3rd UK-Japan Frontiers of Science Symposium

November 7-10, 2019 in Chiba, Japan

List of Sessions

(Sessions in alphabetical order)

Anthropocene

Planning Group Members: Kate Hendry and Kei Yoshimura

INTRODUCTORY SPEAKER:
The Anthropocene in the Ocean
Paola Moffa-Sanchez, Durham University

SPEAKERS:
Human influence on global water cycle
Naota Hanasaki, National Institute for Environmental Studies

Deep sea impacts: out of sight, out of mind, still happening…
Michelle Taylor, University of Essex

Black Holes

Planning Group Members: Andreea Font and Keiko Kokeyama

INTRODUCTORY SPEAKER:
Black holes: from imagination to image
Ziri Younsi, University College London

SPEAKERS:
Gravitational-waves: black holes are LOUD!
Vivien Raymond, Cardiff University

First Ever Image of a Black Hole
Fumie Tazaki, National Astronomical Observatory of Japan

Computational Brain Modeling and Brain-computer Interfaces

Planning Group Members: Liz Tunbridge, Junichi Ushiba

INTRODUCTORY SPEAKER:
Brain, Computational Brain Modeling, Brain-Computer Interfaces, and the Integration of them
Kazuhisa Shibata, RIKEN Center for Brain Science

SPEAKERS:
Closed-loop neural interfaces
Andrew Jackson, Newcastle University

Brain-machine interface to reconstruct and modulate neural function
Takufumi Yanagisawa, Osaka University

Signal from Noise

Planning Group Members: Julia Gog and Shinjiro Umezu

INTRODUCTORY SPEAKER:
Signal from noise: making the most of the data we have
Tim Rogers, University of Bath

SPEAKERS:
New knowledge from old signals
Jenny Venton, National Physical Laboratory

Microbiome shift for colorectal cancer progession
Takuji Yamada, Tokyo Institute of Technology

Smart Material

Planning Group Members: Akihito Ishizaki and Paul Lusby

INTRODUCTORY SPEAKER:
Structure and Dynamics in Soft Active Matter: Towards Smart Material
Yusuke T. Maeda, Kyushu University

SPEAKERS:
Tuning properties and functionality in modulated self-assembly of metal-organic frameworks
Ross Forgan, University of Glasgow

Bio-inspired Self-Healing Materials: Damage and Autonomous recovery
Toshio Osada, National Institute for Materials Science

Synthetic Biology

Planning Group Members: Ichiro Hiratani and Yulia Yuzenkova

INTRODUCTORY SPEAKER:
Challenges toward creating man-made cells
Yutetsu Kuruma, Japan Agency for Marine-Earth Science and Technology

SPEAKERS:
A toolkit for manufacturing an artificial cell, from scratch: microfluidics, membrane design, and biomolecular engineering
Yuval Elani, Imperial College London

Construction of evolvable artificial cell from scratch
Kensuke Kurihara, National Institutes of Natural Sciences

The Anthropocene in the Ocean

Paola Moffa-Sanchez, Durham University

Humans have influenced the climate since early times through the development of agriculture, colonization of new territories, production and release of new materials ad products. However, the burning of fossil fuels has increased the atmospheric levels of greenhouse gases such as CO2 to levels outside the natural range for the past 3 million years. The release of greenhouse gasses into the atmosphere has affected the Earth´s radiative balance by reducing the outgoing infrared radiation from the atmosphere and consequently warming the planet.

The ocean covers 73% of the Earth's surface and its sheer volume and properties such as the ability to store and distribute heat, nutrients and gasses makes it an important player in the climate system. As a result of the recent warming, the oceans have increased their temperatures and the dissolved CO2 has turned the waters more acidic, both factors severely affecting the marine life. The Earth´s warming has also melted the ice caps and reduced the sea-ice extent, which has not only increased the sea level but also the flux of freshwater reaching the ocean. In addition, the changes in the key physical properties that govern the ocean's vertical circulation such as temperature and salinity have increased the stratification of the upper layers of the ocean and are predicted to reduce the overturning circulation. Yet, coherent evidence for the timing and the mechanisms of changes in the vertical ocean circulation is still debated and it remains to be the focus of much of the oceanographic research. In this talk, I will review our knowledge to date on the natural variability of the ocean's circulation and its response to anthropogenic changes.

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Human influence on global water cycle

Naota Hanasaki, National Institute for Environmental Studies

As of today, more than seven billion people are living in the world. Human activities have a great influence on the earth system. The most prominent examples are the change of the climate system due to energy use, and the change of land cover accompanied by the destruction of ecosystem mainly due to agriculture, livestock, and forestry industries, but the change of the water cycle system is also remarkable. In this lecture, the latest knowledge about human influence on global water cycle will be introduced.

The world's land receives 110,000 km^3 of precipitation annually. It turns into 70,000 km^3 of evapotranspiration and 40,000 km^3 of runoff (including groundwater flow). The latter is potential water resources of humanity. The annual total water withdrawal in the world is estimated at 4000 km^3. Because runoff and water withdrawal are unevenly distributed in space and time, it brings deficit and excess in water resources in specific locations and periods. To control them, water infrastructures have been built all over the world which enhances the human influence on global water cycle.

The lecture overviews the present situation of human water use particularly irrigation, manmade reservoirs, groundwater pumping, aqueduct, desalination, and others. These effects are not well monitored globally due to the difficulties in measuring water flows and stocks. Modeling is one promising approach to investigate the effects. Some latest achievements of global hydrological modeling are presented which quantifies the human influence on global water cycle.

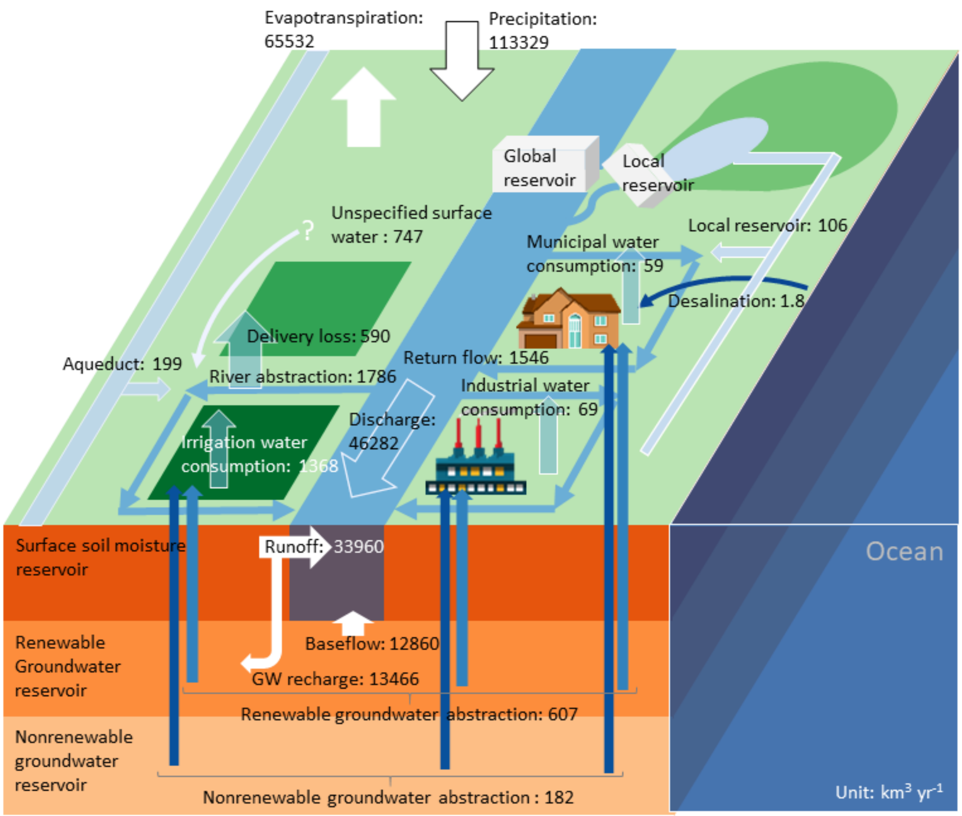

Figure Schematic diagram of the H08 global water resources model. Numbers show the estimated annual mean water flow of each component (unit: km^3 year^{-1}).

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World Resources Institute: Aquedcut https://www.wri.org/aqueduct

Deep sea impacts: out of sight, out of mind, still happening…

Michelle Taylor, University of Essex

As the first line of virtually all deep-sea papers states, the deep-sea is the largest habitat for life on the planet. This vast realm contains almost 90% of space for life available on Earth. Seemingly very far from our everyday lives the deep-sea is often considered buffered against environmental change and unfortunately that is not true. The deep-sea is impacted by changes in global temperatures, and by climate change impacts such as ocean acidification. I will present an overview of these global impacts in a deep-sea context and then focus in on the world's fastest changing region, the Southern Ocean; showing some of the research I undertook on a recent expedition to the Weddell Sea.

References

Extra reading:

Weddell Sea Expedition website: https://weddellseaexpedition.org

Short video of Weddell Sea trip: https://www.facebook.com/watch/?v=2328347120821410

Relevant papers:

Levin, LA, Le Bris N. 2015. The deep ocean under climate change. Science. 350:766-768.

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Black holes: from imagination to image

Ziri Younsi, University College London

Black holes are some of the simplest and yet most enigmatic objects in the known Universe. With gravitational fields so powerful that nothing, not even light can escape, they possess an event horizon. For many decades observational evidence for their existence, whilst compelling, has been indirect. The recent detection in 2015 of gravitational waves provided key theoretical evidence for their existence, as well as important validation of Einstein's theory of general relativity. The first image of a black hole in April this year may now have provided the first direct experimental evidence for their existence.

I will begin by introducing our current theoretical and observational understanding of astrophysical black holes. With the detection of gravitational waves from merging black holes, and now the first direct images of a supermassive black hole, we are beginning to probe the behaviour of matter and radiation in the most extreme environments in our Universe. Black holes provide a unique laboratory to study physics in extreme gravity environments and their study could even lead to a deeper understanding of the geometry of the Universe (Einstein's spacetime).

After discussing the central importance of black holes in modern physics, I will explain how the first image of a black hole from the Event Horizon Telescope collaboration was produced. By comparing calculations of the propagation of light and matter around black holes with these recent measurements, I will then discuss what we have recently discovered about the physical properties of black holes and their immediate environment, the current theoretical and observational challenges and questions that we face, and the frontier research and developments that are already underway to answer these outstanding questions.

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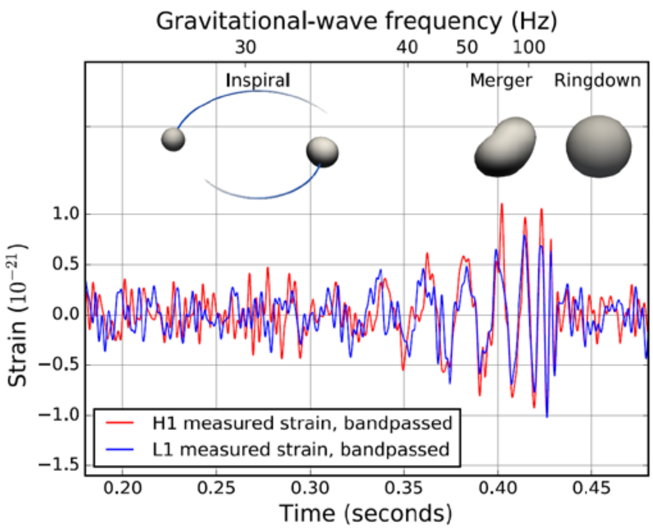
Gravitational-waves: black holes are LOUD!

Vivien Raymond, Cardiff University

On September 14th, 2015 the LIGO-Virgo collaboration made the first direct detection of gravitational waves, nearly one hundred years after Einstein first predicted them. This is widely accepted as one of the biggest breakthroughs of the century, and lead to the 2017 Nobel prize in physics. Since, several more gravitational waves have been detected by the LIGO and Virgo observatories. They are perturbations in the curvature of spacetime propagating as waves at the speed of light. Generated by accelerated masses, they are strongest for densest sources, and with them we have been able to study new black holes and analyse the collision of two neutron stars. Gravitational-wave observations provide a fundamentally different lens to study our universe, and access to invisible phenomena. But this new medium comes with unique difficulties that we are only starting to tackle in the growing network of gravitational wave observatories.

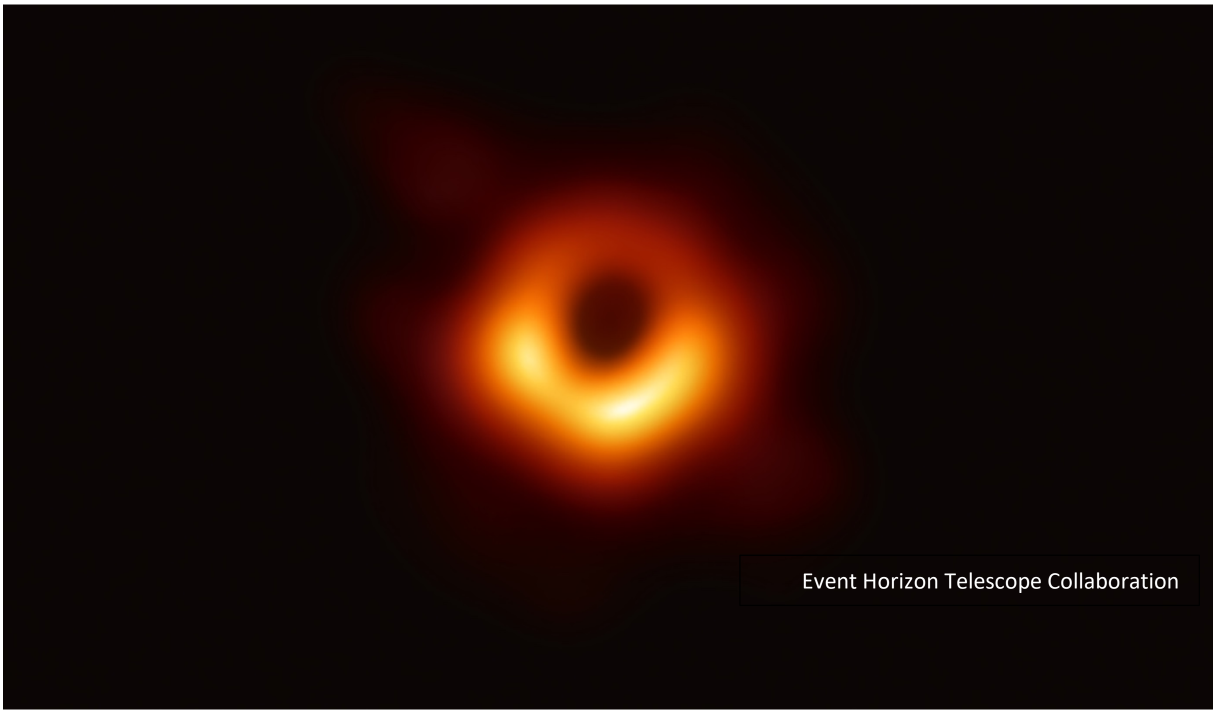
In this talk, I'll give an overview of observational gravitational-wave astronomy: the instruments designs and operations, detection techniques and analysis methods. I will present the most recent results on the searches for binary black hole and binary neutron star mergers as well as searches for other, and potentially unknown, classes of gravitational wave events. Covering the research areas of experimental gravity, data analysis, astrophysical inference and signal modelling, I will present the biggest challenges for this new and interdisciplinary field of astronomy.

GW150914 in the H1 and L1 LIGO detectors



First Ever Image of a Black Hole

Fumie Tazaki, National Astronomical Observatory of Japan



In 10th April 2019, the first image of a supermassive black hole (see the figure above) was released through a series of six papers [1]-[6]. The black hole resides at the center of Messier 87 (M87), a massive galaxy in the nearby Virgo galaxy cluster, which is 55 million light-years away from the Earth. We detected an asymmetric bright emission ring with the central dark shadow caused by gravitational light bending and photon capture at the event horizon.

To achieve this, we have assembled the Event Horizon Telescope (EHT), a global very long baseline interferometry (VLBI) array at a wavelength of 1.3 mm. EHT consists of eight ground-based radio telescopes in Hawaii, Chile, Spain, Mexico, Arizona, and South Pole, which is the result of years of international collaboration. We confirmed that the ring diameter and width are stable over four different observations carried out in 5th, 6th, 10th, and 11th April 2017, even if we use different calibration and imaging schemes. The obtained image is consistent with the shadow of a black hole with a mass of 6.5 billion times that of the Sun as predicted by general relativity. The asymmetric ring can be explained by a rotating plasma around the black hole with a relativistic velocity.

Imaging a black hole became a new tool to explore gravity in its most extreme limit. The image shows the advent of a new age of astrophysics to study the active and dynamic phenomenon around a black hole.

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Brain, Computational Brain Modeling, Brain-Computer Interfaces, and the Integration of them

Kazuhisa Shibata, RIKEN Center for Brain Science

Neuroscience has aimed at elucidating the mechanisms of the brain in the hope of understanding of what humans are and developments of clinical tools to compensate for malfunctions of the brain. There are two recent technological innovations that made significant advances in neuroscience: computational brain modeling and brain-computer interfaces (BCI). This introductory talk will describe how computational brain modeling and BCI have contributed to basic and translational neuroscience and discuss the possible impacts of the integration of these technologies on an individual and our society in the future.

Computational brain modeling is a mathematical framework to describe the principles of information processing in the brain that underlie our cognition and behavior (Figure 1) [1]. This framework helps neuroscientists to understand how the brain achieves perceptual, motor, and higher-order functions and to develop methods to predict one's cognition and behavior. The framework has also contributed to clarify what information processing of the brain is altered in patients with psychiatric disorders [2].

BCI enables to control computers and robots based on information read out from the brain and to directly send information of the external world into the brain without biological sensors such as eyes and ears. BCI has been used to develop new clinical tools that make it possible for paralyzed patients to control a robot arm (Figure 2) [3] and for eye-damaged patients to see [4]. BCI has also helped neuroscientists to clarify whether a certain area of the brain can be a cause of specific behavioral and cognitive functions [5].

Neuroscientists and brain-tech companies are now beginning to combine computational brain modeling and BCI into a unified system. This unified system will likely lead to brain-machine hybrids and significant augmentation of human abilities, which in turn shake up our current concepts of a human being and society.

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Glossary

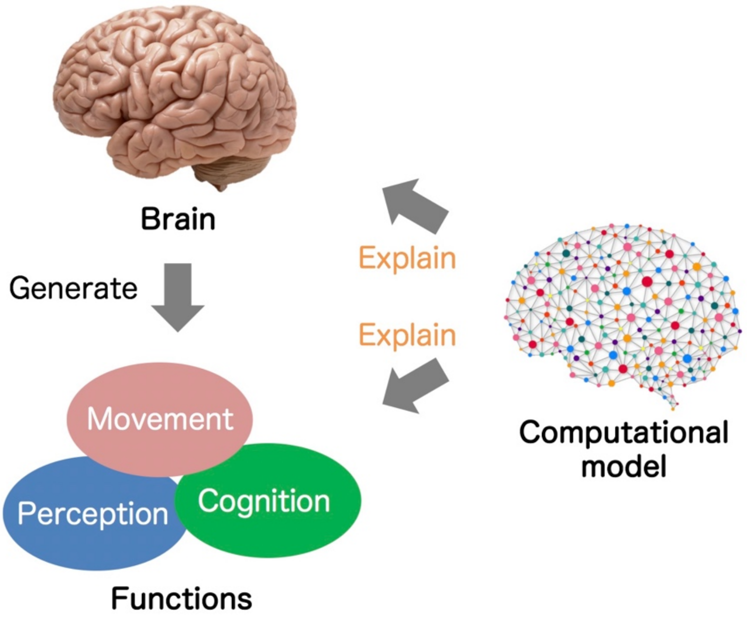

Figure 1. Computational brain modeling.

Figure 2. Human BCI to control a robot hand.

Closed-loop neural interfaces

Andrew Jackson, Newcastle University

Brain disorders present a major challenge for 21st century medical innovation. Recent decades have seen considerable advances in technologies that interact directly with the nervous system, from implantable neurostimulators to Brain-Machine Interfaces for neural control of computers and robots. By combining recording and stimulation capabilities, a new generation of 'closed-loop' interfaces now use brain activity for real-time control of stimulation, thereby allowing us to replace, modify or augment the interconnected networks of neurons in the brain with electronic circuitry. In this talk, I will discuss various therapeutic applications for such devices, including neural prosthetics to replace lost functions, the manipulation of neuroplasticity to restore brain circuits damaged by injury or disease, and closed-loop control of the abnormal network dynamics that underlie many neurological conditions. I will discuss some of the technical challenges involved in establishing bidirectional communication between brains and electronics, as well as new methods such as optogenetics that are revolutionising the precision with which we can manipulate neural circuits. I will argue that the promise of restoring and even enhancing neurological function neural interfaces requires an interdisciplinary effort including neuroscientists, technologists and clinicians, and poses important ethical questions about the extent to which we can and should re-engineer our brains.

Brain-machine interface to reconstruct and modulate neural function

Takufumi Yanagisawa, Osaka University

Brain-machine interface (BMI) is a technology to be applied for severely paralysed patients to reconstruct their motor functions (Figure 1). We have developed the BMI using electrocorticographic (ECoG) signals, which are recorded by electrodes implanted on brain surfaces[1]. Our previous study demonstrated that a severely paralysed patient with amyotrophic lateral sclerosis (ALS) could control a robotic hand and typing software by the BMI using ECoG signals of the sensorimotor cortex[2].

However, it has not been unveiled how the BMI affects the brain activities and human cognition. We have investigated how phantom limb pain is affected by the use of BMI through the neural plasticity. Here, the phantom limb pain is a neuropathic pain after an amputation of a limb and partial or complete deafferentation. The underlying cause of this pain has been attributed to maladaptive plasticity of the sensorimotor cortex after the deafferentation. Therefore, we hypothesized that the reconstruction of the motor function using BMI normalizes the sensorimotor activity to reduce pain. Here, we have developed a BMI based on magnetoencephalography (MEG) signals to control a robotic hand (Figure 2). The training to use the BMI succeeded in enhancing the sensorimotor representation of phantom hand movements. However, the pain significantly increased in accordance with the enhanced representation[3]. On the other hand, the pain decreased by the BMI training to diminish the representation. Contrary to the naïve hypothesis, the simple motor reconstruction by the BMI was suggested to worsen the phantom limb pain. In this talk, I will discuss how to apply the BMI in clinical purposes.

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3. Yanagisawa, T., et al., *Induced sensorimotor brain plasticity controls pain in phantom limb patients.* Nat Commun, 2016. 7: p. 13209.

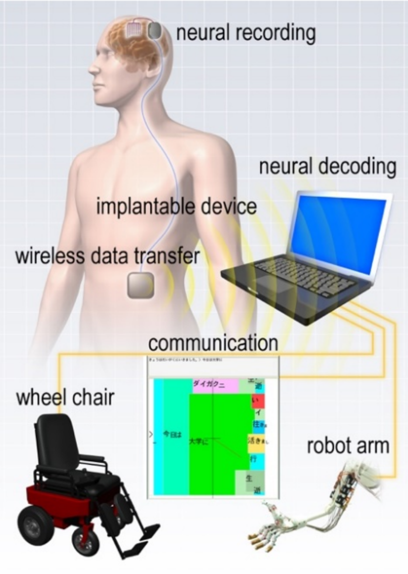


Figure 1: Brain-machine interface using implantable devices
BMI works by first recording neural activity and then converting the recorded activity into the controls of a machine, such as a robotic hand or computer.

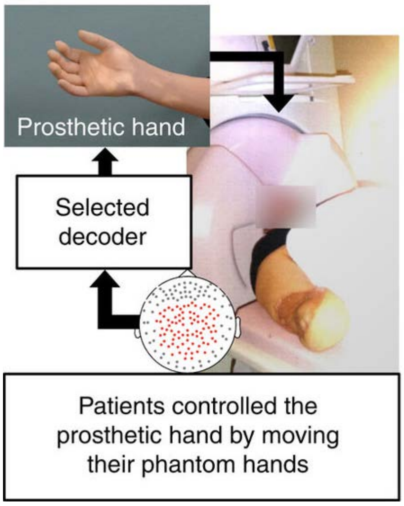


Figure 2: BMI training for patients with phantom limb pain
Patients in the MEG scanner were instructed to control the robotic hand, which moved based on sensorimotor cortical activities by moving the phantom hands.

Signal from noise: making the most of the data we have

Tim Rogers, University of Bath

For centuries, applied mathematicians have drawn their inspiration from the experimental sciences and the needs of industry. Historically, the main objects of study have been differential equations, and a powerful body of theory has been developed. However, with the massive recent growth in data-gathering and processing capabilities of science and industry, applied mathematicians are being forced to move rapidly away from their historical comfort zone. Real-world data exhibit noise and uncertainty coming from various sources, which must be correctly incorporated into mathematical models, if those models are to have predictive power. In this talk I will review three key – and structurally different – sources of randomness relevant to modern applied mathematics. These are: uncertain environmental conditions; demographic noise arising from the discreteness of elements in a model; sampling noise from data-gathering processes. In each case I will describe current developments and some puzzling challenges in the growing field of statistical applied mathematics.

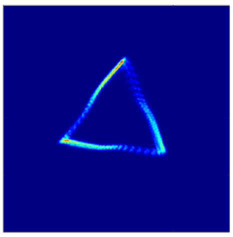
New knowledge from old signals

Jenny Venton, National Physical Laboratory

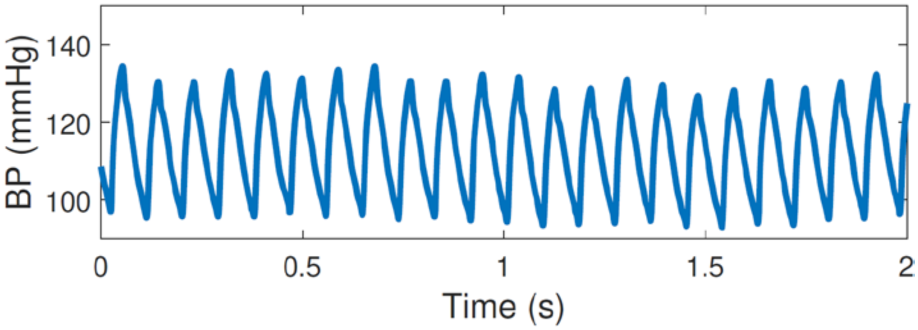
Physiological signals such as ECG, PPG and blood pressure are collected in hospitals around the world every day, generating vast amounts of data. Extracting information from this data allows us to learn more about the state of a patient's cardiovascular system. The method we use to analyse and extract this information determines how useful it is. Are we really making the most of this data?

Conventional methods of analysing physiological waveform signals often involve identifying single points on these complex waveforms – this means that much of the original signal data is discarded.

Symmetric Projection Attractor Reconstruction (SPAR) is a new approach to extracting information from a physiological signal.1,2 SPAR analysis uses the original signal data in its entirety and visualises it in a new way: this new visualisation is known as an attractor (Figure 1). As the attractor contains the original data in its entirety, we can measure features of the attractor to gain more nuanced information about a patient's cardiovascular system.



(a)



(b)

Figure 1. (a) An example of a blood pressure attractor, generated by applying the SPAR method to (b) blood pressure data.

Applying the SPAR method to a variety of datasets has allowed us to explore how the attractor can contribute to a more thorough analysis of physiological signals. Using machine learning methods on features extracted from the attractor allows signals to be classified, which offers the potential for a decision support tool for doctors and has deeper implications for the future of hospital data analysis.

Website:
http://ehealth.kcl.ac.uk/cardiomorph/

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Microbiome shift for colorectal cancer progession

Takuji Yamada, Tokyo Institute of Technology

More than 100 trillion bacteria from thousand species are coexisting in the human intestinal tract [1]. These bacteria are forming a community structure referred to as human intestinal microbiota, and are making a complex ecosystem. Development of new analytical methods including the metagenomic analysis enables us a direct gene sequencing of these microorganisms. This has resulted in a great advance in human intestinal environmental research. These methods have been applied to various diseases such as obesity, diabetes, inflammatory bowel disease, and several types of cancer [2]. We focus on colon cancer. In order to clarify how human intestinal microbiota are related to the mechanism of cancer onset we perform a large-scale epidemiological cohort study on colon cancer patients. In addition to metagenomic data of human intestinal environment, we are collecting metabolome data, lifestyle data, dietary habits and endoscopic findings. Here we introduce our attempts to find microorganisms, metabolites, and metabolic pathways of the microorganisms, which are related to colon cancer onset[3].

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Structure and Dynamics in Soft Active Matter: Towards Smart Material

Yusuke T. Maeda, Kyushu University

“There’s plenty of room at the bottom (R.P. Feynman, 1959)” inspired one of the challenges of the century: engineering complex systems to the microscopic level as small as molecular level[1]. When it comes to downsize, mimicking nature has always proven to be a good bet. Biological materials inside living cells are incredible machines that control autonomous motion, shape deformation, self-organization and self-replication. The understanding of such ordered structure and dynamics of soft and active matter is essential for the bottom-up building of miniaturized smart material. Here, we outline recent developments and challenges in progress from physics, chemistry, and biological disciplines.

A well-known phenomenon that controls the movement of molecules is transport, which induces the movement of molecules by providing a gradient of external field such as temperature and solute concentration[2]. The gradients of surface charge and surface tension drives the directed motion of soft matter and then leads intense accumulation of transported solute. The interplay of counter-acting transport motions induces size-dependent selection of folded species[3], indicating that transport phenomena are promising means to control microscopic system. Furthermore, new class of soft matter that generates a gradient of force and then moves autonomously thanks to self-propelled transport, called active matter, has attracted much attention in recent years[3]. Physical universality behind their structure and rich dynamics will bring novel insights in bio-inspired smart material.

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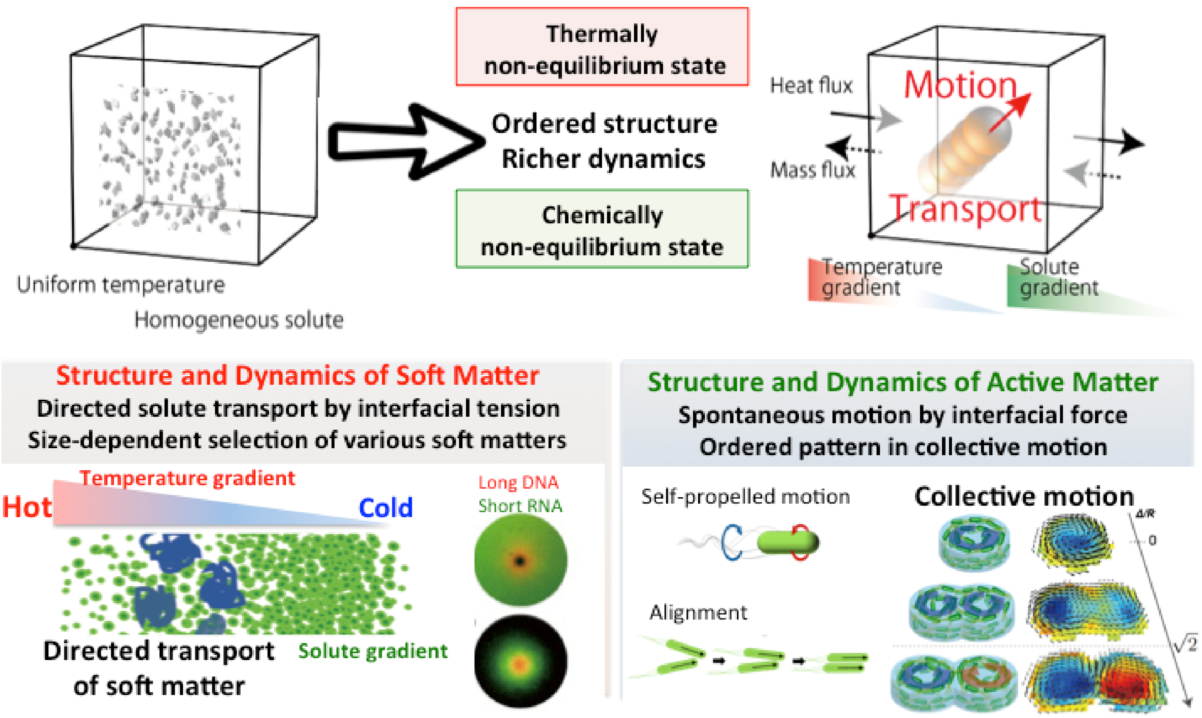

Figure 1: The concept of soft and active matter out of equilibrium (Top). Motion or transport, structural formation that is absent at equilibrium occur at non-equilibrium state under temperature and concentration gradients. Ordered structure of soft matter (bottom left) and collective dynamics of active matter (bottom right) lead to the understanding of design principle for realizing various smart materials.

Glossary

Soft Matter【ソフトマター】:

Soft materials such as a deformable molecule of a gel or a polymer, complex fluid in which fine particles such as colloidal particles are dispersed in aqueous liquid, or a group of substances having a complex composition such as liquid crystals and glasses. 液晶やゲル、高分子、細胞などの軟らかで機能的な物質群を指す用語

Transport phenomena【輸送現象】:

Physical effect as seen in transport of electrons, ions, atoms and molecules under a gradient of potential field. Potential field is not limited to temperature alone, most characterized transport is driven by electric field gradient. This effect is widely used for analysis of molecular size in chemistry and biology laboratories.
温度勾配や電位勾配のもとで分子やイオン等が輸送される物理現象をさす用語

Active Matter【アクティブマター】:

Active matter is a class of materials that move autonomously by consuming energy. The motor protein that moves spontaneously, living cells and bacteria, insects and animals even if the scale is greatly different are classified into active matter. 自発的に動くとともに群れなどの特徴的な構造をうむ物質群を指す用語

Tuning properties and functionality in modulated self-assembly of metal-organic frameworks

Ross Forgan, University of Glasgow

Metal-organic frameworks (MOFs) are materials where metal ions, or clusters of metal ions, are connected by organic molecules into regular, ordered network structures with porosity on the nanoscale. As a consequence of their grid-like internal structures, they contain ordered arrays of pores around 0.5-5 nm in diameter, in which molecules can be stored, sensed, or catalytically transformed; they can be thought of as crystalline sponges. Typical applications include gas storage, small molecule sensing, heterogeneous catalysis, and nanoscale drug delivery. As synthesis of these materials is effectively a crystallisation process, physical properties such as particle size, shape, surface chemistry, porosity, defects and even overall structure can often be difficult to control. We will describe our efforts to enhance and control the synthesis of MOFs through modulated self-assembly – addition of crystallisation promoters or subtle modifications to the ingredients of synthesis – in the context of reaction kinetics, i.e., how can we control the rate of nucleation and crystallisation, and how does this affect the identity and quality of the material formed? By accessing large single crystals of MOFs using these techniques, we will explain how we can probe their pressure resistance and chemical stability at the atomic level using complementary and concurrent crystallographic and spectroscopic techniques, which has implications on their application as fluorescent sensors. We will also show how surface-functionalised MOF nanoparticles are highly promising agents to deliver drug molecules into cells with great enhancements in cancer cell targeting, treatment efficacy, and selectivity.

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Bio-inspired Self-Healing Materials: Damage and Autonomous recovery

Toshio Osada, National Institute for Materials Science

Human bone are long lived and highly reliable, albeit brittle components. The reliability is attributed not only to reinforcing hieratical structures but also self-healing ability consist of inflammation, repair and remodeling stages, leading to autonomous full recovery from injuries[1]. Recently, there have been many attempts to imitate bone healing into man-made materials, such as polymers[2], concrete[3] and ceramics[4]. Learning from strategies of nature that confer to self-healing may extend application of structural materials. Especially, self-healing will be a key for brittle ceramics used as high-temperature components such as turbine blades in aircraft engines. Here, we show a new approach for a self-healing design containing a 3D network of a healing activator, based on insight gained by clarifying the healing mechanism in ceramics by oxidation of a pre-incorporated healing agent [4]. We demonstrate that addition of a small amount of an activator, typically doped MnO localised on the fracture path, selected by appropriate thermodynamic calculation significantly accelerates healing by >6,000 times and significantly lowers the required reaction temperature. As a result, the approach enables the ceramic to fully heal cracks in as little as 1 minute at 1,000oC. The activator on the fracture path exhibits rapid fracture-gap filling by generation of mobile supercooled melts (repair stage), thus enabling efficient oxygen delivery to the healing agent. Furthermore, the activator promotes crystallisation of the melts and forms a mechanically strong healing oxide (remodelling stage). Design learning from nature can be applied to develop new lightweight, self-healing ceramics. The bone-healing inspired ceramics show potential as an aircraft engine materials capable of crack healing during flight.

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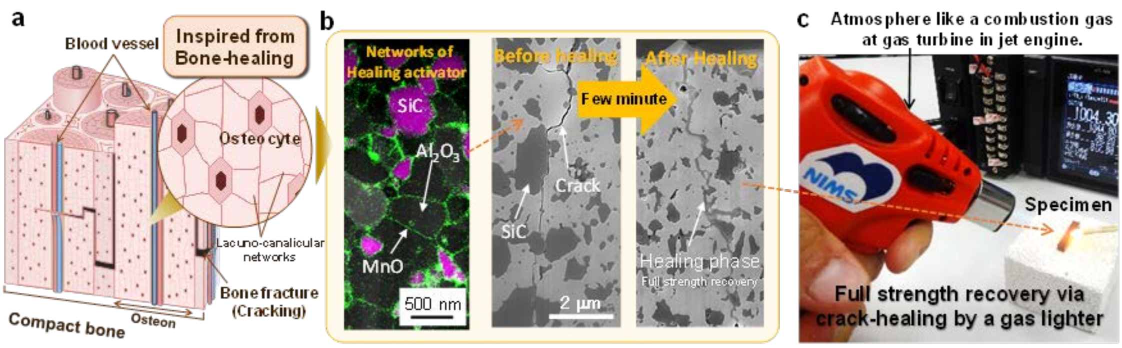

Figure1 Novel design approach for self-healing ceramics with 3D networks of healing activator. (a) Compact bone with networks of blood vessel and lacuna-canaliculi. (b) Images of 3D networks of healing activator (MnO), microstructure of crack before and after healing. (c) Full strength recovery and crack-healing in combustion gas of a gas lighter.

Challenges toward creating man-made cells

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All the terrestrial lives are made up of cells. Cells are the smallest units of life, while cellular components are substances, not life. This simple fact implies that it is possible to constitute a living cell by combing molecules. Since the last century, molecular biology has focused on understanding the molecular mechanisms of life. After the turn of the century, however, more constructive approaches that aim to build and design life systems have been taken.[1] Such research would not only lead to the emergence of novel biotechnologies of immediate industrial use but also expand research interests in early-life-forms that might have existed in early Earth era.

By artificially creating a cell, we can define the minimal set of functions and genes that sustain life phenomena. In particular, membrane vesicles, which consist of lipids, are an important component as outer envelopes of cells. Recent studies are attempting to reproduce various cellular functions (Figure 1), such as protein synthesis,[2] energy production,[3] and even Darwinian evolution[4] inside vesicle compartments. In addition, attempts to artificially reproduce vesicle growth and division have also been performed.[5] However, there is still a lack of tools available and their technological development should accelerate the construction of artificial cells.[6]

What molecules and what conditions are required for the reconstruction of a living cell? When we can practically answer this question, we may be able to take a step closer to addressing the big question of the origin of life.

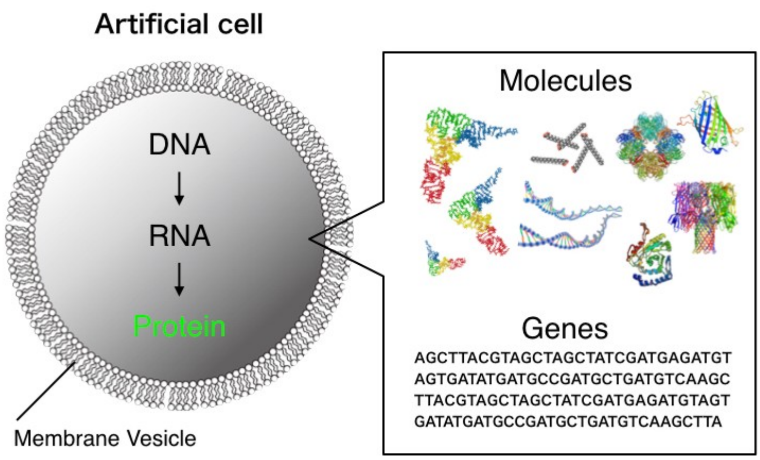

Figure 1. A schematic of an artificial cell.

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Glossary

Vesicle:【膜小胞】

A capsule-like structure made of lipids.

Artificial cell:【人工細胞】

A man-made cell that mimics one or many functions of a living biological cell, often with a combination of multiple molecules enclosed inside a vesicle.

Protein synthesis:【タンパク質合成】

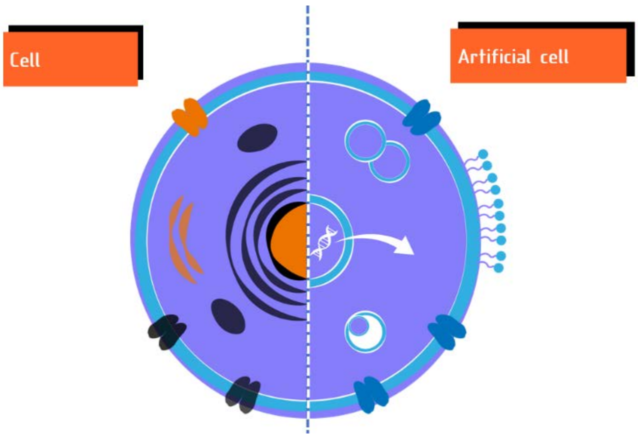
A fundamental biochemical process of cells that produce proteins based on genetic information on DNA.

A toolkit for manufacturing an artificial cell, from scratch: microfluidics, membrane design, and biomolecular engineering

Yuval Elani, Imperial College London

Artificial cells are structures that are constructed from the bottom-up using both synthetic and biological components, which resemble biological cells in form and function. They are used both as simplified cell models, and as smart micro-machines with a range of potential applications in industrial and clinical biotechnology. However, there are a lack of tools available for the construction of artificial cells that allow biomimetic architectures and behaviours can be dialled in a controlled and reproducible fashion. This means that the capabilities of artificial cells cannot match their biological counterparts.

In this talk, I will present some of our efforts to combat this. We have developed a toolkit for the construction of artificial cells of defined size, content, compartmentalisation, and connectivity. These are based on microfluidic, optical tweezer, and novel membrane generation technologies. We are now moving towards mimicking biological behaviours that can be considered the hallmarks of life (sense/response, communication, motility, metabolism, signalling, symbiosis etc.)



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Construction of evolvable artificial cell from scratch

Kensuke Kurihara, National Institutes of Natural Sciences

Recent technologies such as genome synthesis and genome editing have enabled the redesign of genomes, which has become one of the mainstream approaches to understand what life is. On the other hand, some researchers have put forward creating artificial cells to explore the boundary between living and non-living matters by bottom-up approaches.[1] Since this strategy does not segmentalize or re-edit biological systems but aims to create an entire system from scratch, one can explore the essence of 'living' cells.

A living cell requires machineries that help transmit the genetic information to the descendant cells and a compartment that can separate an individual cell from the surrounding environment. Therefore, a cell model must have at least two replication systems: a system for replicating information materials and a system for reproducing compartment molecules. During the past decade, these two replication systems have been successfully integrated into the same vesicle-based cell model.[2] We have also reported an advanced chemical cell that linked replication of informational substances (DNA) with self-reproduction of compartments (vesicles).[3] Self-reproduction of compartments by the use of an organic chemical method revealed the possibility that the polymer behaves as primitive genetic information with a simple physical mechanism. Recently, chemical cells with the potential to evolve or the ability to complete a primitive cell cycle have emerged,[4] and this constructive biology field has received considerable attention.

In this symposium, I will discuss various attempts to create cells and to answer the longstanding question of "What is life?"

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Glossary

Vesicle (Liposome): 【ベシクル (リポソーム)】
A hollow supramolecular assembly composed of lipids

Self-reproduction: 【自己再生産】
The process of molecular assembly proliferating through inner chemical reactions