Earth's Climate History From the Chemistry of Rocks and Ice

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The global carbon cycle sits at the intersection of many of the most compelling questions in science today: *How will Earth's climate system change over the 21st century and beyond? What controls the amount of* CO_2 *and* O_2 *in the atmosphere? How are the geochemical cycles of these gases linked to habitable climates and the evolution of complex life on Earth?* As a geochemist and Earth historian my research focuses on understanding the global carbon cycle - the movement of carbon dioxide (CO_2) from Earth's interior through the ocean-atmosphere-biosphere system and back to the solid Earth - on timescales of thousands to billions of years. Our approach to these questions has been to develop and use chemical and isotopic measurements to probe two geological sources of information on Earth's surface environment: ancient sediments and air bubbles trapped in ice cores. Using the chemical and isotopic signatures preserved in these environmental archives we reconstruct the important chemical and physical processes involved in the global carbon cycle and examine how they have changed over the last 3+ billion years of Earth history.

Reconstructing Ancient Climates – Causes and Consequences of Rapid Climate Change

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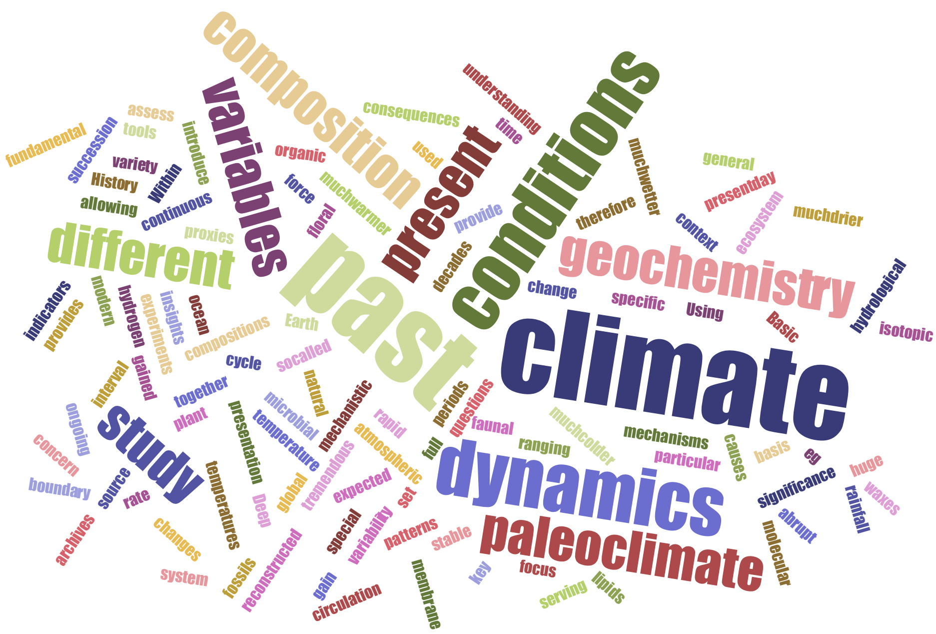
Climate research has gained tremendous significance over the past decades in the context of ongoing, modern climate change. Basic questions concern e.g. the range of climate variability in general, the rate of change that can be expected, as well as the mechanisms that control climate dynamics. Deep- to present-time climate of Earth History portrays a substantial range of natural climate variability, with past climate conditions ranging from much-warmer to much-colder and much-wetter to much-drier than present, different atmospheric compositions and ocean circulation patterns, as well as a huge variety in floral and faunal ecosystem composition. Within that progressive series of changing environments, periods of rapid climate change provide natural climate experiments allowing to study causes and consequences of changing climate under a range of different boundary conditions. The study of paleoclimate therefore provides a fundamental basis for our mechanistic understanding of the present-day climate system. Using organic geochemistry, specific climate variables can be reconstructed from so-called climate archives. In particular, changes in the hydrological cycle and temperature are key variables in paleoclimate research. This presentation will introduce selected tools of organic geochemistry ("molecular fossils") that can be used to assess past climate conditions. A special focus is set on the stable hydrogen isotopic composition of plant waxes as indicators of past rainfall dynamics together with microbial membrane lipids serving as proxies for past temperatures, during an interval of abrupt global climate change in Earth History.



Changes in Antarctic Temperature and Carbon Dioxide over the Glacial Cycles

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Global warming due to increase in atmospheric CO_2 concentration is a major issue for modern and future human society. Besides social and economic problems, the global warming is further complicated by uncertainties about future predictions. In fact, we still do not fully understand the Earth's climate mechanisms. Thus, it is essential to know a long climate records in the past because it provides valuable data during which the Earth has experienced different climates under high/low CO_2 concentrations. In 1990s, an Antarctic ice core revealed a correlation between temperature and CO_2 over the past 420,000 years (Petit *et al*., 1999). This "apparent" correlation was used as an evidence for CO_2-temperatre coupling in a famous movie, "An Inconvenient Truth".

Although there is a correlation between Antarctic temperature and CO_2, previous studies also showed that the start of Antarctic warming leads that of atmospheric CO_2 increases by 800-2,000 years during the last deglaciation (e.g., Monnin *et al*., 2001; Fudge *et al*., 2013). Since past temperature is estimated from stable isotope compositions of water (hereafter, deuterium-temperature), the difference may arise from bias of the temperature reconstruction itself.

I will present a temperature reconstruction based on multiple (both oxygen and hydrogen isotopes) isotopic analyses (Uemura *et al*., 2012). We used a new Antarctic ice core, the Dome Fuji 2nd ice core (Dome Fuji ice core project members *et al*., 2017), and obtained records of temperature variations at this Antarctic site and the oceanic moisture source back to 720,000 years before present. Before 420,000 years ago, during relatively small interglacials, the correlation between temperatures at the Antarctic site and CO_2 was stronger than that between conventional deuterium-temperature and CO_2, revealing a bias in the conventional temperature estimates. Within the obliquity band, changes in annual mean insolation were followed by changes in Antarctic temperatures, CO_2, and oceanic temperatures with phase lags. This result suggests that temperatures in Antarctica are more strongly affected by solar insolation than those in the ocean due to climate feedbacks that modulate obliquity forcing. Thus, these results suggest that regional characteristics of Antarctic climate would contribute the lead of Antarctic warming over CO_2 increase.

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Glossary

Glacial cycle：**【氷期サイクル】**Since the Late Pleistocene (~ 800,000 years before present), Earth has experienced cold periods (“glacial period”), punctuated by relatively short warm periods (“interglacial period”) every 100,000 years.

Ice core：**【アイスコア・氷床コア】**A column of ice (typically ca. 10 cm in diameter) drilled in ice sheet and/or glacier.

Isotope compositions of ice：**【氷の同位体組成】**Stables isotope ratios of hydrogen (2H/1H) is used to estimate past temperature changes (a “proxy” for past temperature) because there is close correlation between temperature and hydrogen isotope ratio.

Proxy：**【プロキシ】**In the study of past climates (paleoclimatology), physical characteristics of past climate are reconstructed from many substitute archives, proxies. For example, past temperature can be estimated based on changes in tree-ring width, trace element in coral, and isotope compositions of ice core.

Gravitational Waves and Their Discovery

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NASA Marshall Space Flight Center

In 2015 a new field of science was born. Gravitational waves were predicted by Albert Einstein's General Theory of Relativity and were first discovered 100 years after Einstein's ground-breaking work. The first detection of gravitational waves, emanating from the merger of two black holes in the distant universe, was made by the Laser Interferometer Gravitational-wave Observatory (LIGO). Now we stand at the dawn of a new era in science as we begin using gravitational waves to learn about extreme astrophysical phenomena, survey the large-scale structure of the universe, and test our most fundamental understanding of physics. This talk will introduce the phenomena of gravitational waves, survey the different techniques for measuring them, and highlight the revolutionary science the field has achieved already and what lies ahead in the near future.

Background Review Article:
https://www.scientificamerican.com/article/the-future-of-gravitational-wave-astronomy/

Rise of Gravitational-wave Astronomy: Prospects for a Network of Detectors

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1. Introduction

An old song about a star says, "up above the world so high, like a diamond in the sky." The lyric assumes a visual observation of a star, and indeed, we all, not only astronomers, have been looking up into the sky with our own eyes for many centuries. Astronomical observations across a wide spectrum of electromagnetic waves have been also pioneered over the last century. This century, gravitational waves have been detected for the first time in history [1]. Today we are about to add gravitational waves to our list of observation methods. We expect our understanding of the Universe will be deepened as a result. In this talk, I will review some essential topics for starting astronomy with gravitational waves, and look forward to the future.

2. Locating a source of gravitational waves in the sky

The revelry surrounding the first detection of gravitational waves has been followed by another question: where in the sky was the astronomical object radiating the observed gravitational waves?

Locating the source in the sky is necessary for starting astronomy. In fact, a single gravitational-wave detector alone is insufficient to determine the direction from which the observed signal has arrived [2]. The direction can be estimated from the difference of arrival time of the signal at detectors a known distance from one another. Therefore, forming a world-wide network of detectors is desirable (Fig. 1) [3].

When these detectors are in operation concurrently, we will be able to localize a gravitational-wave event in the sky. The sky location will be immediately shared among many astronomers, so that they can search for the electromagnetic counterpart in wavelengths such as radio, optical, infrared, X-ray, and gamma-ray [4]. By these follow-up observations, for example, even a moment of a supernova explosion might be observed for the first time!

3. KAGRA

Current gravitational-wave detector projects such as LIGO, Virgo, and KAGRA still need upgrade to reach their goal sensitivities. Their approaches to reaching the required sensitivity are different from each other [5]. The case of LIGO will be introduced in another talk in this session, so the rest of my talk uses KAGRA as an example to review the unique challenges and the prospects.

KAGRA is a large-scale cryogenic gravitational-wave telescope in Japan. Unlike optical telescopes, but as with LIGO and Virgo, it is an L-shaped laser interferometer consisting of several mirrors. Its two arms extend 3 km. KAGRA has two main features. One is that it is built underground below a mountain for low seismic motion (note that gravitational waves are not blocked by the earth). The other is the temperature of main mirrors. These will be cooled down to around 20 K to reduce thermal fluctuations, while being illuminated by high-power light stored in the laser interferometer.

4. Summary

In this talk, I will overview some essential topics for starting gravitational-wave astronomy. Forming a world-wide network of the detectors is necessary to localize a gravitational-wave source. In addition, KAGRA project will be briefly introduced as an example in the network.

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Fig. 1 Gravitational-wave detectors in the world.

Glossary

Gravitational wave:【重力波】 is a group of spacetime strains propagating in speed of light.

KAGRA:【かぐら】is a large-scale cryogenic gravitational-wave telescope in Japan, formerly known as LCGT.

LIGO:【ライゴ】Laser Interferometer Gravitational-wave Observatory; a US project to build and operate a pair of large-scale laser interferometers located at Hanford WA and Livingston LA.

Supernova:【超新星（爆発）】is a huge explosive event from a massive star at the end of its life.

Nonclassical Laser Interferometry for Gravitational Wave Astronomy

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The first direct detection of gravitational waves (GW) in Sept. 2015 – the merger a binary black hole system – heralded the era of gravitational gave astronomy (GWA). GWA will expand our view on the universe, and reveal things so far not understood, unexplainable or even unknown. GWs are tiny perturbations in the metric of spacetime, caused by non-spherically-symmetric changes in mass distributions, and they are a direct consequence of Einstein‘s Theory of General Relativity. Spacetime is periodically stretched and compressed by GWs by tiny degrees: For a „typical“ astrophysical event with a strain of $h=10^{-21}$ the distance changes as little as the diameter of an atom (10^{-10} m) on a distance of that between earth and the sun (150 million km).

Diverse astrophysical sources produce GWs in a wide range of frequencies. Laser interferometric gravitational wave detectors (GWD) on earth (such as advancedLIGO) will be sensitive to GWs in the frequency range above approx. 1 Hz, whereas for GW sources significantly below 1 Hz (due to Newtonian noise) it will be necessary to fly a space mission with a spaceborne laser interferometer with million-km-scale arm lengths (e.g. eLISA).

In this talk I will be focussing on groundbased interferometric GWDs. I will describe some of the techniques (both classical and quantum) already employed or planned to achieve the necessary sensitivity for (routine) detection, and will show how my work in the field of nonclassical laser interferometry contributes to this exciting field or research.

Introduction to Machine Learning

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At an abstract level the goal of machine learning is to automate the process of inductive inference in the natural sciences: making experiments, building a model, and performing predictions. At a practical level the goal of machine learning is to learn from data e.g. face recognition from example images of faces and non-faces. I will provide a schematic overview of different learning methods and highlight recent success stories of machine learning, in particular deep learning, in computer science and the natural sciences. Introduction to Machine Learning

Interactive Machine Learning

Daniel Hsu
Computer Science, Columbia University

The most common mode of machine learning is not very interactive at all: a human provides data to a machine, then leaves while the machine works on fitting a good model to the data. In this talk, I will describe two problem settings in which interaction is indispensable to the machine learning process. The first "active learning", where interaction between the human and machine is used to reduce the human annotation burden and accelerate the learning process. The second is (a special case of) "online learning", where a machine repeatedly interacts with humans (or other external agents) to gather data and to achieve its goals. In both problems, theoretical analysis has played a central role in identifying the core algorithmic and statistical challenges, as well as the state-of-the-art solutions.

Background Review Article:

S. Dasgupta. Two faces of active learning. Theoretical Computer Science, 412(19): 1767-1781, 2011.

Objective Diagnosis of Mental Disorders using Machine Learning

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Currently we are developing a software to assist psychiatrists to screen for and to diagnose major depressive disorder (depression) and dementia. More specifically our software will take audio and video data recorded during a clinical visit, quantize and extract audio and video features, and use machine learning models to generate an objective prediction of the severity of the patient's depression or dementia. Some of the audio and video features that we process include patient's physical features such as facial expression, blinking patterns, body movements, rate of speech, word/sentence-level sentiment, and voice quality features such as mel-frequency cepstrum coefficients (MFCC), cepstral peak prominence, and formant frequencies. Many of these features are qualitative cues that psychiatrists look for when diagnosing a patient, and we convert them into quantitative cues so that their influence can be normalized across all physicians to provide a consistent and objective diagnosis. Features with patient condition labels are used to train a two-level supervised learning model, where the first level consists of different supervised learning models such as support vector machine, random forest, and gradient boosting machine. The results of these models are aggregated at the second level by another supervised learning model to produce the final prediction. Currently, for prediction of depression we can achieve an accuracy of 71.9%, and for prediction of depression severity based on the Hamilton rating scale ranging from 0 to 52, we have a mean absolute error of 4.33. For dementia, we can achieve a 85.1% classification accuracy between dementia and healthy subjects, and a mean absolute error of 6.49 out of a scale ranging from 0 to 30 for the Mini-Mental State Examination (MMSE).

Depression	Meta Algorithm
Full Set	71.9%
Clean Set	85.1%

1. Classification accuracy for depression vs. healthy

Dementia	Meta Algorithm
Full Set	83.2%

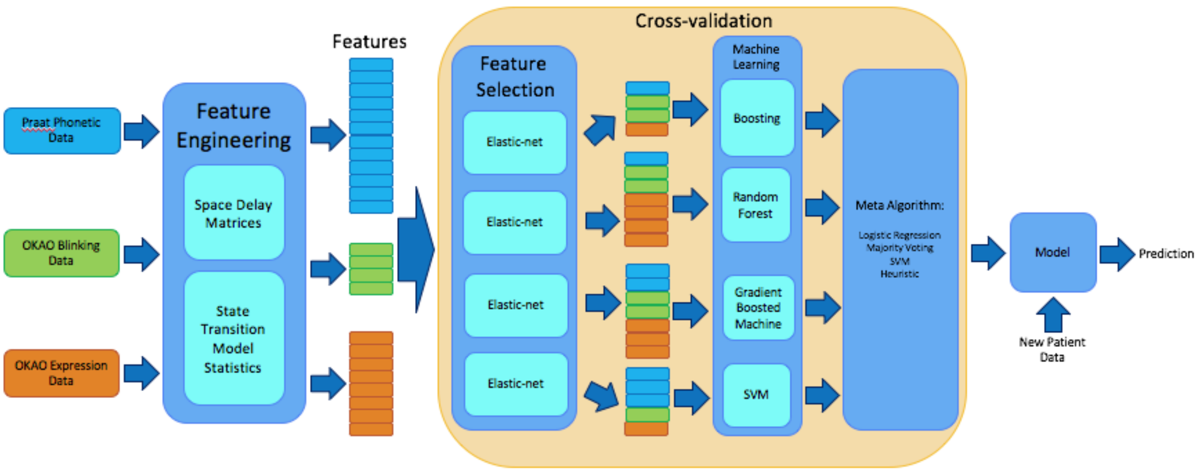
2. Classification accuracy for dementia vs. healthy

Depression	Meta Algorithm
HAMD17	4.33
HAMD6	2.75

3. Depression severity prediction (rating scale) accuracy

Dementia	Meta Algorithm
MMSE	6.49

4. Dementia severity prediction accuracy



Glossary

Bipolar:【双極性障害】is a mood disorder where the patient’s mood swings between extremely high and extremely low moods.

Cepstral peak prominence:【CPP】is a measure of the degree of periodicity in voice signal. Large values of CPP indicates higher level of periodicity in the signal.

Dementia:【認知症】is a mental disorder where the patient’s cognitive abilities are impaired, leading to degradation in thinking, behavior, and memory.

Depression:【うつ病】is a mood disorder where the patient experiences extremely low mood with symptoms such as loss of interest in hobbies, work, being with friends, and may have trouble sleeping, eating, and performing everyday functions.

Detrended cross-correlation analysis:【トレンド除去交差相関解析】is a method for computing the cross-correlation between two time-series signals that may be non-stationary.

Facial action coding system:【顔面動作符号化システム】is an anatomically-based system using Facial Action Units (FAU) to describe facial movement and expressions. Each FAU roughly correspond to a unique muscular action or movement.

Formant frequency:【ホルマント周波数】is the frequency acoustic energy concentrates around in a speech wave. The first two formats F1 and F2 (the two formants with the lowest frequencies) can be used to uniquely characterize vowels in most languages.

Gradient boosting machine:【勾配ブースティング】is a supervised learning algorithm where multiple weak decision trees are constructed, and the prediction for unlabeled data is a summarization of the prediction of the constructed trees.

Hamilton Depression Rating Scale:【ハミルトンうつ病評価尺度】is a questionnaire used to determine the severity of depression. Contains 17 questions, each on a 3 or 5-point scale.

LASSO/Elastic-net:【LASSO】is a regression approach that uses L1 (absolute error) to penalize model complexity. It results in a sparse model where only a subset of the features is. Elastic-net uses a weighted sum of the L1 and L2 (squared error) as penalty.

Mel-frequency cepstral coefficients:【メル周波数ケプストラム係数】are a set of coefficients for filters that alter speech frequencies to a scale that is closer to how human ears process sound. They are often used in speaker and speech recognition.

Random forest:【ランダムフォレスト】is a supervised learning algorithm where multiple fully grown decision trees are constructed, and the prediction for unlabeled data is a summarization of the prediction of the constructed trees.

Space-delay correlation matrix:【スペース遅延係数行列】is a matrix of cross-correlation between different signals (space) and delayed versions of the signals.

Stacking:【Stacking】is an approach in machine learning where many algorithms are combined with a meta-algorithm to improve the final prediction.

Support vector machine:【サポートベクターマシン】is a supervised learning algorithm that classifies unlabeled data by finding a mapping of the data to higher dimensions where data of different class can be separated by the maximum-margin hyperplane.

Materials and Chemistry to Develop Alternative Energy Resources

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Our lives are largely dependent on fossil fuels such as petroleum oil, coal, and natural gas, which are used as the energy resources to generate electricity. However, combustion of fossil fuels is mainly caused by human activity to emits CO_2, which is believed to cause global warming. Therefore, demand for the use of alternative energy resources have been continuously growing in these decades to resolve this issue. In this session, we will discuss how we chemists can contribute to this energy issue. Specifically, we focus on organic photovoltaics, polymer batteries, and solar energy water splitting as next generation technologies for energy generation, energy storage, and hydrogen generation, respectively.

This introductory speaker will introduce the recent advance in organic photovoltaics (OPVs) (Figure 1), a solution-processable solar cell that possesses light-weight, flexibility, and transparency. In particular, I will show the progress of conducting polymers that are used as the photoactive layer in the OPV cells. One of the keys for development of high-performance conducting polymers is to improve the charge carrier transport. Careful design of the molecular structure allows us to control the crystallinity and molecular orientation of conducting polymers, which lead to the high charge carrier transport and thus the high power conversion efficiency. In addition, such conducting polymers can also afford highly stable OPV cells.

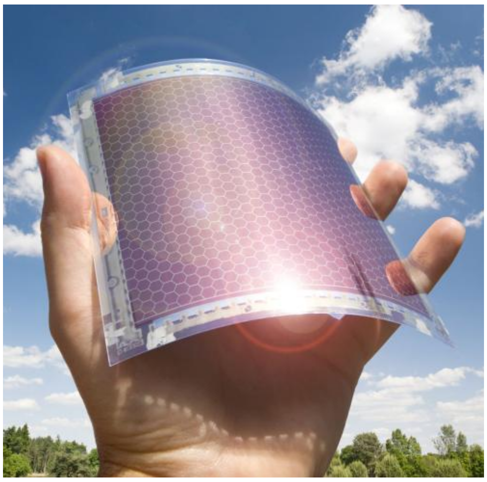

Figure 1. Organic photovoitaic cell: solution-processable solar cell that enables light-weight, flexibility, and transparency.

Glossary

Charge carrier mobility:【電荷移動度】 characterizes how quickly the charge carriers (electrons or holes) move through semiconducting materials.
物質中での電荷（電子あるいは正孔）が流れ易さを示す量.

Conducting polymers:【導電性高分子】 is organic polymers (plastics) that can conduct electricity. These are also called “semiconducting polymers”. These materials can be dissolved in organic solvents, forming inks, and can be printed to form thin films.
電気を通す高分子（プラスチック）

Dye-sensitized photovoltaics (dye-sensitized solar cells):【色素増感太陽電池】is a type of solar cells that used organic dyes as the light absorbing material. Dye-sensitized solar cells can be regarded as a thin film solar cell, but typically uses liquid electrolytes.
有機色素を光吸収層に用いた太陽電池.

Fullerenes:【フラーレン】are molecules of carbon in many structural forms. Spherical fullerenes, referred to as Buckminsterfullerenes (buckyballs), such as C60, C70 and their derivatives are typically used for organic photovoltaics.
閉殻空洞状の多数の炭素原子のみで構成されるクラスターの総称. **サッカーボール状の構造を持つC60やC70、あるいはそれらの誘導体が有機薄膜太陽電池に用いられる**.

Organic photovoltaics:【有機薄膜太陽電池】is a type of solar cells that used thin films of organic semiconductors or conducting polymers as the light absorbing layer.
有機半導体あるいは導電性高分子を光吸収層に用いた太陽電池.

Perovskite:【ペロブスカイト】is a kind of crystal structures similar to $CaTiO_3$, which is originated from the name of Russian scientist, Lev Perovski.
灰チタン石と同じ結晶構造をもつ材料.

Perovskite photovoltaics (perovskite solar cells):【ペロブスカイト太陽電池】is a type of solar cells that used thin films of “perovskite” structured materials, most commonly organic-inorganic lead halide hybrid materials, as the light absorbing layer.
ハロゲン化鉛系ペロブスカイト結晶を光吸収層に用いた太陽電池.

Photoelectrochemical cells:【光電気化学セル】are solar cells that produce electrical energy or hydrogen in a process similar to the electrolysis of water.
光電気化学反応を用いて水を分解し、水素を発生させる装置.

Power conversion efficiency:【エネルギー変換効率（発電効率）】refers to the ratio of sunlight energy that can be converted via photovoltaics into electricity. The efficiency of commercially available silicon solar cells is typically 15–20%.
太陽電池において、入射した太陽光エネルギーに対して変換される電力の割合を表す量.

Photo(electro)catalysis: Light-Driven Chemistry for Energy and Environment

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From the energetic point of view, the entire life of the biosphere is enabled (*via* oxygen production) and driven (*via* conversion of solar energy into chemical energy) by natural photosynthesis, a process occurring in green plants, algae, and some bacteria. During this process, water is oxidized to oxygen, and the electrons extracted from water molecules are used for the reduction of carbon dioxide to high-energy hydrocarbons. In other words, the energy of sunlight is directly *captured*, *converted*, and *stored* in high-energy chemical bonds of sugar molecules. The amount of solar energy available at the Earth is extremely large, and only a tiny portion of it is currently being utilized. The development of *artificial* photochemical systems capable of mimicking the natural photosynthesis by driving useful chemical transformations has therefore attracted significant interest motivated by the need to meet various environmental concerns and to secure the future supply of clean and sustainable energy.[1-2]

Though there is a large variety of photoactive systems, the general mechanism underlying their operation is always very similar. Light-induced excitation of light absorbers leads to generation of charges which can be – in the presence of suitable interfaces – spatially separated by the gradients of electrochemical potential. These separated charges can be then either used for direct production of electric work (solar cells), or utilized for driving various useful redox chemical transformations, just like in natural photosynthesis. The advantage of the latter strategy (*"artificial photosynthesis"*) is that the converted energy does not need to be used immediately (like in case of solar cells), but can be directly stored in the form of high-energy fuels (*"solar fuels*") for later use. The talk will focus on the development of photoelectrocatalytic systems for the production of the primary solar fuel, hydrogen, by sunlight-driven splitting of water.[3-5] In addition, recent progress in the development of photocatalysts for solar water remediation,[6] and light-driven organic synthetic reactions[7] will be discussed.

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Plastic Power: Organic Polymer Batteries

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Artie McFerrin Department of Chemical Engineering and Department of Materials Science & Engineering, Texas A&M University

Plastic power, or energy storage platforms primarily consisting of polymers, offers opportunities never before available in current state-of-the-art prismatic or coin cells, such as flexible, structural, or stretchable batteries and capacitors. This talk will first introduce how electrochemically active polymers operate, their specific challenges, and latest advances. Will organic polymer batteries perform as well as current Li-ion batteries? What new functions may organic polymer batteries address that are not presently tackled by today's technology? The answer to this is complex, as there is a wide materials chemistry space to explore, with different classes of polymers bearing their own unique advantages. We will then touch upon ultra-stable polyaniline cathodes, which are reversibly stable up to 4.5 V vs. Li/Li^+, and spray-on "graffiti" polyaniline nanofiber-graphene based electrodes. Polyaniline is one of the earliest explored electrochemically active polymers, and is still widely explored on its own or as part of hybrid electrodes. We next discuss highly flexible and mechanically tough V_2O_5 hybrid electrodes, enabled by an electrochemically active block copolymer. This study will demonstrate how a specially designed polymer binder can dramatically enhance electrode toughness and eliminate failure by pulverization, all while simultaneously conducting ions and electrons. Finally, we will highlight our recent work in organic radical polymer batteries and their redox mechanism. Organic radical polymers are interesting for their rapid redox kinetics, high power, and radical-based chemistry. These polymers exchange electrons and ions by a process very different from conjugated polymers such as polyaniline. We evaluate the origin of this process, as well as how it may be manipulated by adjusting the polymer backbone chemistry. As we look to the future, polymers may be the enabling factor towards unconventional batteries, possibly merging plastic electronics with plastic power to form a new paradigm.

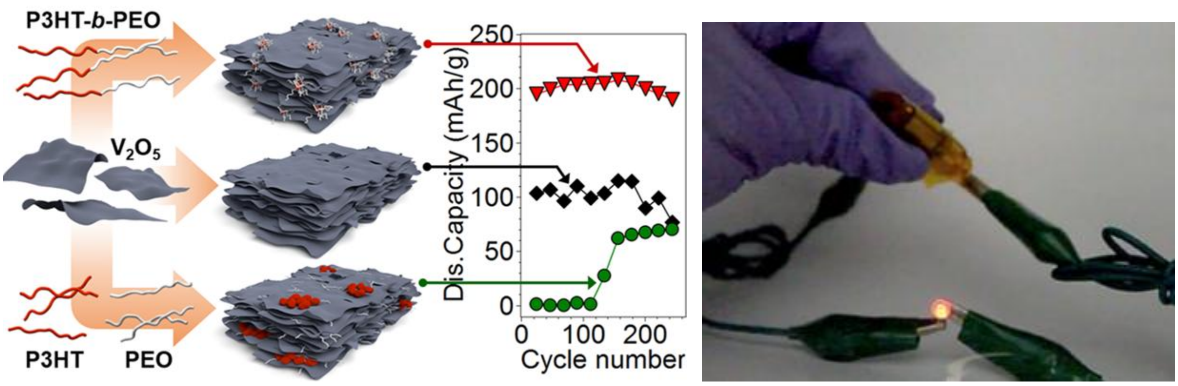

Fig 1. A simultaneously ion- and electron-conducting block copolymer (P3HT-b-PEO) is used as a binder for V_2O_5 cathodes to realize a flexible battery.

Benefits and Mysteries of Sleep in Human

Akiko Hida

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Sleep is regulated by two components: homeostatic drive and circadian drive. Sleep and wakefulness occur sequentially, and sleep propensity increases gradually with extended wakefulness and decreases rapidly after sleep onset. Sleep propensity is under the control of sleep homeostasis, and sleep timing is under the control of circadian clocks. Sleep-wake states and circadian clock are governed by several specific brain regions in the brain stem and hypothalamus. Sleep characteristics vary greatly among individuals, and a dozen genes contributing to an individual's chronotype have been identified.

A recently developed questionnaire, the Munich ChronoType Questionnaire (MCTQ) has been used to study human sleep-activity behavior, the effects of sleep-activity patterns in brain function and cognition, the effects of light exposure and aging on the circadian system, the impact of social jetlag on health, the influence of urbanization and geographical location. The human sleep project has been currently ongoing and collecting sleep-activity data from people all over the world. Data derived from tens of thousands of people would provide new insights into the role of sleep in humans. Sleep is indispensable to us and is associated with a wide variety of biological functions. However, currently, it is not so easy for us to get sufficient sleep, due to the 24-hour operating nature that exists in modern society. A lack of sleep leads to impaired psychological and cognitive functions, including mood, memory and performance. Sleep is known to be required to fix memories in the brain and modulate response to different types of emotions. Recent studies suggest that sleep facilitates creative activities by integrating separate memories and sleep weakens fixation of negative emotions from traumatic memories. The role of sleep in brain function has been extensively investigated. Epidemiological and neurocognitive studies suggest that we need "sleep" to maintain a sound mind and a sound body.

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Glossary

Chronotype:【クロノタイプ】The type of inter-individual differences known as morningness-eveningness preferences. Phases of behavioral and physiological rhythms such as sleep-wake timing, core body temperature and secretion of melatonin are advanced in morning types compared to intermediates, and more so compared to evening types.

Circadian clock:【概日時計】The internal system that regulates behavioral, cognitive and physiological rhythms with a period of ~ 24 hour. These biological rhythms called circadian rhythms are driven by an internal self-sustained clock and are reset by environmental cues.

Electroencephalogram:【脳波】Electroencephalography (EEG) is the recording of electrical activity in the brain.

Electrophysiology:【電気生理学】Electrophysiology is the study of the electrical properties of biological cells and tissues. It involves measurements of voltage change or electric current on a wide variety of scales from single ion channel proteins to whole organs, for example, the heart. In neuroscience, it includes measurements of the electrical activity of neurons, and particularly action potential activity.

Gene polymorphism:【遺伝子多型】Genetic variants within a population. Two or more genotypes occur in frequencies that cannot be maintained by recurrent mutation.

Homeostasis:【ホメオスタシス】The tendency of the body to maintain a condition of stability or equilibrium within its internal environment. Sleep homeostasis is a kind of internal timer or counter that generates sleep pressure: the longer we have been awake, the stronger the desire and need to sleep becomes.

Hypothalamus:【視床下部】The Hypothalamus is a region of the brain that is located below the thalamus, just above the brain stem. The hypothalamus is responsible for certain metabolic processes and other activities of the autonomic nervous system. It synthesizes and secretes certain neurohormones, often called hypothalamic-releasing hormones, and these in turn stimulate or inhibit the secretion of pituitary hormones. The hypothalamus controls body temperature, hunger, thirst, fatigue, sleep, and circadian cycles.

QOL:【キューオーエル】Abbreviation for quality of life

REM sleep:【レム睡眠】Rapid eye movement sleep (REM sleep) is a normal stage of sleep characterized by the random movement of the eyes. During REM, the activity of the brain's neurons is quite similar to that during waking hours; for this reason, the REM-sleep stage may be called paradoxical sleep. REM sleep is physiologically different from the other phases of sleep, which are collectively referred to as non-REM sleep. Vividly recalled dreams mostly occur during REM sleep.

Slow wave sleep:【徐波睡眠】Slow wave sleep is a period of sleep characterized by decreased metabolic activity, slowed breathing and heart rate. During slow wave sleep, EEGs show slow waves. This is also termed non-REM sleep.

Social jetlag:【社会的時差ボケ】Misalignment between the timing of an individual's internal circadian clock and the timing of external environment (work and social schedules). The discrepancy between work and free days, between social and biological time.

Sleep, Memory, and the Brain: How Sleep and Stress Interact to Facilitate Emotional Memory Formation

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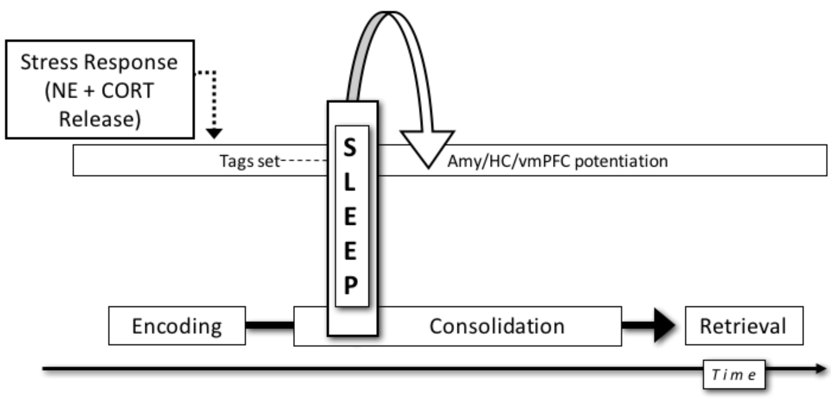
Why do we sleep? It is remarkable that although it is 2017, we scientists still have not answered this question. Although we may not know sleep's function, it is clear that sleep is essential for brain health and for the various cognitive functions the brain supports. Of these functions, memory consolidation – the ability to retain newly learned information – has received the most empirical support. My laboratory and others have demonstrated that sleep is not only essential for simple memory storage, but also for various forms of memory restructuring and transformation that allow us to use our knowledge and experiences in flexible and adaptive ways. Sleep benefits the consolidation of emotional memories in particular, often at the expense of more neutral memories. Interestingly, separate, indeed largely isolated, fields of research demonstrate that both sleep and stress hormones like cortisol can selectively benefit the consolidation of emotional aspects of our experiences. However, the *interaction* of sleep and stress in memory-relevant regions of the brain may be necessary for the consolidation of robust emotional memories. The first part of my talk will examine the distinct roles that sleep and stress play in the formation of emotional memories. In the second part, I will discuss new evidence, from behavioral, psychophysiological, and brain imaging studies, suggesting that stress and arousal interact with sleep to benefit memory consolidation, particularly for negative emotional information. Although preserving memories for negative emotional events is typically adaptive, excessive memory for such events can contribute to mental health disorders such as depression and post-traumatic stress disorder (PTSD). In the final part of my talk, I will present a new model that argues that stress-related neurochemicals may help 'tag' attended information as important to remember at the time of new learning, thus enabling subsequent, sleep-based neural processes to optimally consolidate emotional information in a selective manner. A schematic of the model is presented below.

Abbreviations: NE, Norepinephrine; CORT, Cortisol; Amy, Amygdala; HC, Hippocampus; vmPFC, Ventromedial Prefrontal Cortex

Stress-Sleep Interactions Link Short-Term Synaptic Plasticity (i.e. Synaptic or Cellular Consolidation) in Memory Circuits to Long Lasting Systems Consolidation



Studying Human Sleep in Real Life and in Large Numbers: How Activity Tracking Opens up Sleep to Big-data Research

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Sleep remains an enigma: we neither have a good scientific definition of what sleep actually is nor know what function(s) sleep actually fulfils and why it is so often altered in disease and aging. A major limit to progress in sleep research is the difficulty of recording sleep outside the sleep laboratory, thus precluding large-scale sleep studies and big-data approaches.

Sleep is not a simple uniform state but shows intriguing temporal dynamics, with many bodily processes, from brain activity to hormone levels, changing over time during a single sleep episode. Some changes are gradual, whereas others reappear in cyclical fashion commonly known as sleep cycles. It is especially these sleep dynamics that cannot be captured by simple methods such as questionnaires or sleep diaries and, so far, require laborious measurement of brain activity, eye movement and chin muscle tone in the laboratory.

In an attempt to make sleep dynamics accessible for large-scale studies, we turned to activity tracking since it is a simple and commonly used method in sleep research to distinguish between the sleep and wake state. Although the low activity during sleep is usually ignored, we specifically analysed this movement in >16,000 sleep episodes from the close to 600 people in our activity database. Through non-linear conversion of activity to *Locomotor Inactivity During Sleep* (LIDS) - emphasizing inactivity over activity – we exposed clear patterns in movement during sleep: LIDS was very rhythmic with mean cycle lengths close to 2 hours. These LIDS rhythms we found to directly correspond to the classic sleep cycles as determined in the sleep laboratory. In addition, we found LIDS levels to decline gradually during sleep (i.e. activity to incline), also similar to key laboratory sleep parameters. Using these LIDS dynamics for a first large-scale exploration of human sleep in real life, we found sleep dynamics to change markedly with age and to be altered by shift work and psychiatric disease.

As our first exploration of sleep dynamics indicates, the simple method of activity tracking can be an effective tool to assess sleep in large populations outside the laboratory. It makes common and important sleep phenotypes such as sleep cycles and gradual dynamics easily accessible and quantifiable while potentially also uncovering new ones. Furthermore, since activity can be recorded continually over long periods of time in the most diverse life conditions, it will enable research into the daily context of sleep, the influence of the surrounding episodes of sleep and wake as well as the time of day the sleep occurs. Given the widespread use of activity tracking in both research and the general population via health gadgets, one can also capitalize on the great number of already existing dataset. Therefore, we predict that activity tracking will be a valuable resource for sleep research and medicine and significantly advance our understanding of sleep.

Further reading:

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Whither Health Inequality? A Status-quo Assessment of Policies to Address Overweight and Obesity in Advanced Industrial States

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Health inequality is a rising problem in industrialised countries (Borell, Espelt, Rodríguez-Sanz, & Navarro, 2007). A host of studies show how social and socioeconomic inequality correlates with the individual health status (Bambra, 2011; Mackenbach, 2012; Richter et al., 2012) – this is true for Japan, Germany and the Unites States alike. Although we find tremendous leaps in average health status in all these countries, there are still severe health problems that mainly affect specific groups of people in a society (e.g. Bauer, 2014; Picket & WIlkinson, 2015). Although these health problems may seem to be just one single aspect in the wider debate on social and socioeconomic inequality, these problems have a severe impact on various issues: a stable health status is necessary for participating in economy, and has effects on daily routines in modern society. It also reduces the cost of living. With that said the presentation will analyse these nexuses with a special empirical focus on obesity.

Obesity is a problem that has gained and is still gaining large national and international attention (see WHO - http://www.who.int/mediacentre/factsheets/fs311/en/ or,
OECD https://data.oecd.org/healthrisk/overweight-or-obese-population.htm among others). Empirical data shows rising figures of obesity (and overweight) in many industrialised countries. This epidemic phenomenon is attributed to be responsible for many non-communicable diseases (NCDs) like diabetes, coronary heart diseases, orthopaedic problems etc. If a person is obese he or she is likely to suffer from one or multiple of these diseases (sooner or later), which (a) reduces the quality of life individually, (b) increases the risk of being unable to participate in a modern society (e.g. work, leisure activities) and (c) produces costs for the health system, thus for societies.

Studies in Public health and medical research reveal the factors that influence obesity: nutrition, physical inactivity, psychological and emotional stress, genetic factors. Although much of this has to do with individual life styles it is also dependent of the individual's educational status, living and working conditions etc. This bundle of factors highlights the relationship between individual level and societal, economic and ecological factors. Relevant factors that policy-makers should target in a comprehensive approach.

All these issues can be observed in Japan (e.g. Nakade et al., 2015), in the USA (e.g. Shaikh, Siahpush, Singh, & Tibbits, 2015) and in Germany (e.g. Haftenberger et al., 2016), but with very different characteristics and on different levels. The presentation will work out these characteristics and present them in the context of the broader sphere of social and socioeconomic inequalities. With the example of health and obesity the presentation will classify which problem structure can be found in each of the countries and ask how it is addressed by policy-makers.

Since we know that it makes a difference what policy makers do and how they do it, we could expect this to be the case in fighting obesity. It is of utmost importance to understand how, if any, political strategies act in awareness of inequality issues and the complexity of influencing factors. Furthermore, it is relevant to find out if they ignore the nexus between social and socioeconomic inequality and health issues.

The presentation will tackle this problem from a political science view and answer the question how politics try to fight in a combat (“fighting obesity”) that might just have slight chances to be won. Empirical examples from all three countries are analysed. The results will show how social and socioeconomic trigger obesity. In addition, it will provide insights for decisive aspects to foster a surrounding that influences people to reduce weight or prevent them from becoming overweight or obese. Finally, the presentation will bring these issues into line with the overarching theme of social and socioeconomic inequality.

Literature (selection)

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Trends in Inequality of Opportunity

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This presentation discusses recent trends in socioeconomic inequality. The presentation has three parts. In the first part, I briefly discuss evidence of an increase in several types of inequality over the last four decades. While I discuss income inequality briefly, I focus on changes in the equality of opportunity. Second, I present recent changes in society which may be determinants of inequality in opportunity. Third, I discuss the economic and ethical issues surrounding policies aimed at addressing inequality.

To begin, the talk briefly documents the recent growth in income inequality. Across high-income countries, and in particular in the US, there have been notable increases in income inequality. This talk will specifically focus on changes affecting equality of opportunity over the last four decades. Specifically, I discuss increases in the inequality of health, education, and labor force participation.

The second part of the talk will discuss increasing returns to education and changes in the family environment as determinants of inequality of opportunity in the United States. First, the returns to education and skill have increased sharply over the last four decades, yet the supply of workers holding graduate or post-graduate degrees has been slow to respond. The increasing returns to education and skill helped many, but may have those poorly equipped to pursue (or pay for) post-secondary education. Second, notable changes in family composition and early environment may have changed the opportunities available to individuals later in life. Increased disparities in early health, decreased childhood investment, and less stable homes may limit opportunity for the poor.

Finally, I briefly discuss the normative study of inequality, highlighting the potential costs and benefits. Philosophical discussion on inequality tends to focus on how to balance equity with personal responsibility and deserved reward. I focus on how this discussion takes shape within the context of education policy, in particular the challenge of balancing meritocratic principles and equality of access to education.

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Policy to Reduce Wage Inequality: Who Owes the Cost of Minimum Wage?

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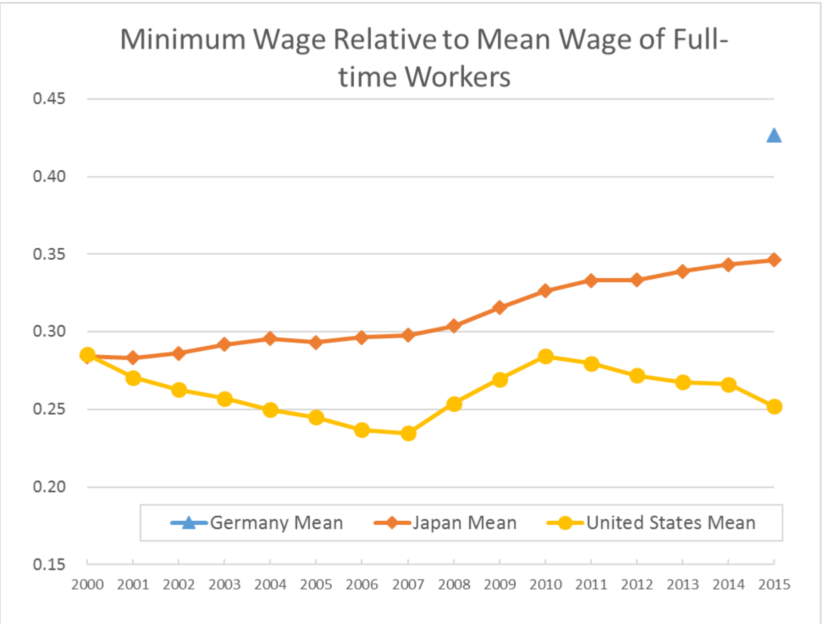
One easy way to circumvent the socioeconomic inequality may be directly raising the earnings of low-wage workers. Minimum wage is a labor market institution which acts this role by enforcing a lower bound to wages paid to workers. The policy is relatively easy to be implemented, and widely employed in many countries. Evidences have shown that an increase in minimum wage has indeed reduced wage inequality.

However, the story does not end here, because someone have to pay for the cost of the wage increase. For example, if firms can immediately adjust the employment level in response to a wage increase, those who lose their jobs owe the cost. Alternatively, if employers can increase their product prices to compensate for an increase in wage cost, consumers owe the cost of minimum wage increase. If neither is possible, firms may absorb the cost by reducing their own profits. Important to the original purpose of the policy, the cost of minimum wage may be passed on to those who are at the lower end of socioeconomic ladder.

This session reviews recent empirical findings to examine who owes the cost of minimum wage and reveals that the answer depends on firm's market power. In a market in which firms have relatively large controls over product prices, the cost of minimum wage is concentrated to consumers who buy those more expensive goods.



Data Source: OECD.Stat; US minimum wage data comes from federal minimum hourly wage rate; Japanese minimum wage is a weighted average of prefectural hourly wage rate

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Glossary

Marginal product of labor：**【労働の限界生産性】**is an increment to a quantity of products produced at a firm by hiring one more unit of labor (e.g. one worker, one man-hour etc.).

Markup：**【マークアップ】**is a ratio between the marginal cost of a good and its selling price. It measures the extent to which firms can control the product price. It drives a wedge between the value of marginal product of input factor and its revenue share.

Minimum wage：**【最低賃金】**is a labor market institution that sets a wage floor or a lower bound to wages paid to workers. It is usually set by statutory rules or through collective bargaining.

Monopsony in Labor Market：**【買手独占的な労働市場】**is a state of the market in which an individual firm has a power to control wage level, due to frictions in the labor market. The frictions occur, for example, if workers are ignorant about other employment opportunities, or if it is costly for workers to move to other regions to obtain better job positions.

Perfect Competition in Labor Market：**【完全競争的な労働市場】**is a state of the market where many firms operate and an individual firm cannot determine the wages of its workers; instead, they pay according to market wages. The market wages are determined such that the labor demand and supply equates.