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New Jersey Center for Teaching and Learning

Progressive Science Initiative

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AP BIOLOGY

Investigation #7

Cell Division: Mitosis and Meiosis

Summer 2014

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Investigation #1: Artificial Selection

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Pacing/Teacher's Notes

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Teacher's Notes

Lab procedure adapted from College Board AP Biology Investigative Labs: An Inquiry Approach Teacher's Manual

Click here for CB AP Biology Teacher Manual

Pacing

Day *(time)*	**Activity**	**General Description**	**Reference to Unit Plan**	**Notes**
Day 1 *(HW)*	Pre-lab	Pre-Lab	CC Day 1 HW	
Day 2 *(40)*	Part 1	Modeling Mitosis	CC Day 2	Use a mitosis modeling kit, clay, pipe cleaners, or sockosomes to model the phases of mitosis
Day 3 *(80)*	Part 2	Counting cells undergoing phases of mitosis	CC Day 4	
Day 4 *(40)*	Independent Inquiry	Testing environmental effects on mitosis	CC Day 5	
Day 5 *(40)*	Part 3	Reading and discussion of cancer cases	CC Day 7	
Day 6 *(40)*	Part 4	Modeling Meiosis	CC Day 9	
Day 7 *(40)*	Part 5	Looking at crossing over in fungi	CC Day 10	
Day 8 *(20)*	Assessment	Lab Quiz	CC Day 11	

Pre-Lab

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Question/Objectives

How do eukaryotic cells divide to produce genetically identical or to produce gametes with half the normal DNA?

In this lab we will:

- Describe the events in the cell cycle and how these events are controlled.
- Explain how DNA is transmitted to the next generation via mitosis.
- Explain how DNA is transmitted to the next generation via meiosis followed by fertilization.
- Understand how meiosis and crossing over leads to increased genetic diversity which is necessary for evolution.

Pre-Lab Questions

Read the background information and answer the following questions in your lab notebook. (from pg S86 in student lab manual)

1. How did you develop from a single-celled zygote to an organism with trillions of cells? How many mitotic cell divisions would it take for one zygote to grow into an organism with 100 trillion cells?
2. How is cell division important to a single celled organism?
3. What must happen to ensure successful cell division?
4. How does the genetic information in one of your body cells compare to that found in other body cells?
5. What are some advantages of asexual reproduction in plants?
6. Why is it important for DNA to be replicated prior to cell division?
7. How do chromosomes move inside a cell during cell division?
8. How is the cell cycle controlled? What would happen if the control were defective?

Safety

You must be careful when preparing specimens for viewing under the compound microscope. Always cover the cover slip with a scientific cleaning wipe, such as a Kimwipe, and press down using a pencil eraser.

You should wear safety goggle or glasses and disposable gloves when handling the chemicals and razor blades in Parts 2 and 5. All materials should be disposed of properly as per your teacher's instructions.

Guided Investigation

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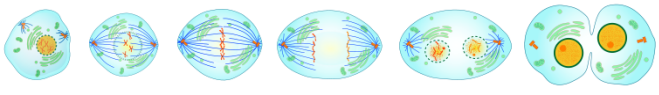
Part 1: Modeling Mitosis

You will investigate mitosis using models. Your teacher will give you sockosomes, clay chromosomes, or pipe-cleaner chromosomes.

Review chromosome duplication and movement using these models chromosomes.



Part 1: Modeling Mitosis

Analysis Questions:

- If a cell contains a set of duplicated chromosomes, does it contain any more genetic information than the cell before the chromosomes were duplicated?
- What is the significance of the fact that chromosomes condense before they are moved?
- How are the chromosome copies, called sister chromatids, separated from each other?
- What would happen if the sister chromatids failed to separate?

Part 2: Materials

- Onion root tips
- Onion root tips treated with lectin
- 12 M HCl
- Carnoy's fixative
- Carbol-fuschin stain
- Microscope
- Slides and coverslips
- Dropper
- Laboratory notebook

Part 2: Preparing Chromosome Squashes

Step 1 Place the onion root tip in 12 M HCl for 4 minutes.

Step 2 Transfer the tip to Carnoy's fixative for 4 minutes.

Step 3 Label a clean slide and place the tip on the slide and cut off the distal 2 mm portion of the tip; discard the remainder of the tip.

Step 4 Cover the root tip piece with carbol-fuschin stain for 2 minutes.

Step 5 Blot off excess stain and cover the tip with 1-2 drops of water.

Step 6 Place the cover slip over the tip and cover the cover slip with a scientific cleaning wipe.

Step 7 Firmly press down on the cover slip with the eraser end of a pencil. Do not twist the slide, and be careful not to break the cover slip

Part 2: Counting Cells

Step 1 Observe the cells at high magnification (400-500 X).

Step 2 Look for well-stained, distinct cells.

Step 3 Within the field of view, count the cells in each phase. Repeat the counts in two other root tips.

Tip	Number of Cells		
	Interphase	Mitotic	Total
1			
2			
3			
Total			

Part 2: Counting Cells

Step 4 Collect the class data for each group, and calculate the mean and standard deviation for each group. You must make a table in your notebook for the class data.

Step 5 Compare the number of cells from each in interphase and in mitosis.

Statistical Analysis and Probability

Mean

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation*

$$S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

Standard Error of the Mean*

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Chi-Square

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

Chi-Square Table

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.21	11.34	13.28	15.09	16.81	18.48	20.09

$\bar{x}$ = sample mean

n = size of the sample

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

o = observed results

e = expected results

Degrees of freedom are equal to the number of distinct possible outcomes minus one.

Part 2: Analysis

Step 1 For this experiment, the number of treated cells in interphase and mitosis will be the observed (o) values.

Statistical Analysis and Probability

Mean

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Part 2: Analysis

Step 2 To find out what your expected values are calculate the percentage of cells interphase and mitosis in the *control* group and multiply the percentages by the total number of cells in the treated group. This will give you the expected number (e).

Statistical Analysis and Probability

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Part 2: Analysis

Step 3 Calculate the chi-square value (x^2) for the test.

Step 4 Compare this value to the critical values table.

Statistical Analysis and Probability

Mean

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation*

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Standard Error of the Mean*

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Degrees of freedom are equal to the number of distinct possible outcomes minus one.

Part 2: Analysis

Analysis Questions:

- What was the importance of collecting the class data?
- Was there a significant difference between the groups?
- Did the fungal pathogen lectin increase the number of root tip cells in mitosis?
- What other experiments should you perform to verify your findings?
- Does an increased number of cells in mitosis mean that these cells are dividing faster than the cells in the roots with a lower number of cells in mitosis?
- What other way could you determine how fast the rate of mitosis is occurring in root tips?

Independent Inquiry

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Designing & Conducting Your Investigation

Now that you have worked with the root tip model system, design and conduct an investigation to determine what biotic or abiotic factors or substances in the environment might increase or decrease the rate of mitosis in roots. For instance, what factors in the soil might affect the rate of root growth and development? Considers, for example, abiotic soil factors such as salinity and pH or biotic factors, including roundworms, that might alter root growth.

Guided Investigation

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Part 3: Pre-Lab Questions

1. How are normal cells and cancer cells different from each other?
2. What are the main causes of cancer?
3. What goes wrong during the cell cycle in cancer cells?
4. What makes some genes responsible for an increased risk of certain cancers?

Part 3: Introduction

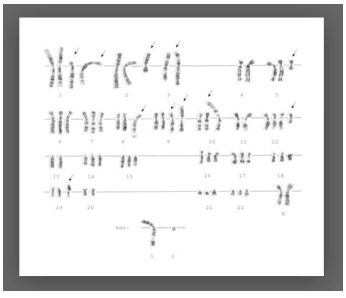
With your group, form a hypothesis as to how the chromosomes of a cancer cell might appear in comparison to a normal cell and how those differences are related to the behavior of the cell.

For each of the following cases, look at pictures of the chromosomes (karyotype) from normal human cells. Compare them to pictures of the chromosomes from cancer cells. For each case, count the number of chromosomes in each type of cell, and discuss their appearance.

- Do your observations support your hypothesis?
- If not, what type of information might you need to know in order to understand your observations?
- If yes, what type of information can you find that would validate your conclusions?

Case 1: HeLa Cells

HeLa cells are cervical cancer cell isolated form a woman named Henrietta Lacks. Her cells have been cultured since 1951 and used in numerous scientific experiments. Henrietta Lacks died from her cancer not long after her cells were isolated. Lacks's cancer cells contain remnants of human papillomavirus (HPV), which we now know increases the risk of cervical cancer.

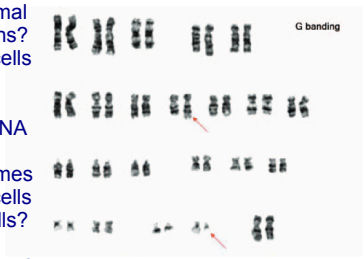


- From your observations, what went wrong in Henrietta Lacks's cervical cells that made them cancerous?
- How does infection with HPV increase the risk of cervical cancer?

Case 2: Philadelphia Chromosomes

In normal cells, mitosis usually is blocked if there is DNA damage. Sometimes, though, DNA damage makes cells divide more often. Certain forms of leukemia have a unique feature called a Philadelphia chromosome.

- What happens in a normal cell if DNA has mutations?
- What would happen if cells with mutated DNA replicated?
- How do cells monitor DNA damage?
- How are the chromosomes different in the cancer cells compared to normal cells?
- How could these differences lead to cancer?

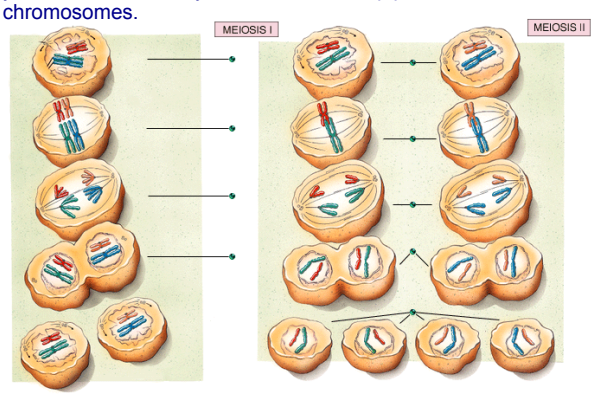


Part 4: Pre-Lab

- How do sexually reproducing organisms produce gametes from diploid progenitors?
- How does the process increase gamete diversity?
- What are the outcomes from independent assortment and crossing over?
- How does the distance between two genes or a gene and a centromere affect crossover frequencies?

Part 4: Modeling Meiosis

You will investigate meiosis using models. Your teacher will give you sockosomes, clay chromosomes, or pipe-cleaner chromosomes.



Part 4: Modeling Meiosis

Analysis Questions:

- When is the DNA replicated during meiosis?
- Are homologous pairs of chromosomes exact copies of each other?
- What is crossing over?
- What physical constraints control crossover frequencies?
- What is meant by independent assortment?
- How can you calculate the possible number of different kinds of gametes?
- What happens if a homologous pair of chromosomes fails to separate, and how might this contribute to genetic disorders such as Down syndrome and cri du chat syndrome?
- How are mitosis and meiosis fundamentally different?

Part 5: Materials

- *Sordaria fimicola* cross plate
- Microscope
- Slides and coverslips
- Dropper
- Laboratory notebook

Part 5: Meiosis and Crossing Over in *Sordaria*

Step 1 Place a drop of water onto the microscope slide.

Step 2 Gently scrape some perithecia from the agar plate near where the two strains meet.

Step 3 Place a cover slip over the perithecia and put a scientific cleaning wipe over the cover slip.

Step 4 Gently press down on the cover slip using the eraser end of a pencil.

Step 5 Count at least 50 asci, and score them as either parental or recombinant (crossing-over)

Part 5: Meiosis and Crossing Over in *Sordaria*

Step 6 Enter the data in your lab notebook and calculate the percentage of asci showing crossover.

The percentage of crossover divided by 2 equal the distance from the gene to the centromere (in mu).

Number of Asci Showing 4:4 Pattern	Number of Asci Showing Crossover	Total # of Asci	% Asci Showing Crossover	Gene to Centromere Distance (mu)

Evaluating Results

Evaluation Questions:

- Why did you divide the percentage of asci showing crossover (recombinant) by 2?
- The published map distance between the spore color gene the the centromere is 26 map units. How did the class data compare with this distance?
- How can you account for any disparities between the class data and the published data?
- Illustrate what happened during meiosis to produce the result you found.
- Do you think Philadelphia chromosomes is a result of crossing over as seen in this part of the investigation or some other chromosomal abnormality? Explain your answer.
- Do you think the cell cycle described for mitosis could be applied to meiosis as well? Explain your answer.