Immune cells change shape to more effectively attack cancer cells

How could your research help fight cancer?

The goal of my research is to develop more effective immunotherapy treatments for skin cancer. Immunotherapy is a new type of therapy in which a patient's own immune cells are used to kill cancer cells. I study how the shapes of immune cells change when they are actively killing cancer cells in melanoma, a type of skin cancer.

Alexandra Signoriello

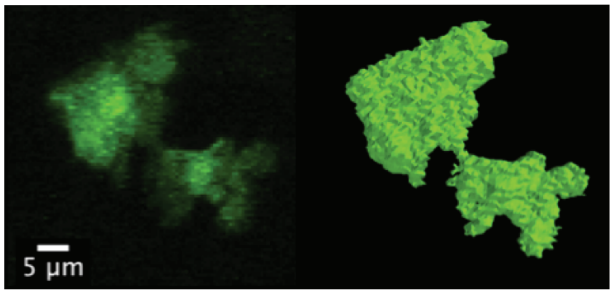
The research group I am part of observes the growth of tumors in two populations of mice that have skin cancer: one population with a healthy immune system, able to fight cancer, and another population with a very weak immune system, unable to fight cancer. Using a specialized microscope, we take images of cells inside the tumors of mice to study the differences in immune cell shape between the two populations.

I write computer programs to automate the processing and analysis of the images taken of immune cells inside mouse skin tumors. Using these programs, I can calculate the shape of cells and measure how far each cell travels inside the tumor. In the figure, I show an image of an immune cell inside a skin cancer tumor (left) and its transformation into a computer-generated mesh (right). A mesh is like a digital painting that captures the dimensions of the cell, making it possible to compute the cell's volume, surface area, and shape. I can track the position of the cells, using many images taken at different time points, and measure how far each cell has traveled in the time between images.

Importantly, my current work suggests that immune cells change shape and become more elongated when they are searching for cancer cells. This is a notable discovery because these changes may allow immune cells to squeeze between other cells to access and fight cancer cells within the tumor. In the future, I will use computer simulations to study whether the flexibility of the immune cells is different in large versus small tumors. Using these simulations, I will understand how rigid or flexible the immune cell is by pulling the computer-generated mesh in different directions and studying how easily the mesh changes shape in response. I will then compare the cells in the simulations to the real behavior of immune cells inside tumors.

As a 5th year Ph.D. student in the graduate program in Computational Biology and Bioinformatics at Yale University, my research project incorporates knowledge from physics, computer science, and cancer biology to explain how skin cancer grows. I am advised by Profs. Marcus Bosenberg, a dermatopathologist who diagnoses skin cancer by looking at magnified images of the cells inside tumors, and Corey O'Hern, a physicist, who studies how particles of different shapes pack inside materials, using computers.

Computer simulations are carried out to model biological and physical processes. An advantage of computer simulations is the ability to gain novel insights into biological systems without carrying out experiments in the laboratory, which often take more time and resources. In addition, model systems that are not as complex as the real biological systems can be simulated to understand the key interactions that control biological phenomena. The simulations are then compared to data from experiments, so that the model can be improved.



(Left) A microscopy image of a macrophage, a type of white blood cell, within a mouse melanoma tumor. (Right) A computer-generated mesh of the macrophage on the left using a new image processing method that I developed. Note that the immune cell – the macrophage – is non-spherical and has a thin middle, allowing it to squeeze between neighboring cells in its search for cancer cells.

What sparked your interest in science?

I have always been fascinated by the simplicity and elegance of mathematics. In particular, I admire simple mathematical equations that can describe complex behavior in biology. For example, the Fibonacci sequence (a sequence of numbers in which the next number is found by adding the two that precede it) describes the spirals in sunflower seeds, the predator-prey set of differential equations can predict whether the Canadian lynx will have enough food to survive the winter, and the simple Vicsek model (used to study self-organizing motion in a group of organisms) can explain schooling in fish and flocking in birds. My passion about science is rooted in the idea that complex patterns emerge from simple rules.

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