

### **Sub-course 1: Advances in Natural Sciences**

Course title	[Code]	(Credits)	
Undergraduate students: Summer Program in English I		[23N3047]	(2)
Graduate students: Special Lectures in Humanities and Sciences I		[23S0151]	(2)

#### 1. Description

Research in natural sciences is advancing day by day. This sub-course provides lectures comprising four subjects to learn about recent advances in several areas of natural sciences: mathematics, physics, chemistry, biology, and computer science. Students can learn about each subject from basics to the latest topics through this sub-course.

#### 2. Teaching Day and Time

Day	Time	Lecturer	Topic/Contents	Place
On-demand video		Dr. Kazue KUDO	Orientation	Moodle
July 25 Tue	9:00am- 12:10pm	Dr. Hiromu MONAI	<ul style="list-style-type: none"> <li>● A brief history of brain science research and development of the tool of neuroscience</li> <li>● How to make your brain smarter</li> </ul>	Room A 2F, Plaza
July 26 Wed	1:30pm- 4:00pm(TBA)	Dr. Kazue KUDO	Field trip (National Museum of Nature and Science)	Ueno, Tokyo
July 27 Thu	9:00am- 12:10pm	Dr. Takanori KONO	<ul style="list-style-type: none"> <li>● Fundamental particles and diversity of nature</li> </ul>	Room A 2F, Plaza
July 31 Mon	9:00am- 12:10pm	Dr. Tsang Sin Yi	<ul style="list-style-type: none"> <li>● Group theory and its applications in check digit algorithms</li> </ul>	ditto
Aug 1&2 Tue	9:00am- 12:10pm	Dr. Mitsuhiro Miyazaki	<ul style="list-style-type: none"> <li>● Molecules, light, and colors. The quantum chemical foundations</li> </ul>	ditto
Aug 3 Thu	9:00am- 12:10pm	Dr. Nathanael Aubert-Kato	<ul style="list-style-type: none"> <li>● Molecular robotics: programming matter at the nano- and micro-scale</li> </ul>	ditto

3. Class Contents:

**Topic: A brief history of brain science research and development of the tool of neuroscience**

Dr. Hiromu MONAI

In this lecture, we will review the fundamental discoveries of the brain and how our understanding of the brain and mind has evolved. We will also explore the technological advancements developed to monitor brain activity, as the functioning of the living brain is not visible to the naked eye. Researchers have faced significant challenges in observing this "invisible brain function," but their curiosity and passion have led to recent breakthroughs in neuroscience.

**Topic: How to make your brain smarter**

Dr. Hiromu MONAI

Astrocytes are a kind of brain cell. We thought they were supporting cells for neurons for a long time, such as maintenance of the extracellular environment and energy supply to neurons. But now we know they are doing more than that. Our lab has developed a system to observe neuronal and astrocytic activities using calcium fluorescence imaging in living mice. When we electrically stimulate the brain with a weak direct current, calcium levels in astrocytes go up, making the transmission between neurons more efficient and enhancing the mice's sensory functions. But detectable neuronal activities didn't show any apparent changes during stimulations. Also, animals with more developed intelligence and cognitive functions, like cats or humans, have more astrocytes per neuron. That is why we think astrocytes are essential for brain functions.

**Topic: Fundamental particles and diversity of nature**

Dr. Takanori KONO

All materials in our surroundings are made of a combination of various atoms, the building blocks of matter. Furthermore, atoms consist of the atomic nuclei and electrons. There are around one hundred different kinds of stable atomic nuclei. The existence of these atomic nuclei are the origin of the diversity of molecules and various phenomena in nature. The study of the diversity of nature based on the atomic interaction and the quest for the constituents of nuclei are both important to deepen our understanding of nature. Particle-physics experiments involve manipulation and detection of tiny particles and collecting and analyzing a large amount of data. Many advanced technologies are used to realize such experiments. In this lecture, I will explain our current understanding of the origin of the atomic species, the fundamental particles and interactions which are responsible for it and the state-of-the-art particle-collision experiments.

**Topic: Group theory and its applications in check digit algorithms**

Dr. Tsang Sin Yi

A group is a set equipped with a binary operation and group theory is about the study of symmetries. In

this lecture, we shall give a very brief introduction to group theory, and then explore its applications in check digit algorithms. A check digit is a number (or letter) calculated based on an original character string and is used to detect human transcription errors incurred in the input process. We shall discuss a few algorithms which are based on basic group theory.

**Topic: Molecules, light, and colors. The quantum chemical foundations.**

Dr. Mitsuhiro Miyazaki

The appearance of a substance that we see originates from interaction between light and molecules composing the substance, and is finally recognized by our brain through neural action. To understand this phenomenon, it is required to know both molecules and light based on quantum chemistry. In this lecture, I would like to explain fundamentals of what is the color of matter and what happens to the energy of light, based on quantum chemistry of molecules and light.

**Topic: Molecular robotics: programming matter at the nano- and micro-scale**

Dr. Nathanael Aubert-Kato

Molecular robotics is an emerging research field that focuses on designing specific interactions at the molecular level. By mixing carefully created molecules, we can perform computation, actuation (movement) and structural assembly at the nano- and micro-scale. The lecture will give a brief overview of the field and of the methods used for designing those systems before covering the use of specific tools for designing molecular networks.

4. Evaluation

The final grade for the course will be determined by the evaluation of Reaction papers. Each participant must submit one paper per lecture, i.e., four papers in total.