

ACTIVITY 1: CLASSIFYING CANCER GENES

INTRODUCTION

You may have read articles that talk about “cancer genes.” But what exactly are cancer genes and what do they do?

Cancer consists of a group of diseases caused by mutations in the DNA of cells. Some mutations are inherited, but most occur during a person’s lifetime as a result of random errors in replication. Environmental factors that damage DNA, such as smoking and sunlight, can also cause mutations to occur.

As a single cell in the body accumulates mutations, one of those mutations could provide a survival or a growth advantage to the cell, causing the cell to divide at a faster-than-normal pace or to not die. The resulting daughter cells with that mutation, which are dividing quickly, are more likely to accumulate additional mutations. Additional mutations that affect cell division may cause those cells to divide even faster. Eventually, a cell may acquire enough mutations that it starts to grow and divide uncontrollably (**Figure 1**).

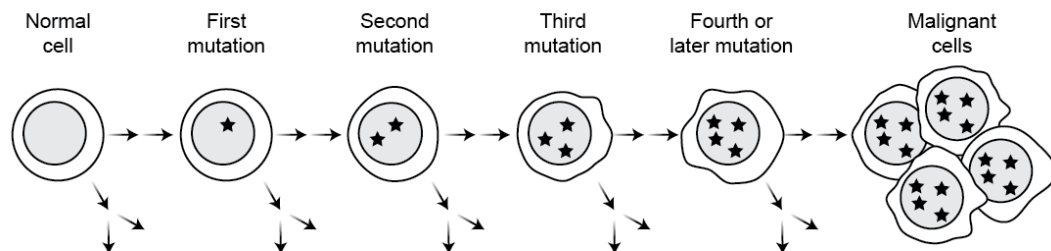


Figure 1. Schematic of cancer development. Cells accumulate mutations as they divide. Mutations that are most advantageous for cell growth and survival are passed on to daughter cells, which, in turn, acquire further mutations and may eventually become malignant cancer cells. (The arrows represent multiple cell divisions.)

In this activity you will examine the locations throughout the genome of genes that when mutated cause cancer to develop (i.e., cancer genes) and you will learn about the normal functions of these genes.

MATERIALS

- [Cancer as a Genetic Disease](http://www.hhmi.org/biinteractive/cancer-genetic-disease-video-highlights) video clip (<http://www.hhmi.org/biinteractive/cancer-genetic-disease-video-highlights>)
- *Activity 1: Classifying Cancer Genes* student document, which includes the *Video Worksheet*

- One or several *Cancer Gene Cards*
- *Human Chromosomes* sheets or poster (one set per class)
- *Classification of Cancer Genes* poster (one per class)
- *Functions of Cancer Genes* poster (one per class)
- colored stickers, colored pens, bingo markers, or beads in five colors (red, green, purple, blue, and yellow)

PROCEDURE

Part 1: To begin, watch the [Cancer as a Genetic Disease](#) video clip (8:30 minutes) featuring cancer researcher [Dr. Charles L. Sawyers](#). Answer the questions on the worksheet at the end of this document to review the important concepts from the video.

Part 2: Your instructor will distribute the *Cancer Gene Cards*. (You will probably receive more than one card.) Each card (**Figure 2**) contains the gene symbol (abbreviated name, e.g., *RB1*, *BRCA1*), the gene's human chromosome location, gene classification (oncogene or tumor suppressor), and the cellular processes in which the gene is involved (cell survival, cell fate, or genome maintenance). Visit the HUGO Gene Nomenclature Committee's [online repository](#) of gene nomenclature, enter your genes' unique abbreviations in the search field, and note the full name of each gene.

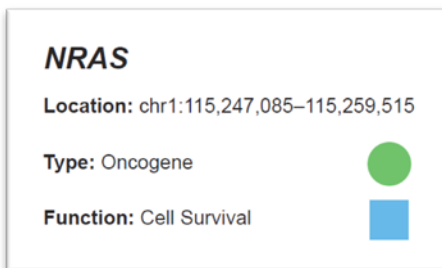


Figure 1. Example of a cancer gene card.

Part 3: Using the information on your cards, mark the locations of your genes on the *Human Chromosomes* sheets or poster. Once you've located a gene, you will further identify it by indicating

- whether the gene is a tumor suppressor gene (red) or an oncogene (green) and
- which functional categories the gene is associated with: cell survival (blue), cell fate (purple), and/or genome maintenance (yellow).

For example, if you have the card for *RB1*, which is located on chromosome 13, you would find chromosome 13 on the sheet and locate *RB1*. Then you would place either a red or a green dot in the first circle next to *RB1*, to indicate tumor suppressor or oncogene (**Figure 3**). In the second circle, you would place a purple, blue, or yellow dot to indicate the gene's function(s).

Note that some genes are involved in more than one function and so may receive more than one dot from the purple, blue, and yellow family.

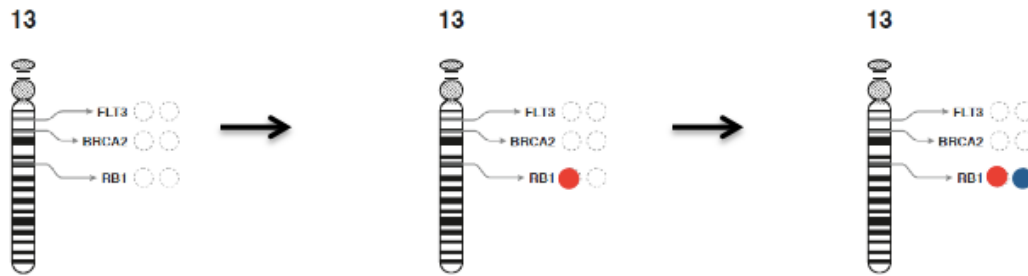


Figure 2. Adding colored dots to the chromosomes. Locate your gene on the appropriate chromosome. Place a green or red dot in the circle next to the gene name. (In this example a red dot shows that RB1 is a tumor suppressor gene.) Then place a blue, purple, or yellow dot in the circle next to the first one. (In this example, a blue dot shows that RB1 functions in cell survival.)

Part 4: Now you will examine the cancer data on your cards collectively, as a class. Using the information on your cards, record the type of cancer gene (tumor suppressor or oncogene) by placing a red or green dot in the appropriate column on the *Classification of Cancer Genes* poster. Record the gene function(s) indicated on your cards by placing a purple, blue, and/or yellow dot in the appropriate column on the *Functions of Cancer Genes* poster. On both posters, fill in the row of blank circles from the bottom to the top with dots as if you were building a bar graph.

Part 5: After your class discussion of the posters, complete a 3-2-1 analysis. In this analysis, you will share

- three things you learned from the activity,
- two things that surprised or interested you, and
- one question you still have.

NAME

DATE

VIDEO WORKSHEET

1. What was the main purpose of the large-scale cancer study that Dr. Sawyers describes in the video?
2. Why was it important to sequence both cancer DNA and normal DNA from people with cancer?
3. How did the investigators share data as they worked? And why was it important to share?
4. As of spring 2013, about _____ genes associated with cancer have been identified. What is the approximate breakdown of oncogenes versus tumor suppressor genes?
5. Using Dr. Sawyers’s analogy (the gas pedal and brake), a mutated oncogene is like _____ and a mutated tumor suppressor gene is like _____. What does this mean in terms of how the cell grows and divides?
6. Distinguish between a proto-oncogene and an oncogene.
7. The mutated allele (oncogene) is **dominant/recessive** compared to the normal, nonmutated allele (proto-oncogene) on the other chromosome. (Circle a choice.)
8. The mutated allele of a tumor suppressor gene is **dominant/recessive** compared to the normal, nonmutated allele on the other chromosome. (Circle a choice.)
9. Does Dr. Sawyers think many more cancer genes will be identified? Will the number grow exponentially?

10. List the three “buckets” in which scientists categorize cancer genes. Approximately how many genes are in each bucket?

11. How do *p53* and *cyclin D1* differ in how they affect the cell cycle?

12. Is *p53* a **tumor suppressor gene/oncogene**? Is *cyclin D1* a **tumor suppressor gene/oncogene**? (Circle a choice.)

13. Consider genome maintenance genes:

- Does DNA polymerase make mistakes during DNA replication?
- How often?
- Explain the proofreading system.

d. Explain what happens if a mutation occurs in the genes that encode proofreading enzymes.

14. Why is it that the longer we live, the more likely we are to develop cancer?