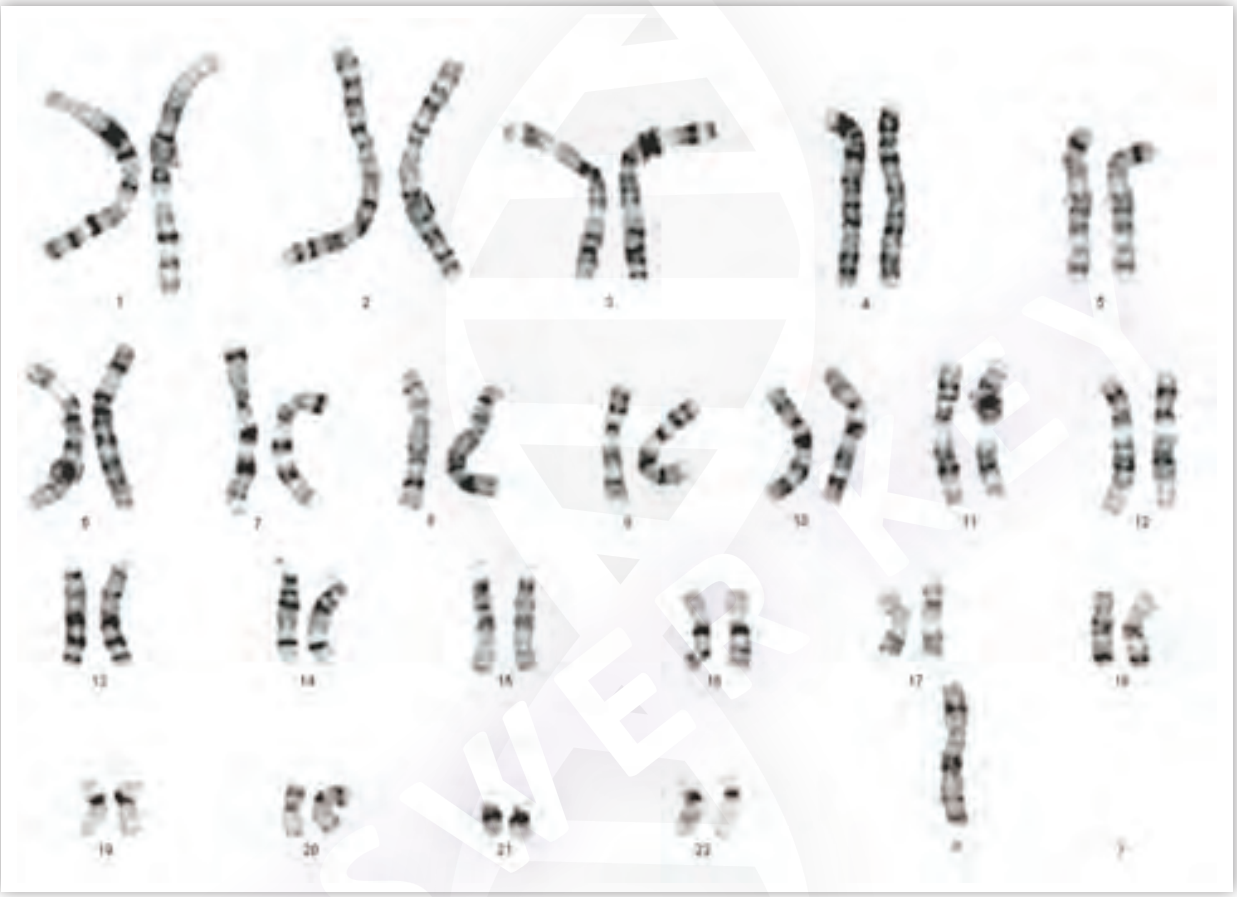
Circle the correct answer and give at least two examples to prove your point: Organisms with the same number of chromosomes can *(always,* ***sometimes,*** *never)* be classified together.

Humans are classified with great apes, but humans have 46 chromosomes and great apes have 48.

Great apes have 48 chromosomes and potatoes have 48 chromosomes, but great apes are not classified with potatoes.

Activity 3: Using karyotypes for medical diagnoses

Look carefully at the following karyotype. Using what you have learned about human karyotypes, what information does this karyotype give you?



1. Is this a typical human karyotype? Why or why not?

This is not a typical human karyotype. The person only has 45 chromosomes because she is missing an X chromosome.

2. Do you think this person is a male or a female? Explain your answer.

This person is a female. She has one X chromosome, but is missing the second X chromosome. The person has a disease called Turner syndrome.

3. How would looking at this karyotype affect the medical care this person receives?

This person would be diagnosed with Turner syndrome and she would be treated to reduce the symptoms and complications of the disease.

Activity 4: Karyotype concentration

You will receive two set of the chromosomes cards, one for a mother and one for a father. These chromosomes are based on the chromosomes in the nuclei of cells of the common opossum. The opossum inherited half of its chromosomes from its mother and half of its chromosomes from its father.

To play the game (2 people)

1. Lay all the cards face down in multiple rows.
2. The youngest person chooses two cards to flip over.
   - If the two cards are matching chromosomes (the word for this is homologous), then he or she says "HOMOLOGOUS" and removes those two cards from the table. Homologous chromosomes have similar banding or lines.
     - ➥ Player then takes another turn.
   - If the two cards are not matching chromosomes, the player says "NON-HOMOLOGOUS" and turns the cards back over.
     - ➥ It is the next person's turn to try to make a match.
3. The game is over when all the chromosomes have been matched. Whoever has the most cards wins the game.
4. Once the game is over, work with your partner to construct a karyotype with the matched chromosomes. Put the largest chromosomes first, second largest second, and so on until the smallest chromosome pair. Your teacher will check off your matches.

What information can you tell from the karyotype of the opossum?

You can tell that this opossum is female and the opossum has 22 chromosomes.

Provide students with the information that the typical number of chromosomes for the opossum is 22, and allow them to complete the answer.

The opossum has a typical number of chromosomes because she has 22 chromosomes and the typical opossum has 22 chromosomes.

Part IV: Conclusion questions

1. What has today's lesson shown us? What have you learned?

The answer to this question will vary for each student.

2. What is a karyotype and what information does it provide?

A karyotype is a picture of the chromosomes present in an organism's cells. It can provide information about the sex of the organism, health conditions, and biological classification.

3. Why would doctors and scientists want to look at chromosomes?

Doctors and scientists examine chromosomes to diagnosis medical conditions.

Part V: Notes

Chromosome Concentration Game Cards: Common Opossum











Common Opossum

(Didelphis marsupialis)

2n+22

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module 3