

Activity: Magnetic Chromosomes

Lecture Concept

Chromosome structure, Mitosis and meiosis

Activity Type

Discussion leader solo presentation, soliciting student answers

Time Needed

50 minutes

Purpose

To allow the students to visually see the process of mitosis and meiosis

To provide the students an opportunity to learn the terminologies of Genetics (see **In Class** for suggested terminologies)

Abstract

Pre-class prep	20 min
Teacher demonstrates mitosis on the white board	10 min
Teacher demonstrates meiosis on the white board	20 min

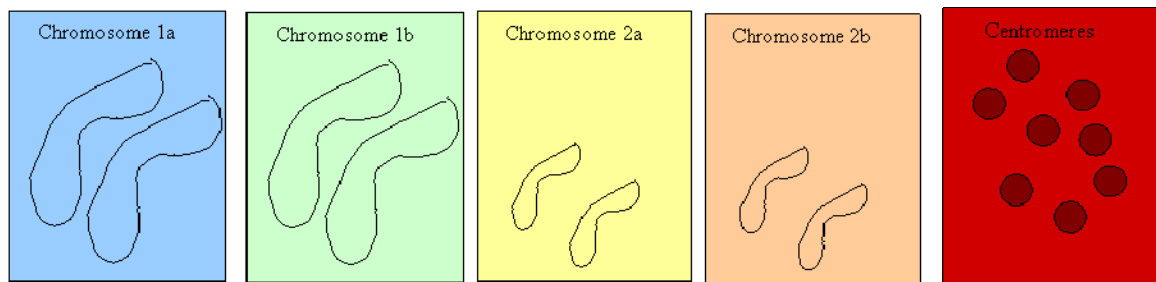
Supplies

- Pre-made magnetic chromosome figures (requires colored construction or other stiff paper, magnet strips, lamination materials if desired).
- Whiteboard, colored markers
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Pre-class prep

- Draw four strands of DNA to represent Chromosome 1 (on two colors of paper for different homologues) and four more (smaller) strands of DNA (in two different colors of paper) for Chromosome 2, and eight centromeres, as shown in Figure 1:

Figure 1:

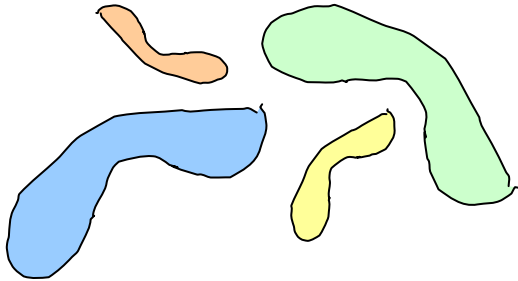


- Cut out each chromosome and centromere and tape or glue magnets to the back of everything.

In Class

Mitosis Demonstration

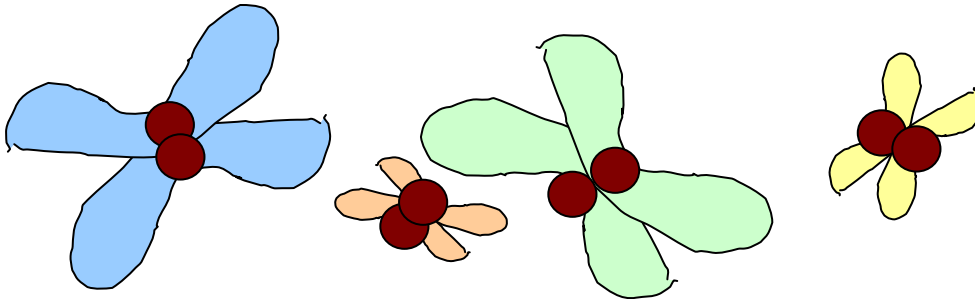
1. (5 min) Set up the starting $2n$ chromosomes on the board as shown:



Draw a large circle around the magnetic chromosome figures to specify that the chromosomes are in the cell membrane after the nuclear envelope has been disrupted. Have the students describe the following concepts:

- Chromosome
- Homologous chromosome
- Haploid vs. Diploid, $n=2$ vs. $2n=4$ (four chromosomes present, but only two types (Chromosome 1 and Chromosome 2))

Create a sister chromatid and centromeres for each chromosome.



Discuss:

- S phase and replication
- Chromatid vs chromosome (8 chromatids, still only 4 chromosomes)
- Centromeres on each chromatid
- Genetic material has doubled, but amount of genetic information has remained the same. Cell is still considered to be at $2n$.

Line up chromosomes and draw in microtubules for metaphase. Discuss:

- Kinetochores
- Microtubules
- Motor proteins

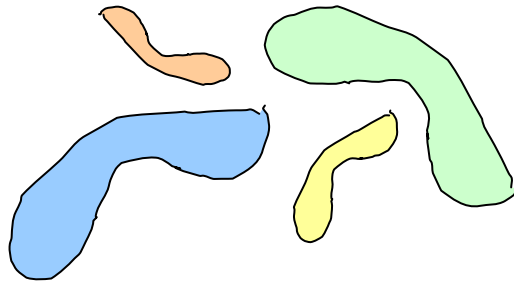
Separate chromatids and centromeres. Discuss:

- Final chromosome number: haploid or diploid, n or $2n$.
- Chromatids turn into single-strand chromosomes
- Genetic material of daughter cells vs. parent cell

Meiosis Demonstration

A comment about teaching meiosis: Students THINK they understand meiosis. They think it's just mitosis twice. But year after year I have found that students AND SOME DISCUSSION LEADERS do not understand the difference between meiosis and mitosis. They don't realize that metaphase 1 is profoundly different than metaphase 2. They confuse chromatids and chromosomes. And they do not understand that the first division changes ploidy. So if any of the answers listed below seem incorrect, ASK FOR HELP before teaching your students.

Reset the original chromosomes on the board as before.



Ask about the purpose of meiosis:

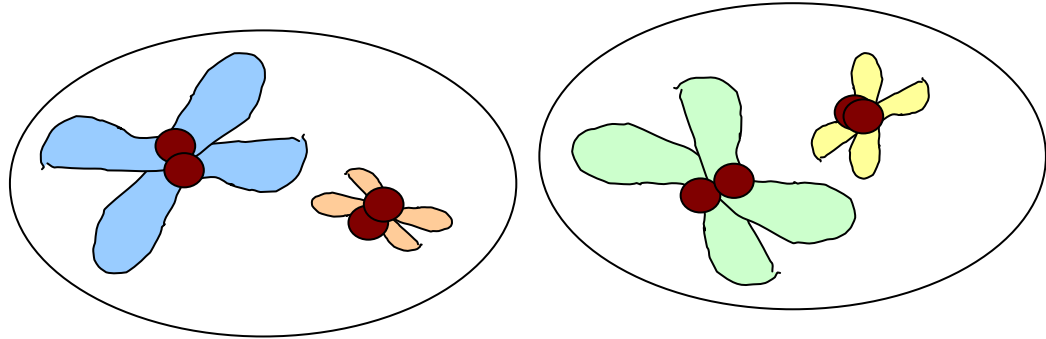
- What is it for?
- What cells are capable of doing it?
- Is it more or less common than mitosis?

Next, have the students guide YOU through meiosis. Ask them, “What comes next?” Call on different students to answer. If you find that students are giving you the wrong answers, stop. Have them get into groups of three, and open their textbooks to the big meiosis figures, and have them try to talk things out before answering you.

Here is a good series of questions to ask:

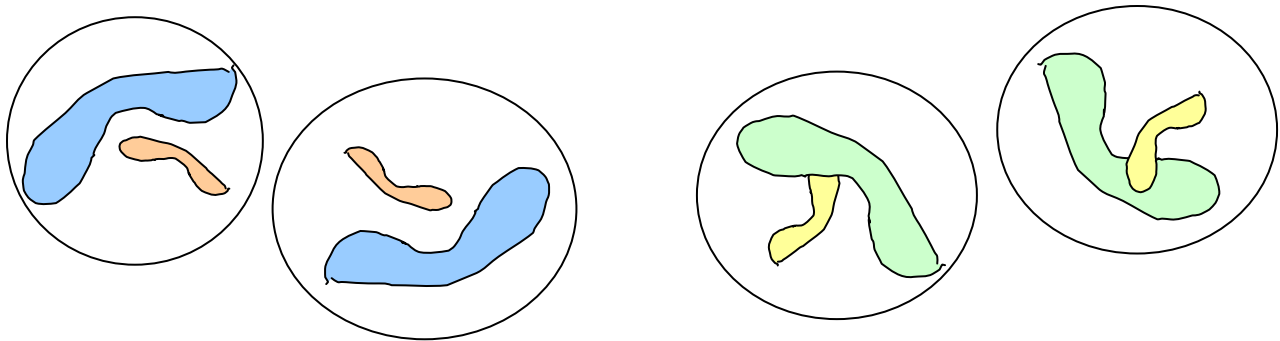
1. How many chromosomes are shown here? (answer: 4)
2. How will these chromosomes look after DNA replication? (add more magnetic chromosomes to create the sister chromatids)
3. How many chromosomes are there now? (answer: still 4, but double-stranded)
4. How many chromatids? (8)
5. How do these chromosomes line up for Metaphase 1? (answer: in tetrads). Don't answer this one for the students. If they want to line them up like in Mitosis, tell them to look it up again)
6. What happens in the tetrads? (answer: crossing over)
7. Why is crossing over important? (answer: creates genetic variation. Pursue why this is important if time allows)
8. What do the daughter cells look like after the first meiotic division? (answer: see below)





9. How many chromosomes are in each daughter cell? (answer: 2)
10. Are the daughter cells haploid or diploid? (answer: they are now haploid)
11. How much genetic information is in the daughter cells compared to the parent cell?
(answer: half as much)

Now go through the second division in meiosis, which IS like mitosis but with half the chromosomes. Line them up on the midplate, separate the chromatids, and create four final daughter cells:

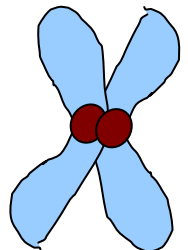


Things to Ask or Emphasize

Students need to learn the phases, but they memorize those easily. Don't spend time on discussion on that. Focus more on haploidy vs diploidy, number of chromosomes, and the cytoskeletal elements involved.

Comments

The naming difficulty with chromatids and chromosomes is widespread. The Bio 93 and Bio 97 faculty themselves disagree on how to refer to them. For instance, a single replicated chromosome made up of two attached sister chromatids as shown here is called a chromosome in the Bio 93 text and by some Bio 93 faculty. But others feel it is fundamentally different than the normal single-stranded chromosome, and calls it "a pair of sister chromatids." I've heard a Bio 97 faculty member call a human cell "4n" after S phase, even though the genetic information has not doubled. It's best not to say "Professor So-and-so is wrong." But you can point out likely sources of confusion and discuss how exam questions will be phrased.



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