Using Nanoparticles to Deliver Cancer Drugs Instructor Guide

*Product of the Scientist Spotlights and Data Nuggets Faculty Mentoring Network*

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# Course Information

Designed for a 50-min class period with online synchronous or in-person delivery. Target student level is introductory biology for majors or non-majors.

# Overview

In this activity, students will review the advantages and disadvantages of currently used treatments for cancer. They will then be introduced to a novel therapeutic approach currently under development: the use of nanoparticles that are selectively engulfed by cancer cells to deliver cytotoxic drugs. They will view images of fluorescently stained cells to determine which type of nanoparticle works best to selectively target the cytotoxic agent to cancer cells while sparing healthy cells. They will then read a bar graph showing quantitative image analysis of the images they have viewed. Finally, students will view an interview with the scientist responsible for this experiment, Dr. Hyeyoun Chang. In this interview, Dr. Chang describes her childhood and education, and talks about why she finds research to be a rewarding career.

# Learning Outcomes

## Quantitative learning outcomes

1. Students will be able to describe how fluorescence intensity can be quantitated and used for statistical determination of differences between samples
2. Students will be able to interpret a bar graph generated using quantitative data about fluorescence intensity

## Content learning outcomes

1. Students will be able to describe the challenges associated with treating cancer and the advantages and disadvantages of current cancer treatments
2. Students will be able to describe how nanoparticles could be used to selectively deliver drugs to cancer cells while sparing healthy cells

## Social justice and/or diversity/equity/inclusion learning outcomes

1. Students will learn that scientists have diverse backgrounds and interests
2. Students will be better able to see themselves as scientists

# List of Materials and Preparation

* Instructor Guide
* In-Class Presentation

# Prerequisite skills or knowledge

* Basic knowledge of how to read a bar graph
* The topics that could be referred to but are not necessary: mitosis, cancer biology, phagocytosis, properties of macrophages

# Part I: Cancer and cancer treatment (10 minutes)

**Slide 3**: Introduces the main challenge addressed in this experiment and activity: how to selectively kill cancer cells without causing excessive damage to healthy cells, since cancer cells are in many ways similar to non-cancerous cells in the body.

**Slide 4:** Asks students to share what they already know about different methods for killing cancer. In an in-person class, this could be done as a quick think-pair-share. For online delivery, it is probably easier to just ask students to raise their hands and share answers. Students will likely list the methods listed in **slides 5–7**. As each method is described by a student, you can advance to the slide that lists that method.

**Slides 8-9:** These slides introduce the novel method of cancer treatment that is the basis for the experiment described in part II. An important thing to emphasize here is that cancer cells, due to their high energetic needs, take up more materials by endocytosis than non-cancer cells, so the use of nanoparticles represents a promising method to selectively target cancer cells.

# Part II: The experiment (10-15 minutes)

**Slide 11:** Introduces the design of the experiment that generated the data shown later in this section. If time permits, you may wish to engage students in a discussion about why macrophages were used as a control cell (because they are highly phagocytic cells, and thus likely to take up nanoparticles). The “experimental” cell line, SCC7, is a skin cancer cell line, so students might propose that skin cells might be a good control. However, because the goal is to try to assess to what extent healthy cells might be damaged by a cytotoxic agent attached to a nanoparticle, the goal here is to choose a control cell with as much endocytic activity as possible. This could further lead to discussion of the limitations of cell culture experiments, as this model does not rule out the possibility that untested cell types could take up high amounts of the nanoparticles, and thus there is a need to test new treatments in animals and then in human volunteers.

**Slide 12:** Experimental design is described in this slide.

**Slide 13:** Students are asked to look at the experimental results and determine which type of nanoparticle would be best to deliver a toxic agent specifically to cancer cells. The column on the left shows the results in control macrophages, and the column on the right shows the results in the SCC7 cancer cell line. Each row is a different type of nanoparticle incubated with the cells. The blue DAPI staining shows where the cells are and the red staining shows the presence of the nanoparticles. The goal of the experiment is to find a type of nanoparticle that will go inside the cancer cells but not in the control cells. The nanoparticle in the bottom row, GCNP, shows the greatest specificity for cancer cells. You could ask students what they think would happen if any of the other nanoparticles shown were used to deliver toxic chemicals to cells.

**Slide 14-15:** These slides introduce the concept of quantitative image analysis. In slide 14, students are asked if they can think of any ways to quantitate an image. This can be done as a think-pair-share.

**Slide 16:** Repeats the experimental data in slide 13 alongside a bar graph showing the results of quantitative image analysis. Students are asked whether they still agree with their original answer about which type of nanoparticle would be best to use for cancer treatment. If time permits, additional questions can be asked, such as:

* What are the variables on the x and y axes?
* What do the two different colors of bars mean?
* How do these graphs relate to the fluorescent image?
* Based on this graph, which nanoparticle would be best to deliver drugs specifically to cancer cells?  Does this confirm your earlier interpretation of the fluorescence image?
* Why are both figures (fluorescence and bar graph) helpful for scientists to understand this research?

# Part III: Meet the Scientist (10-15 minutes)

The video excerpts linked in slides 18-20 are from a video posted to YouTube here: <https://www.youtube.com/watch?v=OhywmvLgGwg>

The entire interview is 13:43 and each question has been timestamped:

0:00 Tell us about your childhood (linked in slide 18)

0:42 Where did you go to school? (linked in slide 18)

2:33 Why did you decide to become a researcher?

3:25 Who have been your mentors?

5:15 Did you ever feel like you did not belong in science? (linked in slide 19)

7:54 What keeps you motivated? (linked in slide 20)

9:50 Tell us about your current position

11:06 What do you do in your job besides research?

11:33 How do you balance work and life?

12:42 What advice would you give students considering a career in research?

*Note that when using the embedded video, you must hit the pause button at the end of each answer. The time to hit “pause” is in the notes section of each slide.*

**Slide 21:** This slide asks students to answer the exit question “Did you learn anything about Dr. Chang in these interview clips that surprised you or changed your perception of what it is like to be a scientist?” The goal of this activity is to introduce students to a counterstereotypical scientist and to expose them to the idea that scientists come from diverse backgrounds and have many interests, hopefully allowing them to see themselves as potential scientists.

This could be replaced by a post-class reflection essay with prompts based on Schinske et al. 2016. Some additional questions that could be addressed in the essay include:

What questions still remain to be addressed about using nanoparticles to deliver cancer treatments?

Did learning more about Dr. Chang change your perception of people who are scientists? If so, how?

What did you learn from this activity about the kinds of people who do science?

# References/resources

1. Schinske, J. N., Perkins, H., Snyder, A., & Wyer, M. (2016). Scientist spotlight homework assignments shift students’ stereotypes of scientists and enhance science identity in a diverse introductory science class. CBE—Life Sciences Education, 15(3), ar47.
2. The Scientist Spotlights Initiative | San Francisco. https://scientistspotlights.org/.
3. Chang H, Yhee JY, Jang GH, You DG, Ryu JH, Choi Y, Na JH, Park JH, Lee KH, Choi K, Kim K, Kwon IC. Predicting the *in vivo* accumulation of nanoparticles in tumor based on *in vitro* macrophage uptake and circulation in zebrafish. J Control Release 2016;244(Pt B):205-213.