Comprehensive Analysis of the Cancer Genome and Epigenome to Clarify and Manage Cancer

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Cancer arises through accumulation of changes in genomic DNA. The changes include substitutions of one nucleotide, insertions/deletions of small segment of DNA, chromosomal rearrangement rejoining the broken DNA segments, copy number changes from two copies to several hundred or to complete absence, and changes in epigenetic marks e.g. methylation of cytosine in genomic DNA. These changes can affect protein-coding genes by activating or inactivating them, and may be induced by external and internal mutagenic factors e.g. tobacco smoking, ultraviolet light, bacterial/viral infections, and ageing. Recent advancement of genome analysis tools and bioinformatics enables us to comprehensively identify these accumulated changes.

Only several of these changes do contribute to growth advantage of cells, and are called “driver” mutations. The rest, 99% of the changes are “passenger” mutations, which do not contribute to tumor development. One of the goals of cancer genome analysis is to identify cancer genes with “driver” mutation, which are recurrently observed and form a cluster whereas passenger mutations are randomly distributed. Because cellular growth of cancer cells are dependent on abnormal proteins encoded by mutated genes, new cancer drugs targeting those proteins can be developed, which is another important goal. For example, ALK can be targeted in some cancer as abnormal fusion protein EML4-ALK was found in lung cancer and copy number increase and mutations of ALK was identified in neuroblastoma.

Comprehensive analysis also enables us to classify cancer. For example, gastric cancer is classified into three types, and one with extensively high DNA methylation hardly shows other kinds of genomic aberrations. Epstein-Barr virus is the cause of the extensive DNA methylation, and its infection can induce the methylation in a short period of time. Cancers harboring different genomic and epigenomic features may develop through different tumorigenic pathways, even though they arise in the same organ. As each cancer gene contributes to tumor development in only a fraction of cancer cases, cancer classification may be helpful to clarify tumorigenic mechanisms and establish specific therapeutic strategies.
References:
Integrate Genomic / Epigenetic Analysis of Pediatric Solid Tumors

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Background:
Pediatric solid tumors are one of the significant causes of death among children, and thus, development of new therapeutic strategy for intractable pediatric solid tumors is a global problem. A better understanding of biological features of pediatric solid tumors is importantly in order to develop more specific and successful treatment strategies, but molecular mechanisms of these tumors are largely unknown. On the other hand, recent advances in genome-wide copy number screening and high-throughput re-sequencing allow us to extensively screen the entire human genome. Using these technologies, several new candidate targets for adult cancers have been identified. To explore the genetic/epigenetic bases of pediatric solid tumors, integrated genome-wide analyses were performed.

Materials and Methods:
More than 300 samples (including neuroblastomas, rhabdomyosarcoma, and pleuropulmonary blastoma) were analyzed using SNP-genotyping microarrays. Furthermore, whole-exome/targeted sequencing was performed in rhabdomyosarcoma and pleuropulmonary blastoma using next-generation sequencing. In addition, Genome-wide DNA methylation analysis in rhabdomyosarcomas was also performed.

Results:
In genome-wide copy number analysis, recurrent copy number gain and high-grade amplification at ALK locus on chromosome 2p were detected in neuroblastoma. Subsequent studies disclosed that ALK is a newly identified genetic target in neuroblastoma. Meanwhile, whole-exome sequencing identified several candidate genes, including PI3 kinase-related genes in rhabdomyosarcoma and DICER1 in pleuropulmonary blastoma. Moreover, based on DNA methylation patterns, rhabdomyosarcoma was clustered into 4 distinct subtypes, which exhibited remarkable correlation with mutation/copy number profiles, histological phenotypes, and clinical behaviors.

Conclusion:
Genome-wide integrated analysis of large number of samples allowed us to obtain a comprehensive registry of genomic lesion in pediatric solid tumors. Our findings shed light on novel mechanisms for some pediatric cancers and may lead to the improvement in pediatric solid tumor survival.

References:

Adenoma【腺腫、アデノーマ】: A benign tumor arising from epithelial cells.

Benign Tumor【良性腫瘍】: An abnormal but non-cancerous expansion of cells caused by mutation of cancer genes. It doesn’t invade the surrounding tissues, unlike malignant tumors.

Carcinoma【癌】: Malignant tumor arising from epithelial cells.

Chromosome, Chromatin【染色体、クロマチン】: Genomic DNA is stored in the cell nucleus in the form of chromosomes. In human cells, 23 pairs of homologous chromosomes are present. Each chromosome is largely made up of a string of genomic DNA wrapped around proteins called histones, which is a DNA-protein complex referred to as chromatin.

Colorectal Cancer【大腸癌】: Malignant tumor in the large intestine.

Copy Number Variation (CNV)【コピー数多型】: Variation in the copy numbers of large segments of genomic DNA among individuals.

DNA Methylation【DNAメチル化】: Covalent bonding of methyl group to DNA at cytosine. A form of epigenetic modification generally (but not always) related to down-regulation of genes.

Driver Mutation【ドライバー変異】: A gene mutation that cause growth advantage of cells. Among many mutations accumulated in a cell, only a part of them are driver mutations and the rest are passenger mutations.

Epigenetics, Epigenome, Epigenomics【エピジェネティクス、エピゲノム、エピゲノミクス】: Epigenetics refers to the study of a form of inheritance that is superimposed on the genetic inheritance based on DNA, often through chemical modifications of chromatin such as DNA methylation and histone modifications. Epigenome refers to the overall epigenetic state of the genome in a given cell, while the term epigenomics refers to the study of the epigenome.

Exon, Exome【エクソン、エクソーム】: Only about 1% of the genomic DNA codes for genes that are transcribed into messenger RNA (mRNA). Exons are sequences within a gene/mRNA that remain in the mature (i.e. processed) form of mRNA that largely correspond to protein coding sequences. Exome is the entire collection of exons within a genome.

Gastric Cancer【胃癌】: Malignant tumor in the stomach.

Genetics, Genome, Genomics【遺伝学、ゲノム、ゲノミクス】: Genetics is the study of genes and heredity. Genome refers to the complete set of genetic material specific to each organism. Human genome consists of 3 billion chemical base pairs of DNA. The four bases of DNA are adenine (A),
guanine (G), cytosine (C), and thymine (T). Genomics refers to the comprehensive analysis of the genome.

Glioma【神経膠腫、グリオーマ】: Brain tumor arising from glial cells.

Histone Modification【ヒストン修飾】: Chemical modification of histones such as methylation and acetylation, which often play important roles in epigenetic inheritance.

Locus【遺伝子座】: A physical location of a gene on a chromosome.

Malignant Tumor【悪性腫瘍】: An abnormal expansion of cells that can invade the surrounding tissues. These cells have more cancer gene mutations than benign tumors and are cancerous.

Microarray【マイクロアレイ】: In practical terms, microarrays are the predecessor of Next Generation Sequencing. It is a massive collection of microscopic DNA spots on a glass slide surface used to interrogate amounts of specific DNA sequences based on hybridization intensity.

Mutation【突然変異】: A change in the genomic DNA sequence.

Next Generation Sequencing, NGS【次世代シークエンシング】: A recent technology that allows comprehensive sequencing of a variety of DNA specimens, from the entire genomic DNA sequence to its subsets generated by various experimental procedures. While conceptually similar to conventional Sanger sequencing based on capillary electrophoresis, NGS generates millions of sequence reads (typically 50-200 base pairs of DNA) in a massively parallel fashion.

Oncogene, Proto-oncogene【癌遺伝子、癌原遺伝子】: A mutated, activated form of a gene that confers growth advantage to cells when activating mutation occurs in one copy of the gene. In the absence of such activating mutation, such genes are called proto-oncogenes.

Passenger Mutation【パッセンジャー変異】: A gene mutation that does not confer growth advantage to cells. Most mutations accumulated in a cell are passenger mutations.

Pediatric Solid Tumor【小児固形腫瘍】: Abnormal tissue mass without cysts and liquids seen in children such as neuroblastoma【神経芽腫】in peripheral nerve tissues, rhabdomyosarcoma【横紋筋肉腫】in muscles attached to bones, or pleuropulmonary blastoma【肺芽腫】in lung tissues.

SNP, Single Nucleotide Polymorphism【一塩基多型】: A variation at a single position in the genomic DNA sequence that is observed in more than 1% of the population.
Target Therapy【標的療法】: A therapy using inhibitor molecules that specifically target driver genes. In tumors with activating mutations in certain driver genes, inhibitor drugs targeting the proteins encoded by the genes can treat the tumor.

Translocation【染色体転座】: A chromosomal rearrangement where two different chromosomes are joined. An abnormal fusion gene may appear when two separate genes are joined.

Tumor Suppressor Gene【癌抑制遺伝子】: A gene that usually suppresses cellular growth and can increase growth advantage of cells when mutated. Cells acquire growth advantage only when both copies of the normal gene are inactivated by mutation and/or deletion.
From Color Recognition to Molecular Machines: 
The Field of Photoresponsive Molecules

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The origin of color recognition is the different response of three kinds of visual pigments to different wavelengths of light, corresponding to three primary colors. Visual pigment, named rhodopsin, is composed of a colored molecule called retinal and a protein called opsin. When the light is absorbed into retinal, the molecular structure of retinal and also the structure of overall rhodopsin change, then the electric nerve signal is generated. This kind of photoresponsive reversible transformation is one of the examples of phenomena called photochromism. Photochromic compounds change not only their color but also many kinds of physical properties.

Until now several photochromic compounds have been synthesized. Diarylethene is the compound which shows thermally irreversible and fatigue resistant photochromic reaction. The photochromism of diarylethene can switch magnetic interaction and electric conductance. The change of molecular structure is the origin of switching.

The field of application of the photochromic compound is now expanded to the field of molecular machines and molecular electronics. Molecular machines and molecular electronics system using photochromic molecules are attracting wide variety of interests; there are many interesting biological systems which we would like to mimic and there is an interesting molecular electronics system using photochromic molecule as a molecular switch [1].

References:
Angle-independent Structural Coloured Materials
Inspired by Living Organisms

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1. Introduction
We are able to observe a colour due to the interference of light from microstructures composed of different refractive index materials that is comparable to the visible wavelength of light; such a colour is called a structural colour. Because structural colour is fadeless and no energy is lost from the colour mechanism, structurally coloured materials are expected to be used for energy-saving reflective displays and sensors. Previously, however, the word “iridescence” rather than “structural colour” was used to describe the property of a surface that appears to change colour as the viewing angle or the angle of light illumination changes. Thus, people who are aware of the concept of the interference colour have a strong impression that all structurally coloured materials change hues when viewed from different angles, as indicated by the term “iridescence.” In fact, most artificial structurally coloured materials that we and other groups have studied so change their hue depending on the viewing and light illumination angles because these structural colours derived from Bragg reflection. Such angle dependence presents a barrier for developing displays and sensors using structurally coloured materials. Therefore, my group has been working to develop angle-independent structural coloured materials. The latest most notable ones are amorphous array systems that are used for living things. In this paper, I first introduce the microstructures and optical properties of low-angle-dependent structurally coloured amorphous arrays in biological systems, and then describe the fabrication and the optical nature of the artificially prepared imitations of such biological systems.

2. Structural colouration of blue bird feathers
The mechanism associated with the low-angle-dependent structural colouration of blue bird feathers has been debated for over a century. In early work, it was difficult to study the relationship between the fine structures and the colours of blue bird feathers because there was no means by which to identify the structures, such as electron microscopes. We can perceive that the researchers were having a hard time understanding the phenomenon.

Fig. 1 (a) A photograph of Cotinga maynana (Plum-throated Cotinga), revealing a low-angle-dependent blue structural colour, taken by Mr. Joel N Rosenthal. (Reproduced with permission from Mr. Joel N Rosenthal) (b) TEM image of the nanostructured medullary keratin-air matrix of the feather barb of Cotinga maynana. The scale bar is 0.5 μm.
time investigating the mechanism of the structural colouration not only of blue bird feathers but also of other anatomical structures and materials in nature. It was suggested that the blue colours in some bird feathers are caused by the microstructure of the feathers based on experimental studies demonstrating that there is no blue pigment in the feathers. Thus, many researchers have worked to understand the mechanism for a long time. Recently, Prum et al. explained that the nanostructure of the medullary keratin matrix of the feather barb is sufficient to yield a blue structural colour by constructive interference (Figure 1).[1]

3. The fabrication of Amorphous Arrays Composed of Submicron-sized Particles to Produce Structural Colours

Due to the existence of many living objects exhibiting low-angle-dependent structural colours, our group has tried to produce such a property in artificial materials. In particular, we focused on the low-angle-dependent structurally coloured anatomies that are composed of monodispersed submicron spherical particles and air cavities that are observed in the blue bird feather.[2]

We successfully prepared various coloured amorphous arrays without angular dependence using submicron-sized silica particles and black substances. For different-sized fine silica particles between 200 nm and 400 nm, various vividly coloured arrays can be produced (Figure 2).[3,4] This newly prepared, angular-independent structural-coloured colloidal amorphous array composed of submicron silica particles and black substances presents an environmentally friendly and non-fading pigment; thus, these coloured materials may have potential applications in various fields where highly toxic heavy-metal-containing pigments are used.

References:
Rare earth (RE) such as europium (Eu) forms a molecule with organic moieties and luminesces from the center RE ion via photo-induced energy transfer. Molecular structure and design have been difficult because of the electronic configuration. Recently, we succeeded to develop luminescent molecules with RE as shown in Figure 1. The molecules with a series of RE ions form helical structure and luminescence brightly even in solutions. Eu, Tb and Nd in the molecule show red, green and infra-red emission, respectively.

These luminescent compounds can be applied to hybrid-materials as the molecular films and the polymeric chain-structured compounds. The former one shows linearly polarized luminescence, and latter one does color-tunable luminescence by the mixing of Eu and Tb (Figure 2).

Glowing in the Dark –
The Colorful and Unique Luminescence of the Lanthanoid Metals

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Light-emitting systems are an integral part of almost all fields of modern scientific endeavors, for example as universally applied laser systems or in the form of biomedical fluorescence assays. The color and intensity of the emitted light are two of the immediately obvious characteristics accessible to the human eye but there are also a number of more subtle physical aspects to light that are at least as important for technological applications. The presentation will introduce the lanthanoid elements and the unique properties of the light that they emit upon excitation with photons (e.g. great color purity, long lasting light emission, emission of “chiral” light, etc.).\cite{1} These very favorable characteristics make the colorful lanthanoids an indispensable component of many high-tech photonic technologies of the future.

References:
**Azobenzene**【アゾベンゼン】: One of the representative photochromic compounds. Its molecular structure has benzene rings bonded to each end of a nitrogen-nitrogen double bond. Azobenzene shows photochromic reaction between the colorless trans isomer and the colored cis isomer. The following is the photochromic reaction of azobenzene.

![Azobenzene Reaction Diagram](image)

**Blue Bird Feather**【青い鳥の羽】: The mechanism associated with the low-angle-dependent structural colouration of blue bird feathers has been debated for over a century. In early work, it was difficult to study the relationship between the fine structures and the colours of blue bird feathers because there was no means by which to identify the structures, such as electron microscopes. We can perceive that the researchers were having a hard time investigating the mechanism of the structural colouration not only of blue bird feathers but also of other anatomical structures and materials in nature. It was suggested that the blue colours in some bird feathers are caused by the microstructure of the feathers based on experimental studies demonstrating that there is no blue pigment in the feathers. Thus, many researchers have worked to understand the mechanism for a long time. Recently, Prum proved that the observed blue colour is caused by the constructive interference of light by fine air cavities through spatially distributed scattering.

**Colloidal Amorphous Array**【コロイドアモルファス集合体】: In contrast with the colloidal crystal, we call the array with short-range order the "colloidal amorphous array". The colloidal amorphous array has short-range order, although the arrangement of the colloidal amorphous array appears random compared with the colloidal crystal. The arrangement of the colloidal amorphous array is isotropic due to the lack of long-range order. Thus, colloidal amorphous array can display angle-independent structural color.

**Diarylethene**【ジアリールエテン】: One of the representative photochromic compounds. Its molecular structure has aromatic groups bonded to each end of a carbon-carbon double bond in cis configuration. Diarylethene shows photochromic reaction between the colorless open-ring isomer and the colored closed ring isomer. The following is the photochromic reaction of one of the representative diarylethene.

![Diarylethene Reaction Diagram](image)
**Molecular Electronics**【分子エレクトロニクス】: The study of electrical and electronic processes measured or controlled on a single molecule or very few molecules. It has been developed by accessing individual molecules with electrodes or other probes and exploiting their structure to control the flow of electrical signals from them and to them.

**Molecular Machine**【分子機械】: An molecule or an assembly of molecules that produce mechanical movements in response to specific stimuli, resembling functions of macroscopic machines. Molecular machines are easily found in biological systems, such as muscles.

**Photochemical Reaction**【光化学反応】: Chemical reaction which is induced by the absorption of light. When the light is absorbed into the molecule, the energy of the photon is transferred to the molecule and then the molecule becomes excited state. The molecule in the excited state can undergo chemical reaction. Photosynthesis is one of the photochemical reactions.

**Photochromism**【フォトクロミズム】: Reversible transformation of a chemical species between two forms in which at least one direction of the reversible transformation is induced by the absorption of light. Because two forms have different color in general, this phenomenon is called photochromism.

**Structural Color**【構造色】: Structural colour is generally defined as a colouration caused by complicated and diverse interactions between light and materials, such as interference effects, diffraction grating, light scattering, and dispersion of refractive index, and it essentially does not lose the energy of the light. For the reason, structural colour has been the subject of extensive studies for applications in energy saving mobile devices with a reflective full-color paper-like display.

**Visual Pigment**【視物質】: Substances that function in light reception by animals by transforming light signal into nerve signals. A colored molecule called retinal and a protein called opsin compose the overall visual pigment named rhodopsin. When the light is absorbed into retinal, the molecular structure of retinal and also the structure of overall rhodopsin change, then the electric nerve signal is generated.
Natural User Interfaces: Introduction and Overview

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The term “Natural User Interfaces” (NUI) encompasses interaction styles and techniques enabling users to interact with computer systems in a “natural”, intuitive way. Thus, NUI extend the notion of classical Graphical User Interfaces (GUI), which contain interface elements such as windows, icons, menus and so forth and are usually controlled with input devices like keyboard and mouse.

The term “NUI” summarizes a wide variety of interaction techniques, including multi-touch displays, which are already widely used (e.g. in smartphones or tablets), speech-based systems, gesture-controlled interfaces (to be found e.g. in gaming applications such as Nintendo Wii), but also seemingly more “futuristic” interaction techniques such as eye gaze control or Brain-Computer Interfaces.

In my introductory talk I will introduce different types of Natural User Interfaces and discuss their potential, but also the challenges associated with these interaction styles from a usability viewpoint. Also, similarities and differences will be explored. In doing so, promising application areas will be explored, which will pave the way for the subsequent talks.

Suggestion for Reading:
To Support, Improve and Enhance Human Capabilities – Robot Suit HAL

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1. Introduction
Wearable robot was developed to enhance human ability by physically integrating the human and the machine. One of the important issues in developing wearable robot is the interface technology to seamlessly connect the human and the machine. A novel wearable robot, we have developed - “Robot Suit HAL (Hybrid Assistive Limb)” is designed to support, enhance, and improve human physical functions. As innovative interface technology for motion support, HAL has a hybrid control system that uses two distinct controllers, which consist of a voluntary controller based on the wearer's voluntary drive and an autonomous controller providing pre-defined motion. Currently, an advanced challenge of medical application using HAL's interface technology has begun. During this symposium, we will introduce the basic technology to seamlessly connect the wearer and HAL, and the leading edge its advanced application.

2. Robot Suit HAL
HAL has an articulated structure designed to support the mechanical functions of the human lower body. It consists of a frame and active joints, and is closely attached to the user's lower limbs. The assistive torques are generated by the power units at the hips and knees. Each unit integrates an actuator, a microprocessor, and a communication interface into one sub-system. The motion support is achieved by transmitting the torques of the power units to the user's legs through the exoskeleton’s frames.

3. Motion controller for the HAL
Voluntary Control: The voluntary control provides the physical support according to the wearer's voluntary muscle activity. The power units of the HAL generate assistive torques, thereby amplifying the wearer's own joint torques. The joint torques are estimated from the wearer's bioelectrical signals, which are detected at the surface of the muscles. These signals are then used as input commands to
control the HAL according to the wearer's intentions to move. By using this property of the human body, the controller can predict the start and the generation of the muscles' forces, and use these as the motion commands.

Autonomous Control: The autonomous control uses the phase sequence method with human motion characteristics to enable HAL to generate human-like motion in an autonomous way. First, the functional motion of an able-bodied person is recorded, and analyzed based on motion variables and the wearer's physiological data. Then, the reference motion patterns are divided into motion sequences or motion phases. This division is made according to specific intended motions such as "swinging the leg" or "lifting the body". The motions of the resulting phases are then stored in the HAL. Each phase is further adjusted in terms of duration and amplitude depending on the wearer's characteristics such as his/her body parameters or medical condition. Finally, the phases are combined to obtain the whole motion pattern to be executed by the HAL. As a result, the HAL allows the wearer to perform required functional motions such as walking, sitting, and so on, in an autonomous way.

4. Clinical Applications of HAL

Clinical application of HAL for patients with motor disability has been steadily promoted. The HAL assists motion by myoelectric activity on the basis of the patient's voluntary drive. The voluntary drive and thus the motion normalized by the assistance provided by the external device forms the foundation for a proprioceptive feedback loop for patients with lesions involving the sensory pathways. The neural activity associated with voluntary drive and normalized motion while repeatedly and intensively executing specific tasks promotes learning and then leads to the reinstatement or restructuring of appropriate proprioceptive feedback. This mechanism explains the therapeutic effect of locomotor training using HAL from the viewpoint of neurorehabilitation. Bergmannsheil university hospital in Germany has developed a treatment approach for on the neurorehabilitation using HAL. Significant improvement of the motor functions for patients with spinal cord injury was reported.

Conclusion

We introduced the hybrid control system which consists of the voluntary control to operate the HAL with the wearer's voluntary drive and the autonomous control to generate human-like motion as the key technology of the interface to seamlessly connect between human and wearable robot. Furthermore, we demonstrated the advanced clinical applications of the HAL. Near future, we expect to extend HAL applications other fields as heavy work support, entertainment, etc. Moreover, we are going to widely apply the HAL interface technology to communication and life supports for severely-disabled persons and those who require nursing care.
On the Role of Machine Learning in Brain-Computer Interface Research

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The reliable decoding of brain states in real-time is a hard problem, and only the massive use of machine learning methods has led to the breakthrough of brain-computer interface (BCI) systems. While originally designed to establish a novel communication channel for severely motor impaired patients, BCI neurotechnology today has gained influence on neuroscientific research and allows to address novel clinical research topics which require an instantaneous classification of brain signals, e.g. to provide closed-loop feedback. In my talk, I will first explain the basics of BCI systems. Then I will point out current data analysis challenges in the field of mental state decoding (non-stationarity, multimodal recordings, high dimensional signals, low number of data points, low signal-to-noise ratio) and review the latest machine learning approaches to tackle them.
Bioelectrical Signals【生体電位信号】: the electrical signals detected from nerves or muscles for example brain, eyes, heart, skeletal muscles, etc. In case of HAL, the bioelectrical signals are detected from muscles’ activity and used to determine the wearer's intentions to move.

脳、眼球、心臓、筋の活動に伴って計測される微弱な電位信号．HALでは、筋から検出される生体電位信号を運動指令信号として使用する。

Neurorehabilitation【ニューロリハビリテーション】: an advanced rehabilitation to promote neural function recovery based on neuroplasticity that allows the neurons (nerve cells) in the brain to compensate the loss of function due to injury and disease, and to adjust their activities in response to new situations or to changes in their environment.

脳損傷後の機能回復過程において、中枢神経の構造や機能が再構成されるという神経可塑性に基づき、脳・脊髄損傷後の神経機能回復の促進を目的にしたリハビリテーション

Wearable Robot【ウェアラブルロボット】: a specific type of wearable device with actuators that is used to enhance a person's motion and/or physical abilities. It is also can be called “exoskeletal robot”, and “powered suit”.

アクチュエータを供えた人体に装着する機器．装着者の運動の支援や身体能力を高めるために利用される．外骨格ロボットやパワードスーツと呼ばれることもある．
Interaction Rituals in a Globalizing World

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Sociological research about globalization and world society usually is concerned with real “big things” like increasing structural interconnectedness and global cash and trade flows. Most authors don’t care about studying such small and putatively irrelevant phenomena like face-to-face encounters. There are only a few exceptions: One of them is Karin Knorr Cetina (2009) and her research about the “global microstructures” of interbank currency trading in global investment banks.

Another example are the studies of Bettina Heintz (2014) about global interactions which refer to a special kind of face-to-face meetings reaching out far beyond the locality or region where they take place. One of the most striking examples for such global interactions are international conferences where people from all over the world come together to talk to each other about global issues. Despite the development of new communications technologies people are still traveling to meet face-to-face instead of talking via telephone or video conferencing. Therefore, Bettina Heintz claims the indispensability of face-to-face interaction, namely in a globalized world. Actually it seems that face-to-face interaction can perform some quite important functions, which cannot be substituted by telecommunication.

In my introductory talk I like to present some examples for global interactions from an actual research project about United Nations World Conferences (URL: http://www.uni-bielefeld.de/soz/iw/research/projects/observe.html). The issues dealt with are at the cutting edge of at least three different disciplines: sociology, media sciences and political sciences.

References for further reading:
General Review Article on Face-to-face Interaction in the World Society

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The concept of face-to-face interaction

The concept of “face-to-face interaction” is one of the rare cases in sociology with a common understanding. According to Erving Goffman face-to-face interaction is “the reciprocal influence of individuals upon one another’s actions when in one another’s immediate physical presence” (Goffman 1959: 12). Goffman was one of the most popular sociologist of the 20th century, who established a sub-field of sociology to study the practices of interaction. Thus, co-presence is a necessary prerequisite of interaction, which means that “persons must sense that they are close enough to be perceived in whatever they are doing, including their experiencing of others, and close enough to be perceived in this sensing of being perceived.” (Goffman 1963: 17)

When people enter the presence of others they are able to sense each other with their unaided senses and everybody can see what the other is doing and can also see that the other can see this, too. Furthermore co-present people are sharing immediate surroundings and experiences. You don't have to explain where you are and that the sun is shining, because everybody knows and can see by itself. So under the condition of co-presence a special mutuality arises (even a kind of we-feeling), and some sort of interdependency of action is bound to arise. In the immediate presence of each other people are inevitably sources of information for one another producing a kind of compulsion to present yourself. So people give (and get) information about each other through their actions (resp. the observation of them) and the content of their talk, but they also give information involuntarily as a product of their presence and appearance. So if one (EGO) perceives the perceiving of the other (ALTER), he (EGO) inevitably will orientate his behavior towards his assumption about the interpretation of his own conduct by the other (ALTER) – and vice versa. So, this co-presence is the “body to body starting point” of a special kind of social reciprocity and results in the emergence of a special social order, which Goffman (1983: 2) calls “interaction order”:

“In speaking of the interaction order I have so far presupposed the term “order,” and an account is called for. I mean to refer in the first instance to a domain of activity—a particular kind of activity, as in the phrase, “the economic order.” No implications are intended concerning how “orderly” such activity ordinarily is, or the role of norms and rules in supporting such orderliness as does obtain. Yet it appears to me that as an order of activity, the interaction one, more than any other perhaps, is in fact orderly, and that this orderliness is predicated on a large base of shared cognitive presuppositions, if not normative ones, and self-sustained restraints.” (Goffman 1983: 5)
**Mediated Communication as substitution of face-to-face interaction**

In the last 20 years the sociology of interaction has become more peripheral within sociology. Especially since the proliferation of mass media and new information and communication technologies, there is fairly little research about the interaction order. Most sociological theories even assume that in modern societies there is a loss of face-to-face interactions. New communication and information technologies are often considered as a substitution for co-presence (Boden/Molotch 1994). So, in contrary to the former understanding of interaction as physical encounter of people at the same place and the same time, recent media research drop the criteria of co-presence. Often the terms of interaction and interactivity are used synonymously for phenomena of synchronous communication which results in a generalization of the concept of face-to-face interaction.

**Face-to-face interaction and globalization**

With a view to processes of globalization most sociologists recognize the advent of new communication technologies as a key condition for establishing world society. So, research about globalization and world society usually don’t care about studying face-to-face encounters. There are only a few exceptions. One of them is Karin Knorr Cetina (2009) and her research about the "global microstructures" of interbank currency trading in global investment banks (Knorr Cetina/Bruegger 2002). In her analysis the central characteristic of those electronically mediated trading deals all over the world is that physical co-presence is not as important for communication as temporal synchronicity: to observe the market and its prices simultaneously on a monitor in Frankfurt as well as in Tokyo makes it possible for traders around the world to talk to each other as if they were at the same place.

Another example for research about global microstructures are the studies of Bettina Heintz (2014) about global interactions. Global interactions are a special kind of face-to-face meetings, which reach out far beyond the locality or region where they take place. One of the most striking examples for such global interactions are international conferences where people from all over the world meet and talk to each other about global issues. Starting point of her considerations is the observation that in spite of the development of new communications technologies people are still traveling for many opportunities to meet face-to-face instead of talking via telephone or video conferencing (Denstadli et al. 2012; Urry 2002; Greschke 2012). And everybody knows from his/her own experience that it still makes a difference considering your own behavior whether you talk to somebody face-to-face or via internet (Boden/Molotch 1994). Actually, there is even an increasing scale of real-world traveling that has grown simultaneously with the proliferation of communication devices that might substitute for travel. Therefore, Bettina Heintz claims the indispensability of face-to-face interaction, namely in a globalized world. Actually it seems that face-to-face interaction can perform some quite important functions, which cannot be substituted by telecommunication.
References


1. Theoretical background: The agency of nonhumans and ritual performativity

In recent years, most anthropologists influenced by Science and Technology Studies (STS) have tried to establish a new approach to analyzing human-nonhuman relations, to pioneer a new genre of posthuman/multispecies ethnography. Focusing on interactions between humans and various nonhumans such as animals, plants, spirits and technologies, these scholars have explored the actual effect of nonhuman agency on humans. This new approach has opened up a way to transcend the anthropocentric analysis of social science: it has shown that we are not always the primary subjects in interactions with nonhumans, but rather are patients affected by and entangled with the force and agency of nonhuman entities.

This new perspective has important implications for the analysis of ritual, one of the most ‘traditional’ topics of anthropology. The new approach focuses on not merely the symbolic or the epistemological, but rather actual and ontological human-nonhuman relations and their effects. As we will see in this paper, in a ritual where various actors meet and interact, the agency of nonhumans—such as spirits and deities—affects people’s practices in constructing a new reality, even though not all the participants consciously ‘believe in’ these nonhuman entities. This study focuses on this performative effect of ritual conducted by both humans and nonhumans.

2. Case: Engineers meet spirits; spirits meet machines in the SEZ

In this paper I analyse the relationship between humans and nonhumans, including deities and machinery, focusing on new mega-industry and būta (spirit) worship in Mangalore Taluk, Karnataka, India. Būtas are generally considered as both the wild animal spirits and the śakti, or power, in the forests. In the būta ritual, the performances of the mediums embodying this wild śakti are crucial: incarnated in the mediums’ bodies, nature is personified as a social agent that can interact with humans.

Since the 1990s, an extensive project has aimed at the construction of the Mangalore Special Economic Zone (MSEZ). In the course of this project, several villages and numerous būta shrines have been destroyed. At the same time, through the discourse of the environmental movements opposed to the MSEZ, būtas have begun to be recognized as symbols of nature and ‘traditional culture’ in the area.

Furthermore, the agency of the būtas has had a considerable effect on people’s lives, even within the MSEZ. People often infer the agency of the būtas from the operation of machines in plants. After an explosion, plant workers—including foreign engineers—double their efforts to ensure that technological
solutions are in place, but they are also forced to deal with būtas, which the workers and villagers regard as the deeper cause of the accident. Here, būta worship inside the plants functions as the intermediator between the people and the new environment of machines, technologies, and invisible power. Through spirit possession and ritual practices, people performatively relate themselves to this environment, transforming the machines from mere materials into social agents, and thus (re)create their ways of inhabiting the world.

References
Transnational Migration, Border Regimes and the Localization of Inequality in Southern Ghana

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The presentation examines how macrostructures of global inequality and their inherent contradictions become localized by transcontinental migrants in southern Ghana. Empirically the focus will be on a class of migrants which is called Burgers. In abstract terms, Burgers can be defined as persons that have achieved middle class status in Ghana by doing working class jobs in Western Europe or North America. As a result, they experience a status inconsistency that I call the transnational status paradox of migration. It is a manifestation of gains of buying power that can be achieved by transferring resources across unequal border regimes. The Burgers’ appearance in the emigration areas of Ghana creates irritations especially among the established middle classes. They are overtaken in terms of wealth by migrants who in respect to other status markers (like education or family background) should be below them in terms social hierarchy. The Burgers’ contextless economic capital based on transnational transfer gains could become a threat to the established status order in Ghana if it does not achieve some legitimacy within the local field of status attribution. In this context, redistribution of resources and collaborative silences within local reference groups were important social means through which the paradox of migration could be translated into an ambivalent but partly legitimate local social status.
GLOSSARY

Culture 【文化】: Patterned ways to behave and think shared by a certain group people.

Globalization 【グローバリゼーション】: The fact that different cultures and economic system around the world are becoming connected. As a result, it strengthens (the perception) of worldwide social networks, communication, practices, symbols, events, risks and rights.

Global Microstructures 【グローバル・ミクロ構造】: Social structures that connect and integrate people and things on a global scale and bring them into close social proximity even though they are territorially dispersed.

Interaction 【相互作用】: An encounter between individuals in which the participants exchange signs in order to coordinate their behavior.

Multispecies Ethnography 【多種民族誌】: Multispecies ethnography is a new genre of ethnography that investigates and describes human-nonhuman relations and cross-species interaction. With a focus on various nonhuman subjects linked to human social worlds, multispecies ethnography challenges traditional ways of defining the boundary between the human and nonhuman and has facilitated non-anthropocentric ethnographic writing.

Ontological Turn 【存在論的転回】: Ontological turn is a term that describes a recent theoretical shift in anthropology from questions of knowledge and epistemology toward those of ontology. It is a shift in analytical focus from the question of how we/they recognise the world around us/them to one of how heterogeneous worlds emerge and are transformed through interactions and encounters with humans and nonhumans.

Performativity 【パフォーマティヴィティ】: The term performativity originally derives from How to Do Things With Words (1962) by J. L. Austin, who introduced the term ‘performative utterances’ to analyse situations where saying something did something and did not simply describe reality. This notion has broadly influenced the anthropological study of ritual and magic, which has developed the idea that magical spells can effectually construct reality itself. Judith Butler has further developed the idea of performativity. Butlerian performativity is not necessarily based on the internal identity of an intentional subject; rather, a particular identity is constituted, as well as deconstructed, through the repetition of performative actions, behaviours, and gestures. Performativity problematises notions of internal intention and agency and presents a new perspective for analysing the constitution of subjects, identity, and reality.

Ritual 【儀礼】: A formalized mode of behavior in which the members of a group regularly engage. In contrast to routine behavior rituals have symbolic meaning: they allow participants to have experiences they usually, in every-day life, can not have (talk to gods, meet their dead ancestors etc.). Rituals cause strong emotional reactions and create a sense of community even among people who never meet and do not know each other in person.

Science and Technology Studies 【科学技術論】: Science and technology studies or Science, Technology and Society (STS) is a new academic field that studies science and technology as social practices embedded in social relations and cultural meanings. The field encompasses
historical, sociological and anthropological studies of science and technology, and it typically studies how social and political structures, and cultural values affect scientific research and technological innovation and vice versa.

**Spirit Possession** 【精霊憑依】: Spirit possession is a comprehensive term for phenomena in which animas, demons, gods, or spirits enter the human body and influence a person in various ways.

**Symbol** 【シンボル】: A type of sign that allows for the experience of transcended realities. While ordinary signs cross boundaries within the world of everyday life, symbols cross boundaries to social realities that are lying beyond the horizon of direct experience.
Formation of Structure in the Cosmos: 
Confronting Theory with Observations across Cosmic Time

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Remarkable progress has been made in our understanding of the formation of structure in our Universe from the initial density fluctuations present just after the Big Bang to the massive galaxies and their large-scale distribution that we see today. While cosmological simulations and semi-analytic models of galaxy formation appear to reproduce many of the observed properties, it is unclear whether they accurately reproduce the detailed physics. Especially because key astrophysical questions remain such as what process is responsible for shutting down the global formation of new stars in galaxies and halting the mass buildup of supermassive black holes from the peak epoch of growth to today. The rapid development of wide and deep observational surveys of the galaxy distribution with large telescopes from both the ground (e.g., ESO’s Very Large Telescope) and in space (e.g., Hubble Space Telescope) is paving the way for new insights into such questions. In particular, the Subaru Telescope, recently mounted with a new wide-field imager ‘Hyper-Suprime-Cam (HSC)’, will build upon surveys, such as COSMOS, by mapping the sky with an unprecedented combination of area and depth. To follow, Prime-Focus-Spectrograph (PFS) will trace the three-dimensional distribution of close to one million galaxies thus elucidating our understanding of the relationship between galaxies and their larger-scale environments dominated by dark matter, an enigmatic component of our Universe.
Cosmological Structure Formation on Supercomputers

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Large-scale cosmological simulations utilizing the modern supercomputers play a significant role in the theoretical studies of the structure formation in the Universe. They are essential tools to accurately calculate theoretical predictions of the distribution and state of the baryonic and dark matter in the Universe. Since their beginning in the 90th they are one of leading applications for high performance computing. Current generations of simulations take into account a large range of physical processes and thereby come very close to resemble the real universe throughout the entire epoch of structure formation. I will introduce recent simulation campaign, where the formation of cosmological structures are followed in so far unaccomplished detail, covering up to Gpc\(^3\) volumes, which allow a self consistent comparison to observations at multiple wavelength.
Cosmic Microwave Background Radiation (CMB) –
Seeds of Structure Formation in the Universe

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Cosmic Microwave Background radiations (CMB) are remnant of the Big Bang. The Big Bang was very hot and dense epoch in early universe, its thermal radiations are observed as radio waves, i.e., CMB, today. In the long history of universe, there was almost no interaction for CMB. Therefore, CMB shows us a childhood image of the universe, approximately 380,000 years old. That is the epoch before the first star formation, i.e., the image of CMB shows seeds of the structure formation.

First discovery of CMB was 1965 by Penzias and Wilson as uniform background radiations from the universe. They got Nobel prize about the evidence of the thermal radiations of Big Bang. More precise measurements were done by COBE satellite experiment (1989). COBE also found the anisotropy of CMB, i.e., seeds of the structure formation. WMAP (2001) and Planck (2009) satellite missions gave us very precise map of the seeds, which also provides deep knowledge about cosmology.

In this presentation, I would like to cover the latest hot topics. Recent observations for polarization components of CMB have potential to prove Inflationary Universe, which is the source of the Big Bang.
**Active Galactic Nuclei (AGN)**: A supermassive black hole that is accreting heated matter from its surroundings. AGN is usually extremely bright such that it outshines its host galaxy.

**Anisotropy**: see Isotropy

**Baryon**: A composite particle made of three quarks. Protons and neutrons are baryons most familiar to us.

**BICEP2**: An experiment which observed CMB polarization pattern precisely using a ground-based telescope at the south pole.

**Big Bang**: A cosmological model for the early development of the universe. The basic idea is that the universe is expanding. Consequently, the universe was denser and hotter in the past.

**B-mode and E-mode**: Patterns in CMB polarization. There are two components. A symmetric pattern, E-mode (named in analogy to electrostatic fields), represents the anisotropy of CMB. The other is an asymmetric pattern, B-mode (named in analogy to magnetic fields).

**CMB (Cosmic Microwave Background Radiation)**: Thermal radiation derived from the Big Bang. It is fundamental to observational cosmology because it is the oldest light in the universe, dating to the epoch of recombination. The accidental discovery of CMB in 1964 by American radio astronomers Arno Penzias and Robert Wilson earned the 1978 Nobel Prize. The seeds of the structure formation are observed as anisotropy of CMB.

**COBE**: A satellite dedicated to study CMB launched in 1989. It discovered the anisotropy of CMB as well as very precise blackbody-spectrum of CMB. The former was the first observation of the seeds for the structure formation in the universe. The latter was the strong evidence for the Big Bang.

**Cosmic Web (Large Scale Structure)**: large scale distribution of galaxies (and dark matter) that form a filamentary pattern in three-dimensional space with regions either highly-populated or devoid of galaxies.

**Dark Energy**: A pervasive form of energy that provides a pressure responsible for the accelerated expansion of our Universe.

**Dark Matter**: Most prevalent form of matter that does not interact with light and hence can only be accounted for through the effects of gravity.

**Inflationary Universe**: Accelerated expansion of space in the early universe “before the Big Bang”. Quantum fluctuations were the seeds for the growth of structure in the universe.
**Isotropy**【等方性】: The flatness of the observed universe. Anisotropy is the non-flatness. The standard universe is thought to be isotropic and if an anisotropy is observed, that could be an evidence of quantum fluctuations.

**Gravitational Lensing**【重力レンズ】: a technique to detect dark matter through the deflection of light due to a warping of space by a mass concentration in the foreground to a more distant light-emitting object.

**Gravitational Waves**【重力波】: Ripples in the curvature of space-time that propagate as a wave. It was predicted in 1916 by Albert Einstein to exist on the basis of his theory of general relativity.

**Planck【PLANCK衛星】**: A space observatory operated by the European Space Agency (ESA). It was launched in 2009 observed anisotropy of CMB and cosmic infrared background radiations, with high sensitivity and small angular resolution.

**Recombination**【再結合】: The epoch at which charged electrons and protons first became bound to form electrically neutral hydrogen atoms. Universe was roughly 378,000 years old.

**Redshift**【赤方変移】: displacement of light towards the red end of the electromagnetic spectrum due to the expansion of the Universe causing all galaxies to be moving away from each other.

**Spectrograph**【分光装置】: An instrument that can disperse light in wavelength usually in the optical or near-infrared when mounted on ground-based telescopes such as Subaru Observatory.

**Stellar Mass**【星の質量】: An amount of matter locked in stars as observed in ultraviolet to infrared light as given off by the population of stars in individual galaxies.

**Subaru Telescope【すばる望遠鏡】**: A ground-based telescope in Hawaii equipped with a 8.2m diameter mirror in the optical and near-infrared wavelengths.

**WMAP【WMAP衛星】**: A satellite CMB telescope (2001 – 2010) which aimed for precise measurements of CMB anisotropy. It gave a deep knowledge about the universe, e.g., age, energy composition.
The Diversity of Exoplanet Atmospheres

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Nearly two thousand planets have already been detected around other stars (http://exoplanet.eu). Each new discovery highlight the stunning diversity of planetary systems, including giant planets orbiting their host stars within a few days, extremely hot rocky planets with a lava ocean on their surfaces and even potentially rocky planets in the habitable zone of their stars. All these different worlds are expected to have very different atmospheres (Miguel et al., 2011; Kaltenegger et al., 2012). Current observational techniques allow us the detection of chemical species as well as physical structure of some exoplanet atmospheres (e.g., Snellen et al., 2008; de Kok et al., 2013; Brogi et al., 2013; Birkby et al., 2013). The spectral signature coming from an exoplanet atmosphere gives us the information to explore them over light years away, providing information of its origins and controlling its size and appearance. The study of exoplanet atmospheres is crucial to understand planetary formation and exoplanetary physics. In this talk I will present the last advances in this exciting field and the prospects for the future.

Further Reading:
The Exact Timing of the First Rise of Free Oxygen in Early Earth’s Atmosphere

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The oxygenation of our planet’s atmosphere is one of the major prerequisites to stabilize climatic Earth surface conditions and thus allowing the development of higher life-forms. Observations from the geologic rock record place a first significant increase in free atmospheric oxygen somewhere between 2.6 and 2.0 Gyrs ago. Mass-independent fractionation of S isotopes (MIF-S) dates the rise of O₂ to > 10⁻⁵ of the present atmospheric level – the great oxidation event (GOE) – even more precisely between 2.4 and 2.32 Gyrs [1]. Recent studies propose stable isotopic variations of transition metals in oceanic sedimentary archives to be yet more sensitive tracers for the detection of oxygen in Earth’s atmosphere-hydrosphere system than MIF-S. Thereby, stable Cr and Mo isotopic variations in up to 2.9 Gyr-old paleosols, banded iron formations (BIFs) and black shales were interpreted to indicate that oxidative weathering on the continents was already initiated some 500 Myrs before the GOE [2-4]. However, interpretation of these isotope signatures as unequivocal evidence for free O₂ so early in Earth’s history was challenged [5], as was the continuity of an oxygenic atmosphere after the GOE.

I will present new stable isotope data of redox-sensitive transition metals from 2.9-1.85 Gyr-old marine sediments from the Pilbara Craton (AU), the Fennoscandian Shield (RS) and the Kapvaal Craton (ZA) indicating (i) a relatively constant increase of free O₂ starting at 2.54 Gyrs and (ii) the continuity of free oxygen in the atmosphere-hydrosphere system after the GOE down to 1.85 Gyrs.

References:
Bioavailable Energies in the Hydrothermal Systems on Early Earth and Enceladus

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It is believed that life emerged in a seafloor hydrothermal vent system on Earth during Hadean era (before 3.8 billion years ago). In the Hadean hydrothermal system, a mixing between hydrothermal fluid and ambient seawater likely caused various redox reactions that had the potential to provide exergonic energies to proto- or early life forms as bioavailable energies. However, it is still uncertain which redox reactions generated sufficient energies to maintain the earliest life. Thus, we thermodynamically calculated bioavailable energies generated in the Hadean mixing zone. The results revealed that the redox reactions using CO2 in seawater and H2 in hydrothermal fluid could generate sufficient energy to maintain life forms, suggesting that the primordial metabolism might be established based on these redox reactions. Ideally, this hypothesis should be supported by objective evidence but almost all the Hadean geologic records have been obliterated over the Earth history. Accordingly, the clues to the origin of life on Earth can only be found in extraterrestrial oceans. A recent research by Cassini spacecraft suggests that hydrothermal activities are going on in an ice-covered ocean on the Saturnian moon, Enceladus. Therefore, we thermodynamically estimated the composition of a possible hydrothermal fluid and calculated bioavailable energy in the mixing zone between the hydrothermal fluid and seawater in the Enceladus’ ocean. The calculations indicate that a certain level of bioavailable energy is also generated by the redox reactions of CO2-H2 pair in the Enceladus hydrothermal system. The chemical and energetic similarity between the hydrothermal systems on Hadean Earth and Enceladus implies that Enceladus’ ocean can be a modern analogue of the Hadean terrestrial ocean.
Exergonic Energy 【発エルゴン反応】: Energies generated by chemical reactions (antonym: endergonic energy). Life uses exergonic energies generated by reduction-oxidation reactions as metabolic energies.

Hadean Mixing Zone 【冥王代（熱水・海水）混合域】: A mixing zone between a hydrothermal fluid and ambient seawater in the Hadean era (before 3.8 billion years ago). It is believed that life emerged in the Hadean mixing zone. A mixing between hydrothermal fluid and seawater potentially caused various reduction-oxidation reactions that generate energies necessary for early life.

Hydrothermal System 【熱水システム】: A place where underground hydrothermal circulation occurs. In a subseafloor hydrothermal system, seawater infiltrates subseafloor rocks and descends downward, then heated by a heat source (e.g., magma) and rises up to the seafloor as a hydrothermal fluid. During hydrothermal circulation, original seawater chemically evolves due to reactions with surrounding rocks and inputs of magmatic gases.

Hydrothermal Vent 【熱水噴出孔】: A hole or crack in a planet’s surface (e.g., seafloor) from which hydrothermal water discharges. Hydrothermal vents are the final exits of whole underground hydrothermal circulation driven by magmatic heat source, which are commonly found near volcanically active places. Seafloor hydrothermal vents generally form cylindrical chimney-like structures owing to mineral precipitation.

(Hydrogenotrophic) Acetogenesis 【(水素酸化型)酢酸生成代謝】: A metabolic reaction through which acetate is produced from hydrogen and carbon dioxide (2CO2 + 4H2 → CH3COOH + 2H2O).

(Hydrogenotrophic) Methanogenesis 【(水素酸化型)メタン生成代謝】: metabolic reaction through which methane is produced from hydrogen and carbon dioxide (CO2 + 4H2 → CH4 + 2H2O).

Komatiite 【コマチアイト】: A type of low-silica volcanic rock, which erupted on the early Earth. Komatiites are considered to have been generated in the early hotter mantle that has cooled over the Earth history.

Redox Reaction (Reduction-Oxidation Reaction) 【酸化還元反応】: Reactions in which atoms have their oxidation state changed or electrons are transferred. Life uses redox reactions as metabolisms.

Serpentinization 【蛇紋岩】: A low-temperature hydration process of low-silica rocks (e.g., mantle rocks), in which ferrous iron in rocks is oxidized to ferric iron while water is partially reduced to hydrogen (e.g., 2FeO in rocks + H2O → Fe2O3 + H2).