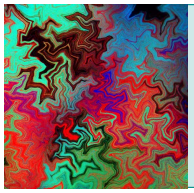

Cancer Cell Invasion

hhmi | BioInteractive

Phenomenal Image Educator Materials

HOW TO USE THIS RESOURCE

The image for this resource can serve as a phenomenon to explore the key concepts described below.

The pedagogical practice of using phenomena to provide a context for understanding science concepts and topics is an implementation practice supported by the Next Generation Science Standards (NGSS). Phenomena are observable occurrences that students can use to generate science questions for further investigation or to design solutions to problems that drive learning. In this way, phenomena connect learning with what is happening in the world while providing students with the opportunity to apply knowledge while they are building it.

The "Implementation Suggestions" and "Teaching Tips" sections provide options for incorporating the images into a curriculum or unit of study and can be modified to use as a standalone activity or to supplement an existing lesson. The student handout includes reproductions of the images and the "Background Information" section.

Additional information related to pedagogy and implementation can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

A. Mutations in specific genes can lead to abnormal cell division and proliferation, which can lead to cancer.

BACKGROUND INFORMATION

Follow the leader? This image shows cells in a primary breast cancer tumor invading the surrounding muscle tissue (blue). Both the green- and pink-stained cells are tumor cells, but the pink cells represent "leader" cells: cells that break off from the main body of the green tumor and begin to metastasize, a process by which cancers from a primary tumor invade and colonize other tissues. These leader cells are both genetically and behaviorally different from the main body of the tumor. Researchers hope to identify the genetic mutations that cause cells to become leaders to give them new opportunities for treating breast cancers and preventing metastasis.

IMPLEMENTATION SUGGESTIONS

The following suggestions outline several options for incorporating the images into a unit of study as phenomena:

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by asking students to independently consider what words they associate with the "biology of cancer." (Given that students' prior experience with cancer may be sensitive, you may want to tell students in advance that you will be having this conversation or ask them to brainstorm words outside class time and submit them anonymously, such as via Post-its that you collect and read aloud.)
- Student terms may include "cells," "death," "disease," "tumors," varieties of common cancers, chemotherapy, etc. Students may also associate cancer with environmental mutagens such as tobacco or UV radiation, with mutations in genes, or with metastasis.
- Tell students they will be examining a picture related to cancer showing different cell and tissue types in different colors. The colors have been altered to better show contrasts between cells and do not have any intrinsic meaning.
- Ask students to examine the picture and note their observations and questions using the following question stems: "I notice … I wonder …"

- Students should share observations and questions with one another using a think-pair-share protocol. During the "share" section, record students' observations and questions, noting common observations and questions.
- Observations that students may have:
    - Two or three cell types appear to be present, noted by the different colors. The "blue" muscle fibers appear to be emptier and larger compared with the "pink" or "green" cells. (Students may identify the muscle fibers as a cell type. Clarify that these are muscle fibers in the "share" portion of the thinkpair-share.)
    - There appear to be a higher number and density of "green" cells compared with other cell types. These cells appear smaller than other cells present.
    - The "pink" cells appear at the edges of the green cells and seem to be "invading" or "intruding" into the blue fibers.
- Questions that may arise:
    - Why is each cell type different from the others in its phenotype?
    - Why are green cells more numerous than other cells?
    - Why are the pink cells invading the blue muscle fibers?
    - Why are the green cells interspersed in the blue muscle fibers?
- Tell students that cancers arise when cell division becomes poorly regulated in certain cell lineages or cell types. Based on this, ask students which cell type/tissue color(s) (green, blue, or pink) they would associate with cancers.
    - Students may choose green because the number and density of cells is high.
    - Students may choose blue because the tissue appears empty or large in comparison to other cells.
    - Students may choose pink because the cells appear to be "invading" or "taking over" other cells.
    - It may be beneficial to collect student responses anonymously rather than having students share their responses in pairs, since this could lead to misconceptions.
- Have students read the caption in the background information, particularly noting the definition of metastasis. Have students generate between two and four questions they have about leader cells independently before sharing in pairs and finally as a class.
- Students may wonder why leader cells are different in appearance than the other tumor cells. They may also wonder about the following: What makes some cells leaders and some followers?; Can we can predict whether a cell will become a leader?; and How do leader cells interact with tissues they're invading?
    - It may be helpful to clarify that cancer cell invasion isn't the same as invasion by a virus, since metastasizing cells grow alongside noncancerous cells, invading tissues, rather than invading noncancerous cells.
- Transition to the next part of the discussion by asking students what determines the appearance and behavior of cells.
    - Students may connect appearance with phenotype but may believe that phenotype only applies to the external traits of an organism (such as hair color, height, etc.), not to internal tissues or cellular processes. Students may believe that phenotype only refers to cells' appearance and not behavior.
- Student responses may eventually include descriptions of differences in genes or cell instructions, but these answers are likely to be preliminary ideas without many details. The following activities are aimed at solidifying the connection between differences in genes, which result from mutations, and differences in cells' appearance or behavior.

Exploration, assessment, and extension:

- Explore/Investigate: The following blog post has one instructor's learning sequence based around the question "Why don't we have a cure for cancer?". (While HS-LS1-4 excludes understanding specific gene control mechanisms for mitosis, it may be helpful to explore specific gene mutations in order to have students generalize to the model that certain mutations cause abnormal cell division, which can lead to cell proliferation.) It discusses use of some of the following activities:
    - Students can investigate mutations in specific genes that are associated with specific varieties of cancer using the cancer discovery activities. In Activity 1, students identify the locations on chromosomes of genes involved in cancer, using a set of cancer gene cards. In Activity 2, students explore the genetic basis of cancer by examining cards that list genetic mutations found in the DNA of actual cancer patients.
        - Students can then explore the cell cycle—and various checkpoints that regulate cell division—with the Eukaryotic Cell Cycle Click & Learn.
        - Solidify the connection between mutations and cell proliferation using the following p53 Data Point, which shows the relationship between cells whose p53 gene has been deleted via exposure to gamma radiation and cells' mitotic index: that is, the proportion of cells undergoing mitosis at a given time. This educator blog post uses the "Identify and Interpret" strategy to help students unpack this figure.
- Assessment: Revisit the initial image and ask students to explain how the green cells, which are tumor cells, became cancerous, and to hypothesize about how the pink cells became leader cells. Student answers may include that the green cells had mutations in specific genes regulating cell division, and that unregulated cell division can lead to the formation of tumors and cancer. Students may cite specific checkpoints that may be disrupted, leading to cell proliferation. For the pink cells, students may speculate that those cells have mutations in different genes (or different mutations in the same genes) than the green cells, leading to their becoming invasive, though they share similar mutations with many of the green cells.
- Extension: The Data Point figure is taken from this research paper, which is available through "Science in the Classroom." The paper features embedded BioInteractive media and a variety of annotation tools.

TEACHING TIPS

- Present students with the image first, before they read the background information.
- Background information may be edited to support student proficiency, course sequence, etc.
- The images may be projected in lieu of handouts.
- Pair or group students to work through one or more of the implementation suggestions.

SOURCE

Figure 2a (with modifications to color) from:
Cheung, Kevin J., Edward Gabrielson, Zena Werb, and Andrew J. Ewald. "Collective Invasion in Breast Cancer Requires a Conserved Basal Epithelial Program." *Cell* 155, 7 (2013): 1639–1651. https://doi.org/10.1016/j.cell.2013.11.029.

CREDITS

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