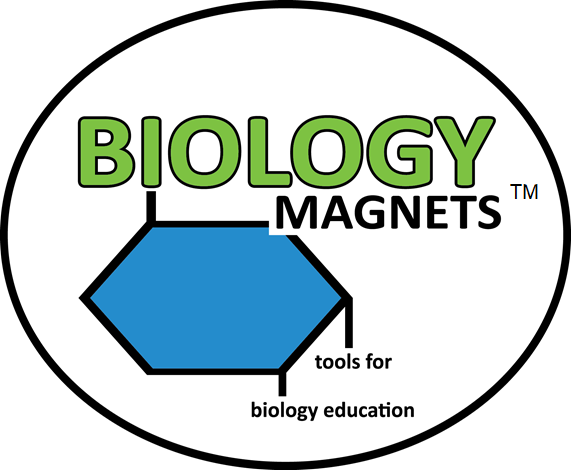
**Biology Magnets Module 15:**

**Karyotypes – Teacher and Student Guides**



**Teacher Information**

This module uses magnets designed for teacher and student interaction to guide learning karyotypes. Contained in this guide are different lesson ideas that can last from 10 minutes each to an entire class period, depending upon teacher preference. Each lesson has both teacher-centered and student-centered activities. The student-centered activities are most effective if students are in small groups. It may be necessary to have multiple magnet sets for large classes. A student handout is provided which can be printed out and given to each student group to help guide their progress as they work with the magnets. If budget or white board space is limited, groups can alternate between using a set of magnets and doing other activities. Teachers can refer to the videos posted at the Biology Magnet web site at Biologymagnets.com for guided teaching instructions.

**Magnet Care and Maintenance**

Biology magnets are made to last for years. Periodically magnets will fall off or are knocked off the plastic. A piece of magnetic tape is included with each module, which should be able to replace around 10-12 magnets if necessary. Simply cut a new magnet and peel off the back to replace. Magnetic tape can also be purchased from a hobby store to replace magnets lost over time. Laminate may peel off, especially on small pieces. Use transparent tape to re-attach laminate that comes loose, curling the tape over the back of the magnet. The machines used to cut Biology Magnets are not always perfectly accurate. Sometimes a bit of white or black outline on the edges occurs or a cut might be slightly off center. Use scissors to remove extra outline that is unnecessary if desired. Store magnets in the clasp envelopes in which they arrived for easy organization.

**Karyotypes Copyright and Licensing Information**

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**Chromosomes:** This file is licensed under the Creative Commons Attribution 3.0 Unported license. By OpenStax College - Anatomy &amp; Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013., CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=30148620. Chromosomes have been modified to remove bends and highlight banding patterns. Borders were added around each chromosome. New images are released under the same license.

**Karyotype:** This image is a work of the National Institutes of Health, part of the United States Department of Health and Human Services, taken or made as part of an employee's official duties. As a work of the U.S. federal government, the image is in the public domain. Chromosome banding patterns and chromosome size have been modified to better match the magnetic models.

**Background Information:** Wikipedia contributors, *Wikipedia, The Free Encyclopedia*, 22 July 2004.

**Biology Magnets Module 15 Materials List**

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| **Magnet Name** | **Quantity** | **Pictures** |
| Chromosome | 56 |  |
| 3” Magnetic Tape Strip | 1 |  |
| **Total Quantity** | **57** |  |

**Lesson 15 – Karyotypes (10-50 minutes)**

**Background Information:** A Karyotype is a complete set of chromosomes showing their sizes, shapes and numbers. To make a karyotype, a cell (often a human white blood cell) is arrested using a chemical solution such as colchicine during metaphase of cell division. The chromosomes are then treated with protease enzymes to remove any proteins, and stained using Giemsa stain to show banding patterns. Giemsa stain adheres to areas of the DNA where there are high amounts of A-T (Adenine-Thymine) bonding and gives a dark appearance to those areas. The chromosome pictures in this module have had the sister chromatids removed for clarity and easier viewing of banding patterns. Chromosomes can then be paired together by size and banding pattern to identify matching pairs and if any chromosomal abnormalities exist. This module contains pictures of 48 human chromosomes, the 44 autosomes as well as the sex chromosomes, XX for female and XY for male. The module also contains a folder with other chromosomes for modeling the following abnormalities:

**Patau Syndrome (Trisomy 13):** An extra chromosome 13 is seen in the karyotype of a person with Patau syndrome, occurring in about 1/16,000 births. The person will have a number of abnormalities in development of the nervous system, muscular system, skeletal system, urinary system, and reproductive system. A pronounced cleft lip and cleft palate is seen at birth. Most infants with Patau syndrome die within weeks after birth.

**Edward Syndrome (Trisomy 18):** An extra chromosome 18 is seen in the karyotype of a person with Edward syndrome, occurring in about 1/6,000 births. The person will usually be born with a number of abnormalities, including small size, small head, heart defects, and intellectual disabilities. Most infants with Edward syndrome die in the womb or within a year of birth.

**Down Syndrome (Trisomy 21):** An extra chromosome 21 is seen in the karyotype of a person with Down syndrome, occurring in about 1/700 births with chances of occurrence increasing with age of pregnancy. It is the most common chromosomal condition. The person will usually be born with intellectual disabilities and physical developmental problems. Treatment of problems associated with Down syndrome have improved in the past several decades. The average life expectancy for a person with Down syndrome is about 60 years.

**Turner Syndrome (Monosomy X0):** A missing X chromosome in the female is seen in the karyotype of a person with Turner syndrome, occurring in about 1/5,000 births. A person may have a number of physical abnormalities including short stature, a webbed neck, and swollen hands and feet. Heart problems and learning issues may be present as well. A shorter life expectancy occurs due to heart issues and diabetes, with the average life expectancy in the mid 60s.

**Triple X Syndrome (Trisomy XXX):** An extra X chromosome in the female is seen in the karyotype of a person with triple X syndrome, occurring in about 1/1,000 female births. A person may have some physical characteristics such as widely spaced eyes, small fingers, and increased height. Learning disabilities and lower IQ are common. Most people with triple X live independently as adults with an average life expectancy of 71 years.

**Klinefelter Syndrome (Trisomy XXY):** An extra X chromosome in the male is seen in the karyotype of a person with Klinefelter syndrome, occurring in about 1/700 male births. Physical health complications usually arise around puberty due to underdevelopment of testicles which often leads to infertility, less body hair, weaker muscles, and less coordination. Many people do not realize they may have the condition until puberty. Most people with Klinefelter syndrome live full lives, only two years less than the average male

**Jacob’s Syndrome (Trisomy XYY):** An extra Y chromosome in the male is seen in the karyotype of a person with Jacob’s syndrome, occurring in about 1/1000 male births. Often there are few or no symptoms, but learning disabilities and speech problems sometimes occur. Many people live full lives unaware that they are affected. Some research has shown that a decreased life span might result from the condition but more study is needed to confirm these results.

**Wolf-Hirschhorn Syndrome (Chromosome 4 Deletion):** A partial deletion of the short arm of chromosome 4 is seen in the karyotype of a person with Wolf-Hirschhorn syndrome**,** occurring in about 1/50,000 births. Head and facial deformities are often present, with a small head, small lower jaw, and increased distance between the eyes. Significant intellectual disability is common, as well as seizures and heart defects among other problems. Most affected individuals survive into adult life, but the average life expectancy is unknown.

**Cri-du-chat Syndrome (Chromosome 5 Deletion):** A partial deletion of the short arm of chromosome 5 is seen in the karyotype of a person with Cri-du-chat syndrome**,** occurring in about 1/50,000 births. The syndrome is named after the sound of the cry of affected babies, which sounds like a meowing kitten due to problems associated with the larynx and nervous system. Low birth weight, small head, and severe learning disabilities are common among a host of other symptoms, which can vary widely. A high risk of death in infancy occurs, but survivors often live full lives.

**de Grouchy Syndrome (Chromosome 18 Deletion):** A partial deletion of the short arm of chromosome 18 is seen in the karyotype of a person with de Grouchy syndrome**,** occurring in about 1/50,000 births. Heart, bone, and developmental abnormalities are common in people with this disorder, including clubfoot, cleft lip, and cleft palate. Kidney problems and brain malformations are sometimes seen as well. Life expectancy data is lacking, but does not seem to be severely lessened except for those with brain development issues.

**Instructions:** Teachers should place all of the magnets on the board randomly to represent the chromosomes that have been removed from a cell and stained. The chromosomes should then be paired up, matching homologous pairs by size, difference in position of centromeres, and differences in banding patters. Arrange the chromosome pairs in order starting from chromosome 1, the largest pair, to chromosome 22, the smallest pair. The sex chromosomes are placed as the final pair. This exercise takes time, as pairing chromosomes requires attention to the size and banding pattern for each chromosome. The figures below show the banding pattern to help determine chromosome numbers. The sizes on the diagrams roughly match the sizes of the Biology Magnets. (figure 15.1 A-D).

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| **Figure 15.1.A: Banding Patterns for Chromosomes 1-5 Teacher Set\*** |
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**\*Chromosomes and banding patterns have been altered for simplicity in this exercise\***

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| **Figure 15.1.B: Banding Patterns for Chromosomes 6-12 Teacher Set \*** |
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**\*Chromosomes and banding patterns have been altered for simplicity in this exercise\***

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| **Figure 15.1.C: Banding Patterns for Chromosomes 13-XY Teacher Set \*** |
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**\*Chromosomes and banding patterns have been altered for simplicity in this exercise\***

**Instructions continued:** The teacher can start the process and have the students come up to the board to try to complete it. Have the students refer to the banding pattern diagram above to figure out the numbering of the chromosomes. Several students working at once should be able to finish the process in 15-30 minutes. Teachers may want to check on students’ pairing, as they will often make mistakes. A full finished karyotype diagram is shown on the next page in case anyone gets stuck (figure 15.2.A-B). To simplify the task, hand out the final completed karyotype and have the students just find the matching chromosomes. This moves much faster (figure 15.2.A-B).

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| **Figure 15.1.D: Banding Patterns Chart Student Set\*** |
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**\*Chromosomes and banding patterns have been altered for simplicity in this exercise\***

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| **Figure 15.2.A: Human Karyotype** |
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| **Figure 15.2.B: Human Karyotype Without Borders** |
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**Chromosomal Mutations:** Teachers can change the karyotype using the extra/alternate chromosomes in the chromosomal mutations packet. Students can then analyze the karyotype to determine the sex of the individual and if there are any chromosomal abnormalities. In the insert packet, there are extra chromosomes that can be used to show chromosomal abnormalities (figure 15.3). The following chromosomal abnormalities and syndromes can be demonstrated and diagnosed by adding or removing chromosomes on the karyotype (figure 15.4.A-B):

* Patau Syndrome: Trisomy 13
* Edward Syndrome: Trisomy 18
* Down Syndrome: Trisomy 21
* Klinefelter Syndrome: Trisomy XXY
* Triple X female: Trisomy XXX
* Jacob’s Syndrome: Trisomy XYY
* Turner Syndrome: Monosomy X0
* Wolf-Hirschhorn Syndrome: Chromosome 4 Deletion
* Cri-du-chat Syndrome: Chromosome 5 Deletion
* de Grouchy Syndrome: Chromosome 18 Deletion

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| **Figure 15.3: Chromosomal Mutations Packet** |
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| **Figure 15.4.A: Chromosomal Mutations Part 1** |
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| **Figure 15.4.B: Chromosomal Mutations Part 2** |
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**Extra exercises:**

**Researching Syndromes:** Have the students use their textbooks or the internet to research the syndromes above to learn more about the affect each syndrome has on the person. Have students research other chromosomal abnormalities not listed and try to represent those with the magnets. Most chromosomal monosomies are fatal to the zygote or resulting embryo, but can be modeled with the magnets.

**Other species’ karyotypes:** Have the students use the magnets to show what karyotypes might look like of other species, even though the size and banding pattern would be different. Some examples are Drosophila (4 pairs), nematode (6 pairs), yeast (16 pairs), and mice (20 pairs). Have the students use the internet to research chromosomal abnormalities in other species and to try to represent those with the magnets. Other species karyotypes exist online. Have students print out and compare numbers and banding patterns on other species chromosomes to that on the human chromosomes. For example, are chimpanzee chromosome banding patterns the same as humans? Are dogs? Have students think about chromosome number and banding patterns in relation to evolution. Students can even cut out the chromosomes and use magnetic tape to make side-by-side comparisons with the Biology Magnets.