SigmaCamp 2025 Lectures

August 2 - 9, 2025

Lecture dates are subject to change

SigmaCamp 2025 Lecture Overview

Saturday, August 2

Quantum Advantage
by *Scott Aaronson*

What can we do with a quantum computer that actually beats the best that can be done with a conventional computer? Three decades ago, Shor's quantum factoring algorithm gave a dramatic in-principle answer to this question, but experimenters still struggle to build the error-corrected devices that would be needed to demonstrate Shor's algorithm at scale. In this talk, I'll tell you about the so-called "quantum supremacy experiments," based on random circuit sampling and Boson sampling, that my collaborators and I proposed 15 years ago and that Google and others have used to demonstrate quantum advantages starting in 2019. I'll also tell you about the central drawbacks of these experiments, and what we're doing now to try to address those drawbacks.

About the lecturer: *Scott Aaronson is a theoretical computer scientist at the University of Texas at Austin. He received his bachelors from Cornell and his PhD from UC Berkeley, and previously taught at MIT. He's spent most of his career studying the capabilities and limitations of quantum computers, although he also spent a two-year leave at OpenAI, working on theoretical foundations of AI safety. He's published a book, Quantum Computing Since Democritus, and also writes a popular blog. Attending a math camp when he was 15 was a transformative event in his life.*

Sunday, August 3

What Powers Life: Myths and Truths About Energy in Your Cells
by *Alexander Galkin*

We all know that where there are oxygen and food — there should be life. How do our cells use oxygen and nutrients? 99% of the oxygen we breathe is consumed in small cellular organelles called mitochondria. In school textbooks, mitochondria are known as the "powerhouse" of the cell, but we will look at these cellular organelles from a different perspective. In my lecture, we will discuss how energy is processed in our cells and bust some myths about diets, calories, and aging.

About the lecturer: *Alexander received his PhD in Biochemistry at Moscow State University and completed postdoctoral studies at Frankfurt University and University College London. Dr. Galkin's research lab at the Brain and Mind Research Institute, Weill Cornell Medicine, focuses on studying the role of mitochondria-associated metabolic changes in tissue injury during cardiovascular diseases such as stroke, tissue ischemic damage, and neurodegeneration using various in vivo and in vitro models.*

Benford's Law
by *Alexei Borodin*

If one looks at population numbers of all the towns in the United States, then one sees that the leftmost digit of those numbers is "1" about 30% of the time and "9" less than 5% of the time. The same happens with electricity bills, length of rivers, and street addresses. This observation is known as Benford's law. In this lecture we will investigate this law and explain why it works. We will also discuss how it can be used, for example for detecting fraud in financial documents. The lecture expects that students are familiar with high school algebra and logarithms.

About the lecturer: *Alexei Borodin received his Ph.D. in mathematics from the University of Pennsylvania in 2001. He was a professor at Caltech in 2003-2010, and since 2010 he is a professor of mathematics at MIT. Alexei enjoys working on problems on the interface of algebra and probability.*

Chemistry, AI, and You: Charting Your Course in the Future of Science
by *Yana Kosenkov*

> "The chemists are a strange class of mortals, impelled by an almost insane impulse to seek their pleasure among smoke and vapor, soot and flame, poisons and poverty..."
>
> - Johann Becher, 17th-century German chemist

Do you find excitement in smoke, vapor, and bubbling flasks? If so, you would fit right into a 500-year-old alchemy lab! It is not a secret that modern chemistry is no longer confined to glassware and goggles. Contemporary teaching, research, and industrial labs use robotics, AI, and automated instruments, operated by collaborative teams of scientists. These environments are increasingly inclusive, welcoming diverse talents, interests, and perspectives. As the lines between theory and experiment blur and scientific research becomes increasingly more interdisciplinary, there is growing demand for software developers, AI specialists, data scientists, engineers, designers, user experience specialists in the area. In this interactive session, we will explore how the fusion of theory and experimentation, fueled by emerging technologies and teamwork, is transforming chemistry and other sciences. Then, we will make it personal for you, by exploring how your own personality, learning style, strengths or even perceived limitations, can help you navigate your own unique path in science.

About the lecturer: *Yana Kosenkov is a computational chemist and chemical education specialist whose work focuses on applying artificial intelligence, machine learning, and automated technologies to advance drug discovery and make chemistry labs more accessible to scientists of all abilities. After teaching and advising students at several institutions, Yana recently joined Rutgers University as a teaching professor of chemistry. Outside of work, she enjoys spending time with her husband and three sons solving math and science problems, and enthusiastically cheering (and occasionally screaming) at their basketball games.*

Soft Robotics and Programmable Matter
by *David Bershadsky*

Robots in our every day world rely on the design of complicated mechanisms to improve their capabilities. Soft robotics interact in the world in a more organic way. They can incorporate soft interface layers to prevent from damaging fragile objects. Similar to our own muscles they can move without motors by harnessing shape changing materials. What if we could improve the capabilities of our soft robots by programming the materials they are made of? We will dive into the world of shape memory materials, and other materials with programmable proprieties to explore how they can be synthesized, and used in real world applications through the lens of soft robotics.

About the lecturer: *David Bershadsky is an Electrical and Computer Engineering PhD candidate co-advised in Chemical Engineering working on programmable matter for robotic applications. He studies how we can manipulate the structure of materials in order to control their mechanical behaviors. At SigmaCamp, David is responsible for teaching the Microfluidics semilab.*

Monday, August 4

Healed by Nothing: The Weird Science of Placebos
by ***Olga Komargodski***

Is a placebo really just a sugar pill that does nothing? Or is it one of the most mysterious and powerful forces in medicine?

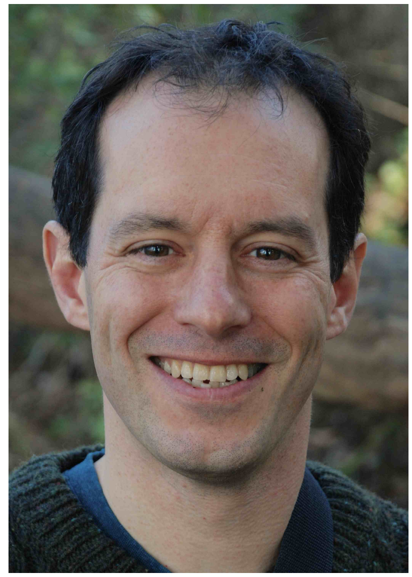
For centuries, self-proclaimed healers have sold miracle cures from snake oil to electric belts, profiting from people's hopes. But what if some of these "fake" treatments actually helped, not because of what they are, but because of what people believe?

In this session, we'll uncover how the placebo effect has shaped medical history, and why it still challenges modern science today. We'll dive into the brain's hidden power, explore how beliefs can change pain perception, and ask: can a lie sometimes heal?

Not all placebos are created equal. We'll test which types work best, and why. By the end, you'll be better equipped to spot hype, ask smart questions, and understand the surprising science behind healing without medicine.

About the lecturer: *Dr. Olga Komargodski MD is a board-certified physician specializing in pain management, with advanced training from Stony Brook and Johns Hopkins. She currently practices in New York, where she helps patients manage complex chronic pain using a combination of interventional techniques and evidence-based approaches.*

What is a Proof? From Euclid to Zero-Knowledge Arguments
by *Adam Smith*



Proofs are a basic concept in math—they allow us to rest easy that a mathematical statement is not just roughly right but really, really true. The ancient Greeks were probably the first to write what we would call a "proof", and many of us still encounter our first proofs in a Euclidean geometry class. But what actually is a proof? What is it for? Can you prove something without explaining anything about it?

In this lecture, we will explore this idea, covering a little bit of history and a lot of recent ideas that have emerged from computer science about how one can prove things in deeply counterintuitive ways—such as with so-called "zero-knowledge" proofs.

About the lecturer: *Adam is a computer scientist at Boston University, where he is a founding member of the Faculty of Computing & Data Sciences. His areas of research include cryptography and information privacy. He is known, along with Cynthia Dwork, Frank McSherry, and Kobbi Nissim, as one of the co-inventors of differential privacy, for which he won the 2017 Gödel Prize. He taught a semilab at SigmaCamp in 2021, and has returned each year since!*

How to Search in the Dark
by *Deniz Erdag*

What is out there in the universe? This simple question has driven many scientists over centuries to study the cosmos. With modern technology, cosmology has shown us that we actually cannot see most of the matter in the universe. The physics we can observe is dominated by invisible, dark matter. We will talk about how dark matter was discovered and why its invisible. After we understand what to look for, we will talk about some big experiments that are searching for dark matter, and just how they can look for the invisible.

About the lecturer: *Deniz Erdag is a recent graduate of Princeton University where she studied physics. Her research focuses on lab-based particle detection, specifically for axion dark matter. As part of the DMRadio and Princeton Axion Search experiments, she has worked on cryostat design and readout electronics. She has previous research experience in computational cosmology, AMO physics, and computational particle physics (detector simulations). At Sigma, she is a counselor who wants Sigma students to love particles that may not exist.*

The Language of Chemistry in Drug Discovery
by *Dmitri Kosenkov*

When we learn chemistry in school, we usually think of it as a language made up of chemical formulas—from the familiar H_2O to complex structural drawings that show how atoms are arranged in a molecule. However, in today's world, especially with the rise of artificial intelligence and machine learning, those traditional ways of representing molecules are not always suitable.

In the fast-moving fields of chemistry and biomedical research, we need a new kind of language to describe molecules—one that can accelerate the discovery of new medicines. In my talk, I will introduce some of the cutting-edge methods scientists use today to represent molecules.

About the lecturer: *Dmitri Kosenkov, Ph.D., is a data scientist at Princeton Precision Health, where he develops AI and machine learning tools to accelerate precision healthcare and drug discovery. He has led research in computational chemistry across academia and industry, taught at Monmouth University. He earned his Ph.D. from Jackson State University, completed postdoctoral training at Purdue University, and is a Cottrell Scholar Award recipient.*

Learning About Learning
by *Daniel Salkinder*

You are here at Sigma to learn... But what exactly is "learning"? Is there a difference between learning a foreign language and learning to ride a bike? What mechanisms control learning? And how could knowing all this help you learn more effectively?

Luckily, the past 100 years of psychology and neuroscience give us models with satisfying answers to these questions. This lecture traces these models, touches on recent experimental results that support them, and compares their predictions with education research on outcomes in the classroom. By the end, you will be equipped with both evidence-based learning tips, and with a framework to help understand whether something is helping you learn or not.

About the lecturer: *Daniel Salkinder is a senior at Harvard studying Math and Physics, and is currently researching quantum knots in a field called representation theory. He spends his free time trying to learn things and then teaching them to other people. He has been coming to SigmaCamp for more than half his life, and you can find him judging tournament, playing board games, or running philosophy evening club.*

Tuesday, August 5

Simpson's Paradox: How Mathematics can Heal Patients and Political Divides
by *Andrey Boris Khesin*

Have you ever seen data that tells two completely opposite stories at once? Simpson's Paradox is a surprising twist in statistics where trends that appear clearly in separate groups can vanish or even flip when you merge those groups together! In this talk, we'll explore how this paradox can be a difference of life and death in choosing the right medical treatment, as well as how it can skew our view of which states lead the nation in education, or whether university admissions processes are fair.

We'll see why thinking carefully and applying solid mathematical reasoning is necessary to uncover hidden biases, avoid disastrous decisions, and build policies that truly serve everyone. The world has no shortage of people who use statistics to tell a biased story and twist the narrative. Learning how to use Simpson's paradox for good is critical to not falling into their traps!

About the lecturer: *Andrey is a Postdoctoral Fellow at the University of Oxford and has been at SigmaCamp since the very beginning. Andrey graduated from the University of Toronto in 2019 and completed his PhD in Mathematics at MIT in 2025. Andrey is always open to chat about math, physics, or computer science! He greatly enjoy board games, puzzles, square dancing, and contra. Andrey's research is in quantum computing and quantum information theory. He is studying large classes of highly structured quantum error-correcting codes known as helix codes.*

On Particle Physics, Curved Spacetime, and Mysteries in Our Universe
by *Avia Raviv-Moshe*

What is everything made of? In this talk, we'll explore the building blocks of matter – starting with Mendeleev's periodic table and diving down to quarks, force-carrying particles, and the Standard Model of particle physics. Along the way, we'll look inside atoms, follow the discovery of the Higgs boson, and the largest experiment ever built: the Large Hadron Collider at CERN. We'll also briefly encounter some open-question mysteries, curved spacetime, and extra dimensions.

About the lecturer: *Avia Raviv-Moshe is a research assistant professor at the Simons Center for Geometry and Physics at Stony Brook University. She received her undergraduate and graduate degrees in Physics from Tel Aviv University. Avia works in the area of Quantum Field Theory and its applications to physical systems in nature.*

We Are Probably Alone in the Universe (But That's Not Certain)
by *Mark Lukin*

In this lecture, I will summarize the current scientific understanding of abiogenesis — the hypothetical mechanisms behind the origin of life, an event that took place on Earth approximately 4.5 billion years ago. We will examine the probability of the first proto-organisms forming in the primordial soup, with a particular focus on the chemist's perspective.

About the lecturer: *Mark Lukin is a researcher at Stony Brook University, NY. The focus of Mark Lukin's scientific interests is nucleic acids (DNA and RNA), the molecules responsible for the storage and transfer of hereditary information in living organisms. How does DNA get copied? What happens when DNA molecules break? To answer these, as well as many other questions, Mark needs to prepare artificial (modified) nucleic acids and their building blocks, the crazy compounds that normally do not exist in nature. The only way to obtain them is to do a chemical synthesis, the thing Mark likes the most. Besides that, Mark loves music, history, Greek philosophy, and science fiction. When he was young, he loved to do simple but spectacular chemical experiments. Recently, he realized he still loves to do that.*

AI: Brains or Big Data? How Smart AI Really Gets
by *Julia Kempe*

Artificial Intelligence is now writing essays, chatting like a human, generating art, and even designing proteins — but how smart is it really? Is today's AI on the path to superintelligence, or is it just advanced data lookup on an enormous scale?

In this talk, we'll take a deep dive into how today's most powerful AI systems really work — from language models like ChatGPT to image generators and game-playing giants like AlphaGo. You'll learn how much data they devour (spoiler: almost all of the internet!), what happens when we start running out, and why some scientists worry about a strange phenomenon called *model collapse*. We'll look at the rising role of synthetic data, and ask whether machines can start learning from information they generate themselves — and how we might need new systems for verification rather than just generation.

You'll also meet AlphaGo, the legendary AI that reached superhuman performance in a complex game without using human data at all. What made it different? And what about AlphaFold — is it just as good as the data it was trained on, or did it create something more than the sum of its parts?

Come join this fast-paced dive into the future of intelligence — and decide for yourself whether the next great mind might be made of silicon.

About the lecturer: *Julia has a PhD in Mathematics and Computer Science and MS degrees in Math and Physics. In the first decade of her research activity she has worked in quantum computation and information, studying algorithms for quantum computers. She has then worked nearly a decade in finance before returning to academia, where she is now a Professor working at the interface of data science, machine learning and science at NYU's Center for Data Science and the Courant Institute. Most recently she has worked on Machine Learning, focusing on Neural Nets and Language Models.*

Wednesday, August 6

Quest for Biological Immortality: The Need, The Fraud, & The Roadmap
by *Leon Peshkin*

In Slavic folklore, Koschei-the-Immortal was bony, thin and lean. Was his condition caused by severe calorie restriction (CR diet)? Did Vampires realize young blood they drunk keeps them younger via short peptide GDF11? What exactly is the molecular mechanism of rejuvenation in embryos and how to properly prepare the rejuvenating ointment with embryo extracts at home? In this lecture we will review the tales, the fakes and the hard science behind thousands of years of human attempts to delay, cancel or reverse the damage of aging. We will examine the exceptional longevity of selected species across the tree of life and try to crack their secrets. We will study nature's own clocks and consider ways to adjust and halt the pace of their ticking. We will focus exclusively on engineering and laboratory science and leave the moral, environmental and philosophical implications for a separate discussion.

About the lecturer: *Leon came into Systems Biology about 20 years ago with a PhD in Artificial Intelligence to help advance probabilistic modeling and data analysis in biological and medical research. Today, his passion lies in understanding the root causes of aging and unlocking nature's own mechanisms for longevity and the reversal of age-induced damage, which naturally occurs in an embryo, known as "germ-line reset". The interface between embryology and aging, the onset of cell differentiation and eventual de-differentiation, is the focus of his work on model organisms such as Xenopus frogs. His group has introduced a scalable platform for intervention testing in Daphnia as a way to obtain data amenable to Machine Learning.*

Why Do Physicists Say That $1 + 2 + 3 + 4 + ... = -1/12$?
by *Zohar Komargodski*

What if empty space isn't really empty? Neutral objects in the vacuum can mysteriously attract each other — even when there's nothing between them! This strange phenomenon, known as the Casimir Effect, reveals the hidden activity of quantum fields and shows that "nothingness" is full of surprises. To calculate this phenomenon one has to calculate infinite sums of the type $1 + 1 + 1 + 1 + ... = -1/2$ or $1 + 2 + 3 + 4 + 5 + ... = -1/12$ or $1 + 4 + 9 + 16 + 25 + ... = 0$.

The results are confirmed in experiments and there are real-world connections to nanomachines and quantum computing that I will explain.

About the lecturer: *I am a theoretical physicist specializing in quantum field theory and related topics such as gravity, and condensed matter. I was born in 1983, and completed my PhD at the Weizmann Institute of Science (in Israel) in 2008. Between 2008 and 2012 I was at the Institute for Advanced Study in Princeton, and then returned to Weizmann until 2017 when I joined Stony Brook University's Simons Center for Geometry and Physics.*

The Surface Was Invented by the Devil
by *Anibal Boscoboinik*

We often hear that what matters is what's on the inside. I disagree. Surfaces may seem superficial, but they're where all the action happens.

At the boundary between matter and the world around it, surfaces play a critical role in nearly every aspect of modern life: from the way your phone's touchscreen responds, to how medicines interact with cells, to how pollution is filtered from the air. In fact, many of the technologies we rely on — like batteries, sensors, and catalysts — wouldn't work without a deep understanding of what happens on the surface.

Austrian physicist Wolfgang Pauli once said, "God made the bulk, but the surface was invented by the devil." This phrase reflects a scientific truth: while the interior of materials behaves in predictable ways, surfaces are far more chaotic. Atoms at the surface lack neighbors, break symmetries, and often behave in strange, surprising ways — giving rise to new electronic, chemical, and physical properties.

In this lecture, I will introduce the strange and fascinating world of surface science — a field that combines chemistry, physics, and materials science to explore how atoms behave when they have one side exposed to the unknown. I will also share stories from my own work in this field, studying how solid surfaces are structured at the atomic scale, and how they interact with gases, light, and energy — and how that knowledge can help develop new technologies, better catalysts, and new materials. The devil is in the details.

About the lecturer: *J. Aníbal Boscoboinik is a scientist at Brookhaven National Laboratory, specializing in surfaces and nanomaterials. He holds a Ph.D in Chemistry and conducts research at the intersection of materials science, physics, and chemistry. His work spans a broad range of topics, from unraveling catalytic processes on surfaces to investigating nanoscale confinement effects and developing novel techniques for surface characterization. Beyond the lab, Aníbal pursues a variety of multidisciplinary projects that blend technology with art, finance, and entrepreneurship. He sees his many hobbies as a creative excuse to connect and collaborate with interesting people across fields.*

Are All Infinities the Same?
by ***Sofya Raskhodnikova***

Are there more whole numbers or real numbers? More computational problems or computer programs? We'll learn how to compare the sizes of infinite sets — and see why some problems will forever stump computers, no matter how powerful they get or how cleverly they are programmed.

About the lecturer: *Sofya received her undergraduate and graduate degrees in mathematics and computer science from MIT. She works in the areas of randomized and approximation algorithms and also data privacy. These areas are part of theoretical computer science. Before joining the faculty at Sigma, Sofya taught at Epsilon Camp and C.A.M.P. (Camp for Algorithmic and Mathematical Play). Her best memories of her childhood are from a math camp she attended in Belarus. As far as her hobbies go, recall that she works on privacy.*

The Engineering of Warfare
by ***Nestor Tkachenko***

This lecture will explore the evolution of modern weaponry, delving into the fascinating science and engineering behind some of the most consequential tools on the battlefield.

We will begin with a brief overview of the science behind nuclear weapons and how they shifted our perception of conflict and war. Then, we will move into an exploration of the physics and engineering involved with weapons seen on the battlefield today, such as Javelins, HiMARS, and bunker-busting bombs.

Finally, we will conclude by discussing what the future of warfare holds.

About the lecturer: *Nestor currently serves as CEO of rito.ai, a company using robotics and data automation to serve curated restaurant food in factories, offices, hospitals, and college campuses. While studying physics at Harvard University Nestor had the opportunity to work om the incubation and investment team at 8VC, a venture capital firm that has invested in top defense startups like Anduril, Saronic, and Epirus. After working in venture Nestor started his own company Rito.ai, and has since grown it to over $1M in revenue, serving top companies like Tesla, AMD, and Dell.*

Thursday, August 7

Cracking the Code of Autism: How Computers Helped Discover 4 Hidden Subtypes
by *Olga Troyanskaya*

What if autism isn't one condition, but four? In this talk, I'll take you inside our recent Nature Genetics study that made headlines worldwide. Using AI and data from thousands of kids, we discovered four biologically distinct subtypes of autism — each with unique patterns in behavior, development, and genetics. This could change everything: from how we diagnose autism to how we support children and families. Even more exciting? This approach could reshape how we understand any complex condition — from cancer to heart disease to mental health — by untangling their hidden complexity and paving the way for smarter, more personalized medicine.

About the lecturer: *Olga Troyanskaya is a professor of Computer Science and Genomics at Princeton University, where she also leads Princeton Precision Health, which uses AI to tackle big challenges in health and medicine, from autism to cancer. Her group builds AI approaches to decode the human genome and understand how genes and cells work together in health and disease. Olga is also Deputy Director at the Flatiron Institute of the Simons Foundation in New York. She's passionate about combining biology and computer science to unlock the secrets of life — and about mentoring the next generation of scientists.*

AI Without the Machine: Physical, Chemical, Evolutionary
by ***Alexei Tkachenko***

Long before neural networks were generating deepfake videos or writing passable essays for lazy students, they began as oversimplified physics-based models of brain cells. Today, AI is powered by massive data centers packed with billions of GPUs, consuming gigawatts of electricity — all to simulate something our brains do effortlessly and efficiently. So it's worth asking: do we really need digital computers for AI? In this talk, we'll explore a different approach: AI without the machine — systems that learn not through software, but through the physics and chemistry of the real world. I will talk about physical systems that can learn from past experiences; chemical reaction networks can be trained to recognize patterns and make decisions – just like a neural nets. How directed evolution can "teach" molecules to solve problems.

About the lecturer: *Alexei Tkachenko is a theoretical physicist at Brookhaven National Laboratory working on nanoscience and in the field called soft condensed matter. He studies problems that range from living matter (DNA, proteins, membranes) to nanoparticles, plastics and even sand.*

Big Numbers
by ***Scott Aaronson***

I'll offer a tour of what might be the biggest numbers you've ever seen, from iterated exponentials to the Ackermann sequence to the famous Busy Beaver or BB sequence — each one illustrating important points about the power of notational systems and models of computation. I'll tell you about recent progress that's determined the value of BB(5) and placed astronomical lower bounds on BB(6) — as well as a line of work, initiated by me and my former student Adam Yedidia, which has now shown that BB(643) can't be determined from the axioms of set theory. I'll speculate on whether BB(6) and BB(7) will ever be known by humans.

About the lecturer: *Scott Aaronson is a theoretical computer scientist at the University of Texas at Austin. He received his bachelors from Cornell and his PhD from UC Berkeley, and previously taught at MIT. He's spent most of his career studying the capabilities and limitations of quantum computers, although he also spent a two-year leave at OpenAI, working on theoretical foundations of AI safety. He's published a book, Quantum Computing Since Democritus, and also writes a popular blog. Attending a math camp when he was 15 was a transformative event in his life.*

The Science of Tradeoffs: Doing Economics with Everything
by *Ori Heffetz*

I'm an economist. Economists study the tradeoffs that people make. Because when resources are limited, we always have to give up something to be able to get something else. So how much are you willing to give up one thing – like time, or money, or health — to get another thing that you'd like to have — like going on a crazy adventure? We will talk about how economists estimate the tradeoffs that people are willing to make, which are called the "marginal rates of substitution" (MRS). We will use examples from everyday life, and discuss how economists use these estimates to put a price, or at least value, on everything, including on being happy and on being outside.

About the lecturer: *Ori Heffetz is a data-based economist, using lab and field surveys and experiments to study the psychological, social, and cultural aspects of economic behavior, well-being, and policy. Heffetz's work investigates what we can and cannot learn from economic and well-being indicators—household expenditures, the unemployment rate, or self-reported happiness—and how governments can use such data to guide policy. Heffetz is a Professor of Economics at Cornell University and Hebrew University of Jerusalem. He holds a BA in physics and philosophy from Tel Aviv University and a PhD in economics from Princeton University. In his spare time he likes to DJ and play soccer.*

Friday, August 8

Imaging the Invisible: How Radiology Sees What the Eye Cannot
by *Victoria Chernyak*

Are you curious about how doctors see inside the human body without making a cut? Join us for an interactive journey into the fascinating world of radiology—a medical specialty that blends cutting-edge technology, physics, and life-saving patient care. In this lecture, we will unravel the fascinating physics behind three cornerstone radiological modalities: computed tomography (CT), ultrasound, and magnetic resonance imaging (MRI). We will explore how CT uses X-ray attenuation to generate detailed cross-sectional images, how ultrasound harnesses high-frequency sound waves and their echoes to visualize soft tissues in real time, and how MRI leverages the magnetic properties of hydrogen nuclei and radiofrequency pulses to produce exquisite images of the body's internal structures.

Through real clinical cases, we will learn how radiology harnesses science and technology to enhance and guide patient care. Whether you're a budding doctor, engineer, or physicist, this lecture will challenge your mind, spark your curiosity, and open your eyes to a career path where science meets humanity.

About the lecturer: *Victoria Chernyak, MD, MS is a radiologist, clinician scientist and Professor of Radiology at Columbia University Irving Medical Center. She is an internationally recognized expert in imaging of liver cancer, and a member of senior editorial board of Radiology, the premier journal in the field.*

How to Count Colorings?
by *Pavel Etingof*

Suppose you want to color faces of a cube in two colors – red and blue. How many indistinguishable colorings (i.e., ones you cannot turn into each other by rotation) do you have? You may try the brute force approach — draw them all and then count, and if you are careful, you will succeed — there are 10. But what about three colors (red, blue and green)? Now this is pretty confusing, and if you are not extra careful, you are likely to make a mistake (the answer is 57). And if instead of a cube you have a dodecahedron, this becomes totally impossible — for three colors there are thousands of possibilities (the answer is 9099). The main challenge is to account for the symmetry — some colorings are very symmetric and others less so, which makes the process messy. Nevertheless, there is a technique, called Burnside's lemma, which allows you to count coloring precisely and efficiently without enumerating all possibilities (and you can do all the required calculations in your head!). Not surprisingly, this is based on a mathematical theory designed to study symmetry, called group theory. I will explain the basics of group theory, then derive Burnside's lemma, and then consider examples of its use, in particular obtaining the numbers 57 and 9099.

The lecture should be accessible to students familiar with a good background in high school algebra ((pre)calculus is not required).

About the lecturer: *Pavel Etingof is Professor of Mathematics in the Mathematics Department at MIT. Pavel received his Ph.D. in mathematics from Yale University. Pavel's research interests are noncommutative algebra, representation theory, and mathematical physics. Pavel led mathematics research programs for high school students at the Clay Mathematics Research Academy, the Research Science Institute (RSI), and SPUR at MIT. He co-founded MIT PRIMES program and has served as its Chief Research Advisor since 2010. Pavel's students have won multiple top awards at national science competitions for high school students. When Pavel isn't doing math, he enjoys mycology and can be found identifying, collecting, and cooking mushrooms for fun(gi).*

Herd Behavior
by ***Katrina Ligett***

Why do groups of people sometimes make such bad decisions, even when it seems like they should know better? Why do certain trends and ideas take off when others that seem basically as good never do? In this lecture we will learn about some of the mathematical models that can be used to study and explain herding behavior. Some of the key insights will be helpful in making sure that the committees you run will make less-stupid decisions.

About the lecturer: *Katrina Ligett is a Professor of Computer Science at the Hebrew University of Jerusalem. Her research interests center around data and people, including issues like privacy, fairness, and questions about making good use of data. She is originally from New Hampshire, did her undergraduate degree in Math and Computer Science at Brown University and did her PhD in Computer Science at Carnegie Mellon University. Katrina enjoys baking, cooking, gardening, singing, playing the violin, and running.*

The Physics of Perception: How Life Interacts with the Seen and the Unseen
by ***Polina Zavyalova***

What if you could see ultraviolet light, hear with echoes, or sense the Earth's magnetic field? Many animals do exactly that: experience the world in ways that are very different from our own. In this lecture, we'll explore how animals and insects sense their surroundings using sensory tools that extend far beyond human perception. These unusual abilities (like detecting electric fields, following magnetic cues, or sensing infrared light) aren't just fascinating quirks of biology; they're grounded in physics.

We'll look at how sensory organs interact with light, sound, molecules, and electromagnetic fields—how bats build 3D maps from sound waves, how snakes detect body heat, how sharks pick up tiny electric signals, and how birds navigate using Earth's magnetic field. We'll also consider why some sensory mechanisms are widespread in nature while others, like sensitivity to radio waves or X-rays, are not.

About the lecturer: *Polina is a PhD student in electrical and computer engineering at the University of Toronto. She received her BSc in Physics in 2019, which was also her first year at SigmaCamp. Her current research revolves around using ultrafast laser fabrication techniques to make compact astronomical instruments for detection of gases in exoplanet atmospheres. She is broadly interested in novel sensing and metrology applications. At SigmaCamp, she teaches the Optics semilab.*