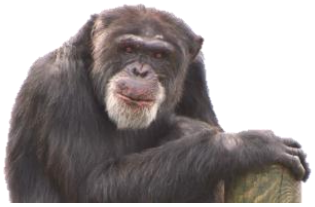
Living Links
Teaching Resources

Chimpanzee & Human Chromosomes



Teacher's Guide

THE ROYAL ZOOLOGICAL SOCIETY OF SCOTLAND
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Chimpanzee and Human Chromosomes

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Introduction to the Lesson

This lesson includes topics such as inversion, chromosome structure and evolution. Therefore it may be suitable as a round up/revision lesson or add on activity for a mutations lesson.

The lesson is split into three activities, each with their own objectives. Teachers may follow the whole lesson plan and do all four activities with students or parts that are most relative to a teacher's lesson content.

Lesson Activities and Objectives:

Activity	Title	Objectives
1	Who are our relatives?	- Students will be able to explain why humans did not evolve from chimpanzees.
2	Chromosome Puzzle	- Students will understand that humans have 23 pairs of chromosomes, that each chromosome contains genes and that these code for specific proteins. - Students will recap what meiosis is and understand the importance of a centromere in this role.
3	Mysterious Chromosomes	- Students will be able to describe the different types of mutations that can occur during cell division. - Students will understand the difference between fission and fusion. - Students will be able to describe what inversion is. - Students will be able to explain the importance of mutations within a genetic population

Lesson preparation

- Print out **large colour copies** of chromosomes (laminate for future use)
- Number the chromosomes on the back
- For chimpanzee chromosomes – make the extra chromosome a second number 2 so that when students match up chromosomes you can discuss the fusion.
- Student Activity Sheets
- My Primate Family Tree – Diagram and mural

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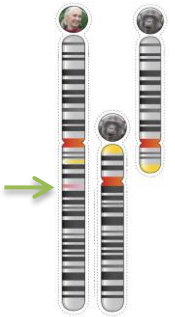
Background Information

Humans (*Homo sapiens*) and chimpanzees (*Pan troglodytes)* evolved from a common ancestor around 5-6 million years ago. From this common ancestor two branches evolved one with hominid species and another with chimpanzees and bonobos. Of all the species of hominids that evolved only humans survive today, the rest are extinct.

In 1929 it was recognised that chimpanzees and bonobos were different species. They split from their common ancestor around 2 million years ago and have evolved to be both physically and socially different from one another. The lesser known Bonobos are much smaller in stature and have a social structure that shows much more equality between males and females. In contrast chimpanzees are much larger, more aggressive and have a more male-dominated society.

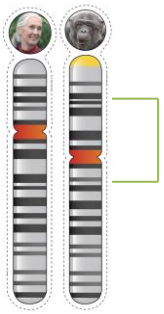
As chimpanzees are our closest relatives, they share with us many similar aspects in their anatomy, physiology and communication skills. In terms of their genetic makeup chimpanzees share around 98% of the same DNA as humans. The theory of evolution allows us to predict that species that share a recent ancestor should have more similar chromosomes than species that split a longer time ago. Chimpanzees have 24 pairs of chromosomes, one more than the 23 pairs found in humans.

Chromosome 2



The different number of chromosomes is a consequence of two chromosomes (Chromosome 2) fusing together in humans while it remains separate in chimpanzees, which explains the extra chromosome. Thus, when looking at both human and chimpanzee karyotypes they appear very similar. You can even see remnants of the second centromere (shown in pink).

Chromosome 12



In looking at the other karyotypes there are also many similarities. Any differences that do occur are mainly a result of **inversions** where chromosome positions have been inverted or interchanged end for end. Inversions, which normally originate during meiosis, are a common mutation and have been documented in many organisms. Inversions that include the centromere are called **pericentric** and those that do not are called **paracentric**. An example of a pericentric inversion occurs on chromosome 12, where a segment of the chromosome has been reversed end to end which has rearranged the position of some genes. However this does not affect the function of this chromosome which remains relatively the same in both chimpanzees and humans.

Many of the chimpanzee chromosomes have bands of heterochromatin (illustrated as yellow) either near the centromere or at the end of the chromosome. At present geneticists think that these bands do not code for any particular function. In fact if you remove these bands man and chimpanzees have 13 identical chromosome pairs:

- Chromosomes: 3, 6-8, 10,11, 13, 14, 19, 22 and XY

Key Terms:

Centromere – The point where two halves of the chromosome are joined.

Chromosome – Structures containing DNA, found in the nucleus of eukaryotic cells.

Fission – The splitting of something into two parts, in this case a chromosome.

Fusion – When two things come together, in this case two chromosomes.

Homologous pairs – A pair of chromosomes that contain genes which code for the same characteristics, one is inherited from the mother and one from the father.

Inversion –A mutation that causes a chromosomal rearrangement where part of a chromosome is reversed end to end.

Karyotype – The number and appearance of chromosomes in the nucleus of a eukaryotic cell.

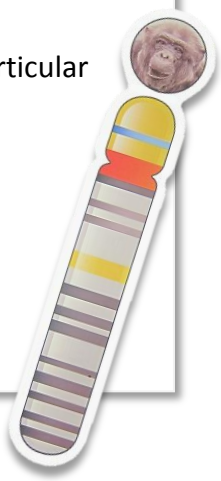
Chromosome Key:

Red bands: Centromere – used by the cell to pull duplicated chromosomes away from each other when the cells divide.

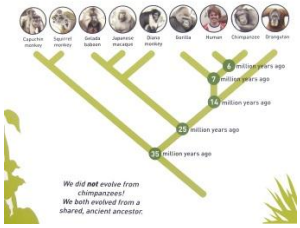
Yellow bands: Heterochromatin – bands of DNA that do not code of any particular function but can sometimes restrict gene expression

Blue bands: Ribosomes – protein making factories.

Pink band: Remnant section of centromere.



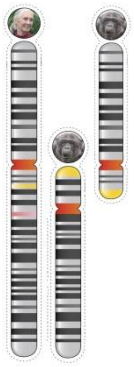
Activity One: Who are our relatives?

Teacher Activity	Student Activity
 Tell the class that today we are going to investigate an animal that is very closely related to us genetically.	Students discuss our most closely related primate relatives.
Incorrect features of primate family tree: - We evolved from a common ancestor that we share with chimpanzees, not from chimpanzees themselves. - Bonobos and chimpanzees evolved from another common ancestor. - The rest of the great and lesser apes are missing – again chimps and apes in general evolved from common ancestors not from the other surviving monkeys and apes found today. - Old world (monkeys found in Africa and Asia) and new world monkeys (monkeys found in central and South America) are missing as well as prosimians. - Humans are not 'more evolved' than other animals each type of primate should be at the same level in time. Therefore humans should not be represented as being at the top of the tree.	**Activity Sheet 1, Question 1:** Students circle the wrong elements of the first primate family tree and draw what they think it should look like.
 Display Living links Family Tree (or correct alternative) and ask students to make any amendments needed to their own correct versions.	**Activity Sheet 1, Question 2:** Students draw correct version of primate family tree on activity sheet.
 **Additional activity:** Use the power point file entitled 'My Primate Family Tree' to have students take their picture in our life size piece of art work which is based here in Edinburgh Zoo.	Students can upload the images to the Living Links website themselves with an appropriate evolution based message. Eg. 'I'm a primate too!' For best photo results students should wear a dark shirt.

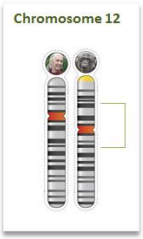
Activity Two: Chromosome Puzzle

Teacher Activity	Student Activity
Order the **human** chromosomes (number the backs) in size from largest (left) to smallest (right). Use the poster to help guide your numbering. 	Stick chromosomes on whiteboard or another easily seen area of classroom.
Recap that each is one part of a homologous pair, except XY (ideally they should already know about sex determination when doing this practical) Remove the X and Y chromosomes and put at the end on the far right – this is a pair. Since each other chromosome piece represents a pair, we can see that humans have 23 pairs of chromosomes including the XY chromosomes.	Ask students to look at chromosomes and to count them, confirming that humans have 23 pairs. Students discuss what is missing from the chromosomes i.e. discuss homologous pairs.
Give out chimpanzee chromosomes – one to each student (or one between two if large class). Ask students to name the animal at the top of their chromosome. Ask students to count the number of chromosomes that you have distributed and ask how many pairs of chromosomes do chimpanzees have (24). Remind (or ask) students that chimpanzees have 98% identical DNA to humans. Ask is students were right about their predictions about the differences between each species chromosomes.	**Activity Sheet 2, Question 1:** Students discuss how many chromosomes they think chimpanzees have and if they think the karyotypes of chimpanzee and human chromosomes will be similar or different. **Activity Sheet 2, Questions 2-4:** Students stick in or draw their chimpanzee chromosome. Students then collect corresponding human chromosome number, stick or draw it beside the chimpanzee chromosome and write down the comparisons between them.

Activity Three: Mysterious Chromosomes Part 1

Teacher Activity	Student Activity
 Ask the class to list all possible reasons why chimpanzees might have one more pair of chromosomes than humans. Remind the class of the four possible types of chromosome mutation that could have led to the difference in chromosome number for chimpanzees and humans. **Possible answers:** 1. Duplication in a chimpanzee ancestors 2. Deletion in one of the human ancestors 3. Fission of a chromosome in one of the chimpanzee ancestors 4. Fusion of two chromosomes in one of the human ancestors	Students recap duplication, deletion, fission, fusion.
Ask students with chromosome 2 to explain their similarities and differences.	**Activity Sheet 3, Question 1:** Students discuss Chromosome 2.
Duplication and deletion should be eliminated quickly due to the absence of two similar chromosomes in the chimpanzee, and by the fact that the bands in human chromosome 2 match up with those of the two combined chimpanzee chromosomes. Ask the students to explain why it could not be duplication or deletion.	**Activity Sheet 2, Question 2:** Students discuss which of the possible answers is most likely given chromosome 2 (i.e. Fusion of two chromosomes in one of the human ancestors)
Most classes will be left with fission or fusion as remaining possibilities. These can be separated by the presence of a small remnant section of centromere (illustrated as the pink band) DNA sequence in the human chromosome 2 at the location of the centromere in the corresponding chimpanzee chromosome. Ask the class if that helps them decide if it was a fusion in the human line or fission in the chimpanzee line that took place after we split from a common ancestor. They should deduce that it was the former.	Students with chromosome 2 discuss their findings with class.

Activity Three: Mysterious Chromosomes Part 2

Teacher Activity	Student Activity
 Tell the class we are now going to look at some of the other differences – ask students with chromosome 12 to discuss what they have found. Recap on Inversion.	**Activity Sheet 3, Question 3-4:** Students discuss Chromosome 12.
Answer: No, all the genetic information is still there- it has just been rearranged, therefore gene function still remains intact. The same is true for chromosome 2 – all the information is still present whether it is in two chromosomes or one.	**Activity Sheet 3, Question 5:** Students vote on whether they think the order of the genes will affect that gene's function.
Ask students to discuss the importance of mutations and variation within a population and how these lead to high genetic diversity within a population.	**Activity Sheet 3, Question 6:** Students write down their discussions on student activity sheet. Students place activity sheet into folders/ exercise books as part of notes.