

SIGMACAMP NEXT LECTURES

August 18-25, 2024

Lecture dates are subject to change

The Good the Bad and the Ugly: Mitochondria, Reactive Oxygen Species, and Aging

by *Alexander Galkin*

These three lectures will explore the relationship between oxygen, reactive oxygen species (ROS), mitochondria, immunity, and the aging process.

Monday, August 19: Good oxygen

Oxygen, a vital component of life, plays a key role in energy production in mitochondria through the process of oxidative phosphorylation. We will examine how food is metabolized to generate energy for cellular needs and oxygen's essential role in this process. Additionally, we will explore the fascinating interplay between oxygen's function as a crucial participant in mitochondrial activity and its role as a precursor to all Reactive Oxygen Species (ROS).

Tuesday, August 20: Bad ROS

We will define ROS and look for their various names, formation, and their role in cellular metabolism. Did you know that mitochondria, the powerhouse of the cell, are both a major source and target of ROS? We will also discuss the mechanism of oxidative damage by ROS and examine the systems that prevent excessive ROS generation in cells.

Wednesday, August 21: Ugly aging

We will examine the dual nature of ROS, highlighting their potential not only to cause oxidative damage but to participate in cell signaling and immune response. We will consider several examples of ROS biochemistry and discuss whether we should train our ROS-metabolizing systems. Finally, we will explore current research on interventions aimed at mitigating oxidative stress such as antioxidants and lifestyle changes, and their potential to promote longevity.

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.*



Mathemagics

by *Ricardo Teixeira*

Monday, August 19

In this engaging presentation, we will explore the intersection of advanced mathematics and magic. Discover how complex mathematical concepts can be illustrated through magic tricks, offering a unique perspective on both fields. We will show examples of how data transmission algorithms can be demonstrated through a lie-detection trick. Additionally, we will perform card tricks that exemplify mathematical structures and principles. Throughout the talk, we will present various other mathematical illusions, revealing some of their secrets while keeping a few magical mysteries.



About the lecturer: *Ricardo Teixeira is the Chair of the Department of Natural Sciences and Mathematics at the University of Houston-Victoria. With a PhD in Functional Analysis from the University of Texas at Austin, Dr. Teixeira has built a career exploring the intersection of mathematics and recreational activities. He has authored several scholarly articles and is particularly renowned for his award-winning book, Mathemagics: A Magical Journey through Advanced Mathematics. This innovative work explores the fascinating relationship between advanced mathematical concepts and magic tricks, revealing how mathematical principles can be used to enhance the art of illusion. Through his research and teaching, Dr. Teixeira continues to bridge the gap between complex mathematics and engaging, practical applications.*

Understanding Climate Change

by *Zohar Komargodski*

Monday, August 19 – Tuesday, August 20

Climate change is one of the greatest threats facing humanity. My goal is to clearly explain the fundamental concepts you need to understand this issue, including what we know, what remains uncertain, which policies are sensible, and which are not. We will discuss cutting edge ideas of how to fight climate change and we will discuss the main arguments of the climate skeptics.

About the lecturer: *I am a physics professor at the Simons Center for Geometry and Physics. I finished my Ph.D. in 2008, spent 5 years in Princeton, then 5 years at the Weizmann Institute and finally in 2018 I have moved to the Simons Center in Stony Brook, NY. My expertise is in theoretical particle physics and condensed matter.*



Introduction to Stochastic Processes: Definitions, Simulations, and Interesting Applications

by *Olga Korosteleva*

Tuesday, August 20

In this lecture, we will cover the fundamentals of Markov Chains, Random Walk, Poisson Process, Branching Process, and Brownian motions and its variants. Just enough theory and must-know facts will be given and the emphasis will be on super cool, practical applications. Prepare to be amazed!

About the lecturer: *Dr. Olga Korosteleva is a Statistics professor at California State University, Long Beach, where she has been teaching a wide range of math, statistics, probability, and stochastic processes courses for over 20 years. As a newcomer to SigmaCamp Next, she is excited to volunteer at the arts and crafts workshops for the first time.*



Infinity, and then some...

by *Paul Sherman*

Wednesday, August 21

What does infinity mean? Can one add, multiply or divide infinities? Philosophers, theologians, and scientists have pondered these questions for thousands of years. We'll discuss how mathematical set theory creates a self consistent model of infinities. From this theory there emerges a surprising ladder of infinities of increasing size.

About the lecturer: *I have always loved mathematics because it provides clear answers to questions (which makes Kurt Gödel my archnemesis). My favorite problems are simple to state but have solutions with deep mathematical connections, especially in the area of combinatorics. In graduate school at MIT, I studied gravitational lensing as a means of directly measuring Hubble's constant. I also researched combinatorial structures within representation theory. Later, I worked at a hedge fund, where we applied an evidence-based, scientific process to investing. Now, as President of the Polynera Fund, I help organizations like Sigma Camp grow and thrive. I'm currently studying Spanish and reinforcement learning, neither of which I'm very good at (yet).*



Nanobots: Directed assembly and applications of functional nanocapsules

by *Eugene Pinkhassik*

Wednesday, August 21

This lecture will give a personal account of the main research program in our laboratory, making nanoscale devices with unusual properties that address global challenges. You will hear three stories describing construction, properties, and applications of functional devices made with nanocapsules. The first story will describe the biologically inspired method for the creation of hollow nanocapsules that act as shells in nanobots. The second story will unravel unusual properties of these nanocapsules. Finally, the third story will highlight current and future applications enabled by superior properties of nanocapsules.



About the lecturer: *Eugene Pinkhassik graduated from Kazan University in Russia and obtained his PhD in Chemistry in the University of Chemistry and Technology in Prague, Czech Republic. After a visiting scientist stay in Parma, Italy and a postdoctoral fellowship at the University of Colorado, Boulder, he began an independent faculty career. He is currently an Associate Professor at the University of Connecticut. His research interests focus on making nanomaterials and nanodevices with new and superior properties to address current problems in energy-related technologies, medical imaging and treatment, and environmental sensing.*

How to Lose Friends and Deceive People

by *Krerley Oliveira*

Thursday, August 22: How to Lose Friends and Deceive People

You might have heard of Dale Carnegie’s bestseller “How to Win Friends and Influence People,” which has sold over 16 million copies. This lecture discusses the exact opposite: how to lose friends and deceive people, utilizing the concept of conditional probability. More specifically, we will take a brief tour through the notions of probability and conditional probability, demonstrating how easy it is to deceive (or be deceived) by seemingly balanced bets that are not. The presentation is inspired by Nicolau Saldana’s article in the Brazilian Mathematics Olympiad magazine (Eureka! Volume 1).



Friday, August 23: How Many Shuffles Does It Take to Properly Randomize a Deck?

There are people (magicians!) who can shuffle a deck a certain number of times and return it to its initial state. I cannot do this and challenge you to find out how it’s done. This lecture seeks to answer the exact opposite question: how many times must we shuffle a deck so that it becomes “satisfactorily random”? You may say fifteen shuffles, but three shuffles is good enough? And what about four?

Much of the lecture will explain what a riffle shuffle is and what “satisfactorily random” means. We will explore what a Markov chain is, how riffle shuffling can be modeled as a Markov chain, and how we can “measure” the distance from randomness. For the curious, the lecture will largely be based on Section 3.3 of the book “Introduction to Probability” by Grinstead and Snell.

Saturday, August 24: Monte Carlo Markov Chain and Applications

This lecture will discuss one of the most important algorithms of the 20th century: the Monte Carlo Markov Chain (MCMC) and some of its applications. Essentially, the MCMC algorithm uses Markov chain theory to conduct simulations with a very very large number of possibilities, substantially increasing the computational capabilities. This algorithm is widely used for simulations and executing tasks that were previously impossible, such as deciphering a letter written by criminals with access only to that letter.

About the lecturer: *Krerley Oliveira holds a BA, Master’s and PhD in Mathematics specializing in Dynamical Systems and Ergodic Theory. He was elected an affiliated member of the Brazilian Academy of Sciences, founded the graduate program on Mathematics at the Federal University of Alagoas and mentored numerous students. He also played a pivotal role in the Mathematics Olympiad Program in Alagoas, nurturing young mathematical talents since 2003. With a background from math competitions, including leading the Brazilian Team at the IMO 2017, Krerley’s expertise is widely recognized. Currently, they are spearheading research projects in Natural Language Processing and Computer Vision applied to justice, public purchases, analysis of medical records and the fight against corruption. These projects are sponsored by the Justice Court of Alagoas, TCE-SP and WHO. Outside the realm of mathematics and research, Krerley possesses a passion for triathlon. He has participated in 12 Ironman races and secured three drafts for the Brazilian national age group team at triathlon world championships.*

Fast Computing

by *Yuri Salkinder*

It is often necessary to ensure that your computations run as fast as possible. But how to achieve this? In our mini-course we will consider three aspects of it: selecting the right data structures, picking the right algorithms and even consider the hardware foundations and approaches.

Thursday, August 22: Hardware

In this lecture we will discuss various aspects of maximizing fast execution of your programs and even touch upon moving the solution to hardware.

Friday, August 23: Data Structures

In this lecture we will discuss importance of selection of appropriate data structures to represent the data in your software, and specifically how such choice affects the speed of the execution.

Saturday, August 24: Algorithms

In this lecture we will look at a few standard algorithms through the prism of their speed and will debate when it is appropriate to deviate from the comfort of standard algorithms and implement custom ones.

About the lecturer: *Yuri Salkinder's career spanned academia, telecommunications and financial technology. Yuri started in research in human-computer interaction, then moved on to help create software development tools for Voice response systems. He participated in creation of some standards in wireless messaging. Nowadays Yuri is dealing with technology that fuels financial markets. Yuri loves art, music, movies and good math puzzles. Yuri has been a member of the Sigma Camp staff since 2013 and is returning this summer.*



Hilbert's Grand Hotel Paradox and The Origin of Life

by *Mark Lukin*

Wednesday, August 21

The origin of life continues to be one of the most puzzling mysteries, and numerous theories have been suggested to explain it. In this lecture, I will introduce a novel hypothesis that has not yet been published. If this hypothesis proves to be accurate, it could imply that life is far more prevalent in the Universe than scientists currently believe.

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.*



Breast Cancer

by *Evguenia Alexandrova*

Friday, August 23

Breast cancer is the most common female cancer and the leading cause of cancer-related death in the women worldwide. Like many other cancers, breast cancer is not one disease but rather, has several molecular sub-types. We will discuss how the molecular mechanisms of different breast cancer sub-types affect the choice of treatment to make it more successful. Specifically, we will focus on hormonal therapy, “targeted” therapy, and chemotherapy. We will also touch upon other major cancer treatments: surgery, radiation, and immune therapy, and their pros and cons.



Saturday, August 24

Several factors make cancer a difficult-to-treat disease, such as the diversity of oncogenic mutations in individual patients, metastatic ability (= spreading to other organs), and the ability of cancer cells to evade therapy (= therapeutic resistance). Using HER2-positive breast cancer as an example, we will discuss how we study therapeutic resistance in the lab and find ways to overcome it and make cancer therapies more efficient.

About the lecturer: *I am originally from Vladimir, Russia. I graduated from Lomonosov Moscow State University (faculty of Biology) and received my PhD from Stony Brook University. My current lab at Stony Brook studies the molecular and cellular mechanisms of breast cancer and new therapies against it. We use a variety of in vitro techniques (=cells in Petri dishes), molecular and biochemical assays, and genetically engineered mice (my favorite :). In addition, we recently uncovered a novel mechanism of psoriasis, a chronic inflammatory skin condition. Outside the lab, I love spending time with my friends and family, traveling, camping, and playing volleyball.*