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Metastasis—A force to be reckoned with

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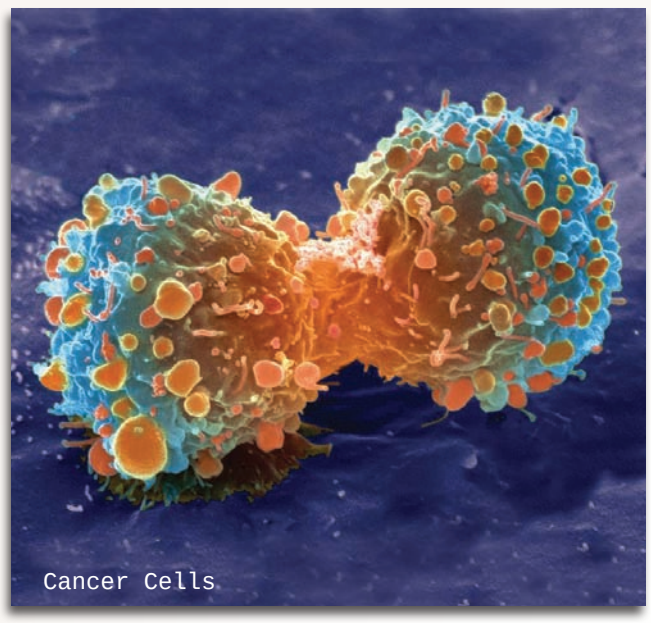


Cancer Cells

Finding a cure for cancer is one of the biggest challenges facing scientists in the 21st century. The problem is that "cancer" is not one disease. Saying a cell is cancerous actually refers to the cell's **phenotype**. The cancer phenotype is an out-of-control growth and division of cells in a single place in the body, called a tumor. Individual cells have to routinely die in order ensure the health of the organism, and this process is hijacked by cancer.

The deadliest form of cancer is metastasis. When a tumor metastasizes, the cancer cells leave their tumor and seek the blood stream to set up new colonies around the body. To understand and battle **metastasis**, biologists have found many of the genes involved, while biophysicists are trying a new approach: study the forces involved in metastasis using the new field of **mechanobiology**. Think of the metastasizing cells as cars, each with a rogue driver. If we understand how cells physically migrate from a tumor to the blood stream, we don't have to understand exactly what that driver is thinking (i.e. its genes), we can just slash the car's tires.

Meet the Scientist

I am a third year physics Ph.D. student at Yale University studying theoretical biophysics. Mathematics was something I was good at, but did not particularly enjoy. I started college wanting to study music production and business, but an acoustics class quickly converted me to physics. I took courses in mathematics and physics, along with philosophy and history. My philosophy courses spawned an interest in the mystery of how life could arise from non-living things.

This is where my research comes in. I am a physics Ph.D. student at Yale University working in the Lab of Living Matter under the supervision of Dr. Michael Murrell. I use computer simulations to study how cells generate forces using the **cytoskeleton**, the cell's version of a skeleton. It consists of **proteins** called **actin**, **cross-linkers**, and **molecular motors** that work together to exert forces, from moving the cell through its local environment to pinching the cell in half during cell division. However, the ways in which these components interact are numerous and complex, making experimental manipulation very difficult. Fortunately, their interactions can be reproduced computationally, and therefore research is not limited by the labor and constraints of experimental manipulation. In my computational simulations, I alter whatever properties I choose, which allow me to approach some of the most fundamental questions, like how these proteins produce forces, and how those forces are related to the cancer phenotype.

A basic understanding of how cells can exert forces is key to stopping cancer metastasis. The goals are to figure out the weakest link in the chain of events that result in cancer cells migrating to the blood stream, and cut the chain off at that point. While these goals are lofty and much more work needs to be done, it gives me great satisfaction to know that my work could one day help millions of people suffering from cancer.

WORDS to know

Phenotype: The outward behavior or appearance of an organism. The same phenotype can be a result of many different underlying genetic changes.

Metastasis: The process by which cancer cells leave a single area and colonize many different areas throughout a living thing.

Mechanobiology: A new field that integrates physics and biology to understand the forces involved in biological processes.

Cytoskeleton: A meshwork of proteins throughout eurkaryotic cells (organisms with cells that have a nucleus enclosed within membranes) that are used to exert forces on the outside of the cell.

Protein: Large molecules that cells make. They perform all of the important tasks needed for cells to survive. The cell is made up of mostly proteins, the "doers" of the cell.

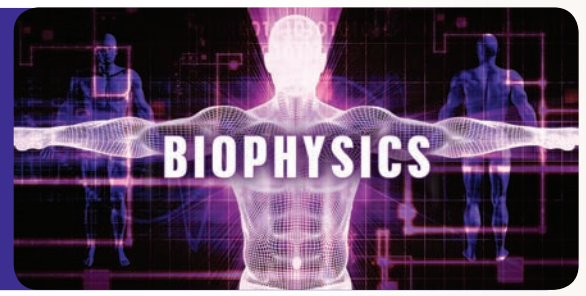
Actin: A long, filamentous protein that makes up the majority of the cell cytoskeleton.

Cross-linker: A protein that glues together different threads of actin.

Molecular Motor: A protein that grabs two actin filaments and pulls on them, acting as the force generator in the cell cytoskeleton.

Cancer Cells

SKILLS and KNOWLEDGE



Biophysics is an extremely interdisciplinary field of study. Biophysicists, whether they do experiments, run computational simulations, or do purely theoretical work, have strong backgrounds in physics and biology. An experimental biophysicist will also know a lot about optics, image processing, and working with cells or living organisms. A theoretical biophysicist will focus more on mathematical descriptions of living things, with training in statistical mechanics, computer programming, and simulation techniques.

For Students and Teachers Making Curriculum Connections, see the following:

Connecticut State Department of Education (CSDE) - Common Core State Standards (CCSS): Mathematics

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others
- CCSS.Math.Practice.MP5 Use appropriate tools strategically

CSDE - Next Generation Science Standards: Scientific and Engineering Practices

- Asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using Mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information.

Hyperlinks:

https://www.quantamagazine.org/jammed-cells-expose-the-physics-of-cancer-20160816/
https://softbites.org/2017/12/13/the-living-silly-putty/
https://softbites.org/2018/01/17/the-living-silly-putty-2/

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