BE 500 – Fall 2024 - Introduction to Systems Immunology

Course Introduction: Welcome to BE 500, "Introduction to Systems Immunology," where we will cover immunology and data science topics. In this age of global health challenges, understanding the complexity of the human immune system and its responses to pathogens is crucial. Our journey will span the latest vaccine development, leveraging systems vaccinology and employing cutting-edge "OMICS" technologies and artificial intelligence (AI) to dissect and understand immunological data.

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Course Description: The BE500 Systems Immunology course offers an engaging, practical approach to bridging theory with real-world applications. Through active participation and critical questions like "Why are some individuals better protected than others?" you will deepen your understanding of systems immunology and its role in tackling infectious diseases. Whether you're focused on advancing vaccine innovation or expanding your immunological expertise, this course equips you with the knowledge and skills to make a meaningful impact on global health challenges.

Course Goals: This course is an introduction to the principles of Systems Immunology, with a particular emphasis on understanding how this knowledge applies to evaluating vaccines against infectious diseases. It will explore the integration of computational tools and immunological data to illuminate the complexities of the immune system and its role in health and disease. Rather than focusing intensively on data analysis, the course aims to familiarize students with the concepts and terminology central to systems immunology and systems vaccinology. The course will leverage current scientific literature to discuss novel approaches to studying and harnessing the immune system for better health outcomes.

Learning Outcomes: Upon completing this course, you will be able to:

1. Critically evaluate current research and methodologies in systems immunology.
2. Utilize AI software to perform exploratory immunological data analysis.

Prerequisites:

- An introductory course in immunology.
- An in-depth understanding of OMICS technologies and data analysis.
- An understanding of AI and other computational analysis concepts.

Major Assessments:

- **Journal Club Presentations:** Dive into recent scientific literature and present your analysis, focusing on how the findings contribute to Systems Immunology.
- **Participation:** Your contributions during discussions are vital. Sharing insights, asking questions, and engaging with presentations will enrich our learning community.

- **Practical Application Sessions:** Hands-on sessions with AI and computational tools will allow you to apply your knowledge to real immunological data sets directly.

Course Schedule:
- **Module 1: Immunology Fundamentals (Week 1)**
  Overview of immune system components, defense mechanisms, and vaccination basics.
- **Module 2: Systems Immunology – Theory & Methods (Weeks 2-3)**
  Introduction to systems-level approaches, AI, and computational tools in immunology.
- **Module 3: Applications in Infections & Vaccinology (Weeks 4-6)**
  Real-world applications of systems immunology in infections and vaccine development.
- **Module 4: AI in Immunological Analysis (Weeks 7-14)**
  Hands-on use of AI and machine learning to analyze immunological data and predict immune responses.

Resources:

- Course materials and additional readings will be available on GitHub:
  https://github.com/atomiclaboratory/systems_immunology_course_2024/tree/main
- Students must have access to a computer for software installation and practical sessions.

Target Audience:

- This course is designed for Master and PhD students in biomedical engineering, immunology, bioinformatics, or related fields.
- Participants should have a keen interest in the intersection of computational technology and immunological research.

Planned Lecture Schedule for Systems Immunology Course

Date	Day	Module Content
Week 1: Immunology 101: Fundamentals		
9/3/2024	Tuesday	**Exploring the Immune System: Defense Mechanisms, Disease, and Vaccination –** self-paced module
9/5/2024	Thursday	***Reflection and Knowledge Check***
Weeks 2-3: Human Systems Immunology & Vaccinology: Theory, Methodology & Prospects		
9/10/2024	Tuesday	**Human Immunology 2.0: Era of Systems Immunology** – *lecture by Dr. Tomic*
9/12/2024	Thursday	**Bridging Science and Practice in Human Systems Immunology** – *lecture by Dr. Tomic*
9/17/2024	Tuesday	***Collaborative Research Synthesis: Application of Systems Immunology Approaches in Real-world Examples****: self-paced module*
9/19/2024	Thursday	
Weeks 4-6: Systems Immunology in Action: Insights into Infections and Vaccinology		
9/24/2024	Tuesday	**Group 1: Predicting Vaccine Success: Systems Biology and the Yellow Fever Vaccine**
9/26/2024	Thursday	**Group 2: Decoding Influenza Vaccination: Systems Biology Insights**
10/1/2024	Tuesday	**Group 3: Understanding Personalized Medicine: How Sex Differences Shape Disease and Treatment Responses**
10/3/2024	Thursday	**Group 4: HIV-1 and Neutralizing Antibodies: A Battle for Control**
10/8/2024	Tuesday	**Group 5: Understanding Tuberculosis: Immune Factors Influencing Infection Outcomes**
10/10/2024	Thursday	**Group 6: COMBATing COVID-19 using Systems Immunology Approach**
Weeks 7-14: From Theory to Practice: AI in Immunological Cases		
10/15/2024	Tuesday	**SIMON says: Advancing Human Immunology using AI** – *lecture by Dr. Tomic*
10/17/2024	Thursday	***Preparation for AI-Driven Immunology****: video-guided and self-paced module*
10/22/2024	Tuesday	**Predicting immunological memory to newly emerging viruses: Practical introduction** – *lecture by Dr. Tomic*
10/24/2024	Thursday	
10/29/2024	Tuesday	
10/31/2024	Thursday	***Hands-On Practical Sessions: Applying AI in Immunology***
11/5/2024	Tuesday	
11/7/2024	Thursday	
11/12/2024	Tuesday	**Group 1 - Unsupervised ML approach: PCA** – *presentation*
11/14/2024	Thursday	**Group 2 - Unsupervised ML approach: tSNE** – *presentation*
11/19/2024	Tuesday	**Group 3 - Unsupervised ML approach: Correlation** – *presentation*
11/21/2024	Thursday	**Group 4 - Supervised ML approach: Naïve Bayes** – *presentation*
11/26/2024	Tuesday	**Group 5 - Supervised ML approach: Deep learning** – *presentation*
12/3/2024	Tuesday	**Group 6 – Supervised ML approach: autoML (SIMON)** – *presentation*
12/5/2024	Thursday	NextGen Immunology: Discussion & Wrap-up

Notes:

- Students are expected to complete the software installation before the hands-on sessions.
- This schedule is subject to change based on student needs and progress throughout the course.