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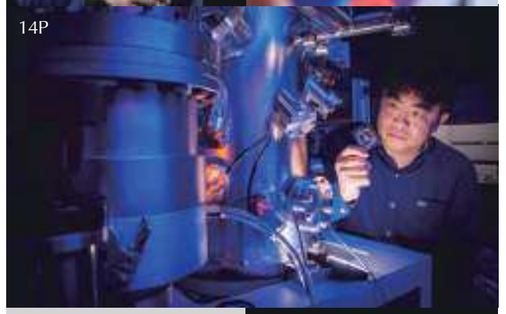

Stories that spark priceless insipirations

Congratulations for the publication of Yonsei Research Magazine Issue 5. I am glad to have this opportunity to introduce you the marvelous contributions made by many researchers.

In 1885, Yonsei University had established the very first hospital in South Korea, initiated the medical education and researches, and fostered Korea's first doctors of medicine in 1926. Going through the industrialization and the era of information, the research capacity of Yonsei has developed into a diverse spectrum of fields, now revealing its achievements across humanities, engineering, life system, and pharmaceuticals. As of 2019, we stand strong as a research-oriented university with the announcements of 2,002 published papers, and 737 registered patents with the utilization of the research fund of KRW 3,631 billion. Especially, we have been acknowledged for our accomplishments in establishing local start-up businesses and various industry-research collaboration models as we were ranked the first in the world in Industry, Innovation and Infrastructure by the UK's global university evaluation institution, THE(Times Higher Education), in 'The University Impact Rankings 2019'.

Yonsei of today is truly the fruit of our endeavor to build a research infrastructure of the global standards such as the launch of the global research collaboration platform, 'Frontier Research Center' and promoting the establishment of 'Yonsei Science Park', etc. We will continue to put efforts in reviewing our excellence in research by maintaining our focus on strategic decision making and actions, which includes our works of inviting outstanding researchers, building a sustainable research support system, etc.

Through Yonsei Research Magazine, I wish you to encounter interesting stories of Yonsei's hard-working researchers in each field. At Yonsei campus where lights never go off, our passion-driven researchers unfold their research performances. Brought to you, these stories will surely spark priceless inspirations in your heart.

The 19th President of Yonsei University *Seoung Hwan Suh*

Greetings from the President

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Life Science

Prof. Baik-Lin Seong's team determined

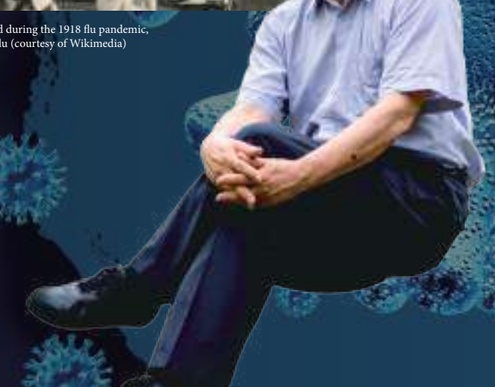
The cause of the high mortality rate of the 1918 Spanish flu

Professor Baik-Lin Seong's team (Department of Biotechnology, College of Life Science and Biotechnology) determined the cause of the high mortality rate of the 1918 Spanish flu, which is known as the deadliest infectious diseases in human history. The Spanish flu killed over 50 million people, which is several times more than the number of combatants who died in the First World War that had occurred around that time. Such high-risk influenza pandemics can cause immense human casualties and economic losses, and thus there is an urgent need for research on the etiology and treatment of such diseases. A joint research team led by Professor Baik-Lin Seong, Professors Kyun-Hwan Kim and Eun-Sook Park (Konkuk University), and Professor Kwang Pyo Kim (Kyung Hee University) identified the key factors and principle involved in the virulence of the Spanish flu virus.

The researchers noted that there was a mutation in a protein called PB1-F2 in the Spanish flu virus. They determined that this protein increases the virulence of the virus by strongly inhibiting interferon beta which fights against virus infections in our body. In other words, if the Spanish flu virus is like a long-range missile, then PB1-F2 destroys the interceptor missiles launched against it, thus rendering the human body vulnerable to viral infection. The PB1-F2 protein displays this capability only when there is a mutation in the amino acid at specific locations in the protein, as in the Spanish flu virus. A regular flu virus that lacks this mutation, and is less virulent, does not display this capability. The mutant PB1-F2 neutralizes the body's ability to defend against viruses by dissolving DDX3 (corresponding to an interceptor missile), a protein that is essential to interferon signaling. This increases the virulence of the virus, leading to a sharp increase in fatalities. Here, it is worth noting that genetic mutations that have nearly disappeared over the past 100 years are reappearing in recent viruses. For instance, after the global spread of the novel flu virus in 2009, a mutated strain similar to the Spanish flu virus was discovered in a severely ill patient, thus calling for vigilance on our part.

This study was supported by grants from the Ministry of Science and ICT and the National Research Foundation of Korea, and it was published on April 12, 2019 in the EMBO Journal (IF = 11.2).

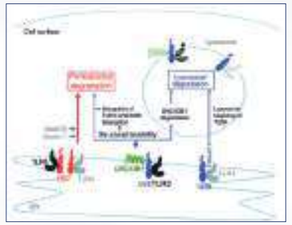
Hospital ward during the 1918 flu pandemic, aka Spanish flu (courtesy of Wikimedia)



Life Science

Prof. Bo-youn Park's Research Team

Discovers How a Chronic Infectious Virus (HCMV) Evades the Immune System



Schematic diagram of the immune evasion mechanisms of the US7 and US8 proteins derived from the HCMV virus.

The research team led by Professor Boyoun Park (Department of Systems Biology, College of Life Science and Biotechnology) discovered a mechanism by which proteins encoded by the human cytomegalovirus (HCMV) in the Herpesviridae family suppress antiviral immunity in the human body during infection. This study was published in the online edition of Nature Communications, a leading international journal ("HCMV-encoded US7 and US8 act as antagonists of innate immunity by distinctively targeting TLR-signaling pathways", Nature Communications, 2019 Oct.11; 10(1):4670).

When infected by a virus, the human body secretes interferons that play a key role in inducing an antiviral immune response, thus inhibiting the proliferation of the virus and activating the host's immune defense system. However, chronic infectious viruses such as herpesviruses can evade the body's immune response. Thus these viruses can remain in the body for a long time, and lead to various immune disorders causing infectious diseases, cancer, etc. Currently, about 60-90% of the world's population is infected with HCMV, and it can lead to a fatal disease in newborns with underdeveloped immunity or patients with a weakened immunity system (e.g., organ transplant and cancer patients, the elderly, etc.). However, at present there is no vaccine for HCMV infection, and there has been a dearth of research on the cellular immunological mechanism of HCMV. Therefore, it has been difficult to diagnose the virus and develop a cure for it.

Professor Boyoun Park's research team is the first to identify a mechanism by which the proteins US7 and US8, which are made independently by the HCMV virus, inhibit the signaling process of toll-like receptors (TLRs) that is essential for the antiviral immunity activation mechanism in the human body (Figure 1). It is expected that the results of this study will be useful in developing new drugs for treating chronic infectious diseases and autoimmune diseases. In addition, the study findings are expected to provide important clues to the development of treatments for immune disorders such as cancer and autoimmune diseases induced by the HCMV virus's immunity-suppressing mechanism or the generation of excessive immune activity through HCMV-derived proteins.

This study was led by Dr. Areum Park (first author) in Professor Boyoun Park's research team, with Dr. Sungwook Lee (Senior Researcher, National Cancer Center) and others collaborating in the research. Moreover, it was conducted as a strategic research project for mid-career researchers sponsored by the National Research Foundation of Korea, and as a disease-centered translational research project sponsored by the Ministry of Health and Welfare.

Life Science

Prof. Myeong-Min Lee's Research Team

Update understanding epidermis cell differentiation in plants

To become a fully functioning multicellular organism much like ourselves, developing cells need to "know" what their jobs are, what they should look like, and where they should be located—a process called cellular differentiation. To understand how cells differentiate, scientists have used model organisms such as the plant Arabidopsis. In Arabidopsis, roots develop properly only after two kinds of epidermal cells (hair and non-hair) form in the appropriate locations. A group of researchers from Yonsei University and the University of Michigan has now updated our current understanding of how plant cell fate is determined.

In a study published in the journal Nature Communications, the scientists led by Dr. Myeong Min Lee "mutated" or manipulated Arabidopsis genes to understand the molecular signaling pathway involved in differentiation of root cells. Previously, scientists had figured out that non-hair cells form due to the expression of a gene called GL2. The protein WEREWOLF directly triggers GL2 expression, whereas the protein CAPRICE suppresses this expression. WEREWOLF and CAPRICE have an interesting interaction: in cells with WEREWOLF, the protein increases CAPRICE expression. CAPRICE then moves to adjacent cells to suppress WEREWOLF and GL2 expression. On top of that, the signaling molecule SCRAMBLED is required for this entire process and also seems to repress WEREWOLF in cells with CAPRICE. What we do not know is how SCRAMBLED is regulated. To understand that part of the pathway, Dr. Lee and colleagues decided to look at QUIRKY, a protein that interacts with SCRAMBLED for unclear reasons.

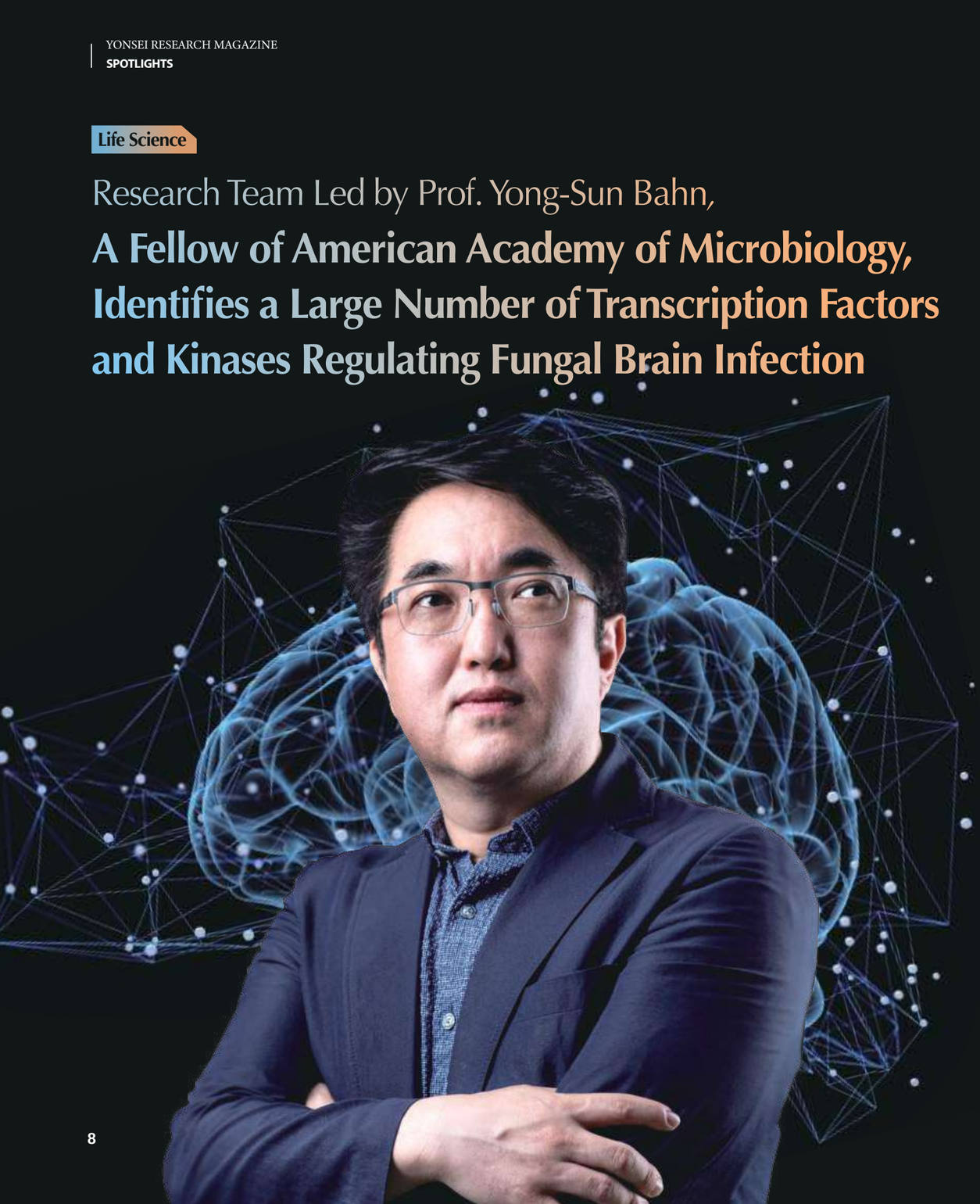
The researchers identified a mutant Arabidopsis plant harboring a mutation in the QUIRKY gene. The root cells in these plants were not properly developed, and experiments showed that WEREWOLF and CAPRICE genes were expressed in some epidermal cells regardless of their position, instead of being expressed in a position-dependent manner. Further experiments using plants with mutant QUIRKY and SCRAMBLED showed exactly how the two proteins interacted.

The protein QUIRKY (QKY) directly regulates the level of the protein SCRAMBLED (SCM) by preventing its degradation, which triggers the accumulation of another protein, called CAPRICE (CPC), in plant cells. This in turn suppresses the expression of the protein WEREWOLF (WER) and eventually leads to the formation of "hair cells," which form the plant epidermis to SCRAMBLED and thus stops the latter's breakdown by plant cells. This breakdown keeps SCRAMBLED from building up in certain cells, which allows WEREWOLF to work and trigger non-hair cell formation. So, when QUIRKY stops SCRAMBLED from degradation, it allows hair cells to form."

Life Science

Research Team Led by Prof. Yong-Sun Bahn,

A Fellow of American Academy of Microbiology, Identifies a Large Number of Transcription Factors and Kinases Regulating Fungal Brain Infection

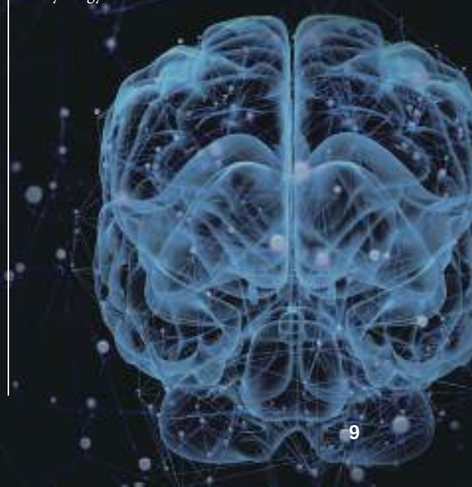


A research team led by Yong-Sun Bahn, Professor of Biotechnology at Yonsei University, has identified a large number of genes regulating brain infection by fungal pathogens*. This opens up new avenues for developing antifungal drugs and fungal brain infection medicine, a market worth KRW 15 trillion per year. Every year, about 1.5 to 2 million people across the world die of fungal diseases. Moreover, a series of recent studies have found that fungi are associated with various brain diseases including dementia, but there is still no clear explanation of how these fungi can cross the blood-brain barrier to cause such diseases. Among these, cryptococcosis is known to be a major fungal disease that infects at least 200,000 people worldwide and kills 180,000 people each year, and the market for treating the disease amounts to KRW 6-7 trillion per year. Professor Bahn's research team at Yonsei University collaborated with Professor Eunji Cheong's research team in the same department and AmtixBio Co. Ltd. to determine how the fungal pathogens cross the blood-brain barrier and to identify a large number of brain infection regulators. To achieve this feat, the research team used Cryptococcus neoformans, a fungus causing brain infections, as the model system in their study. The team was able to identify genes in the pathogenic fungus that are involved in adhesion to cells forming the blood-brain barrier or in crossing that barrier, along with genes that are important in the survival of the fungus within the brain tissue. In particular, a transcription factor called Hob1 was found to be the master regulator for the expression of key genes in the brain infection process, and also for the gene expression of previously established factors in brain infection. When these key genes regulating brain infection by the pathogenic fungus were inhibited, adhesion to blood-brain barrier cells, barrier crossings, and the degree of brain infection were reduced, and the survival period of the animal subjects was increased. Inhibitors for these key genes that regulate brain infection have not been developed yet, so developing such inhibitors for key genes such as Hob1 can lead to new kinds of antifungal treatment in the future.

Fungi that cause brain infections exist in various forms around us, and can infect us through our respiratory system. Although these fungal diseases usually affect patients with reduced immunity (such as HIV-infected, organ transplant, or cancer patients) or older persons, people with normal immunity can also be infected. Nonetheless, there are still no antifungal drugs that can effectively prevent these diseases, or treat them without harmful side-effects such as kidney and liver toxicity. In particular, after the fungal pathogens enter the bloodstream, they freely cross the blood-brain barrier between blood vessels and the brain, but even drugs that are quite small in size cannot cross the barrier easily. This imposes limits on using extant antifungal drugs to treat fungal infection in the brain. Currently, therefore, the research team is working with AmtixBio Co. Ltd. to obtain the relevant intellectual property by applying for a patent* on the use of genes regulating brain infection, and so on. Through such efforts, the team plans to lay the stepping stone for the domestic industry to enter the global antifungal drug market worth KRW 15 billion per year. Professor Yong-Sun Bahn stated, "Given the findings of our study, I believe it is possible to develop new antifungal drugs that inhibit the factors regulating brain infection by fungal pathogens." One of the co-researchers, Professor Eunji Cheong, also noted, "At present, the efficient delivery of drugs to the brain is the biggest obstacle for treating various brain diseases. However, by exploiting the factors regulating the crossing of the blood-brain barrier by brain-infecting pathogens, we can develop a novel drug delivery system that can cross that barrier. This could be an innovative drug delivery system with a wide range of applications that has a great value for the industry." The study, titled "Fungal kinases and transcription factors regulating brain infection in Cryptococcus neoformans" was published on March 23, 2020 in Nature Communications, one of the world's leading journals in life sciences.

Earlier, Professor Bahn's research team conducted a comprehensive study of the signaling networks regulating the biosynthesis of melanin, which is a key virulence factor for brain-infecting pathogenic fungi. This study was published as the Editor's Pick in the October 2019 issue of mBio, a world-renowned academic journal in microbiology, and selected as a recommended paper in F1000Prime by top scholars worldwide.

Based on his excellent research achievements in the field of mycology, Professor Yong-Sun Bahn was elected as a Fellow of the American Academy of Microbiology (AAM), which is affiliated with the American Society for Microbiology (ASM), on January 28, 2019. Fellows of AAM are selected through rigorous screening of scholars with outstanding academic achievements among ASM members working in the field of microbiology. Among Korean scholars, Professor Bahn has the distinct honor of being the fifth person to be elected as an AAM Fellow and the first in the field of mycology.



Medicine

A Pioneer in Genome Editing, Prof. Hyong-bum Kim

At the Department of Pharmacology of Yonsei University College of Medicine, the research team led by Professor Hyongbum Kim, who is currently an IBS researcher at the Korea Institute for Advanced Study, has succeeded in comparatively analyzing and verifying 13 different gene scissors using a high-throughput validation technique.

The gene scissors, known as CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), are artificial restriction enzymes that can cut a specific area of a given gene sequence to enable gene editing. Since their development, CRISPR gene scissors have been applied in a wide array of research fields, including gene therapy, the construction of disease models, and the elucidation of gene functions. At present, the most widely used CRISPR scissor is the Cas9 nuclease originating from Streptococcus pyogenes (SpCas9).

To solve the persisting problems of the SpCas9 requirement of a protospacer adjacent motif (PAM) sequence for cutting the target gene and the high off-target efficiency, a number of PAM variants and high-fidelity variants have been proposed. However, there has been no study to date that has made an accurate comparison of the proposed variants to identify which one should be used, leading to much confusion among researchers.

Prof. Kim's research team used a large-capacity validation technique to measure the editing efficiency according to the guide RNA target sequence of various SpCas9 variants. Consequently, the team has verified which variant to use for a specific PAM sequence as well as the difference in accuracy of various high-fidelity variants. Additionally, the team has developed an algorithm that predicts the guide RNA efficiency of different variants, thereby allowing accurate selection of the variant to use in a given research study.

As the study compared 13 types of variants simultaneously in large quantities, it was crucial to maintain identical conditions throughout all the experimental procedures. The challenges were in minimizing the differences among each experiment by conducting them simultaneously to avoid variation among different variants and in maintaining constant conditions, such as time, for several experiments.

On the basis of the system developed in this study, future experiments can be conducted in optimum conditions, where the most efficient guide RNA and variant for allowing accurate editing of the intended gene can be selected. The selected guide RNA and variant will be used to conduct genome editing studies regarding the treatment of various genetic disorders. For its excellence in research, this study was published in Nature Biotechnology, a renowned international academic journal, on June 8, 2020.

Prof. Kim has published globally recognized research findings in the field of genome editing. His most notable research achievements are a technique for measuring the activity of genetic scissors on a large scale and a technique based on deep learning or artificial intelligence that can measure CRISPR activity with great precision.

In recognition of his accomplishments, Prof. Kim has been awarded the Young Leading Scientist Award (2014), Pfizer Medical Research Award (2017), and Scientists of the Month Award (2019), among numerous other awards. From 2017, Prof. Kim served for two years as the coordinator of the Young Korean Academy of Science and Technology, and he has been the President of the Korean Association of Genome Editing since 2019.

Medicine

Prof. Sung-Joo Hwang Research Team

Tackling 'the Pain Points' of Painkillers

Most nonsteroidal anti-inflammatory drugs (NSAIDs) are known to cause gastrointestinal side effects because they disrupt the activity of enzymes that protect the gastric lining. The selectivity of one such NSAID, celecoxib (CEL), means that it does not have gastric side effects, and therefore, it can be used in the treatment of rheumatoid arthritis, osteoarthritis, acute pain, and inflammation. Interestingly, it is also known for its anticarcinogenic activity.

Its applications, however, are limited because CEL is poorly soluble in water. This is a problem, as poor solubility decreases the drug's bioavailability—the amount that enters the body's circulatory system. Instead of dissolving in water, the molecule tends to aggregate. Scientists call this poor wettability, a term used to refer to a solid's ability to attract and interact with liquids. Think, for example, about water-proof jackets, and how rain tends to flow down instead of making you wet. Something similar happens with this drug—instead of dissolving in the water of the bloodstream, it shuts itself off like a small, water-proof blob. This prevents cells from interacting with the beneficial chemicals that it carries inside. This broadly means that the actual utility of CEL is still limited owing to some very real drawbacks. So, how to develop a more effective drug that has immediate real-world applications?

To improve the properties of CEL, a group of scientists led by Prof Sung-Joo Hwang from Yonsei University, South Korea, decided to mix the drug with a water-soluble carrier. They used a eutectic mixture technique, which refers to a mixture in which components do not chemically interact, but rather improve the solubility of the other component(s). After screening various candidates, two chemicals were chosen to prepare eutectic mixtures: adipic acid (ADI), a compound naturally found in beet and sugar cane and used as a precursor in nylon production and as a gelatin additive, and saccharin (SAC), a sugar substitute.

Both ADI and SAC improved the solubility of CEL, increasing their wettability and dissolution rates. Prof Hwang states, "eutectic mixtures may be a novel formulation strategy to improve the solubility and oral bioavailability of CEL." In particular, the CEL–ADI mixture showed a higher dissolution rate, meaning that it dissolved faster than the CEL-SAC mixture.

"These mixtures significantly improve the solubility of CEL, increasing its potential for further anticarcinogenic applications as well as commercial uses as a painkiller," says Prof Hwang. Despite their gastric side effects, traditional NSAIDs are the most commonly used painkillers. Developing more efficient selective NSAIDs such as CEL, which do not have these side effects, could radically change the perception of NSAIDs and benefit millions of patients worldwide.

Medicine

The research team of Prof. Sang-woo Kim,

On Eliminating Contamination in Cancer Genome Analysis of Patient-Derived Models

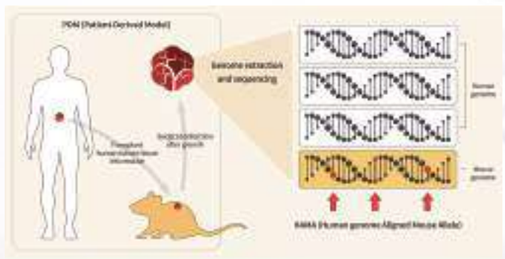
The research team of Prof. Sangwoo Kim (Biomedical Systems Informatics) has developed a method for enhancing analysis accuracy by reducing external factors which may occur during the analysis of patients' specimen of cancer cells.

Currently, the cancer research field has been actively conducting researches analyzing patient-specific genomic characters and drug sensitivity, etc. through the cancer tissue and genome of the patient in order to treat the patient's cancer accurately. Since having only the specimens taken from the patients may not be sufficient, the team gathers sufficient cancer cells by creating PDMs (Patient-Derived Model) such as the PDX (Patient-Derived Xenograft) method which multiplies patients' tumor cells in the bodies of test mice, or the PDOrg method (Patient-Derived Organoid) in which the multiplication takes place in materials similar to ECMs, calleed Matrigel. These methods, however, inevitably lead to contamination of mice DNA. This means the result of the research may include false mutations derived from the mice DNA should the typical genome analysis method for human be taken as it is. As such, the research team has developed an optimized method of analysis that analyzes the human genome contaminated by mouse genome, as it may happen in patient-derived models; and even prevents its occurrence in advance.

The research team has defined the false positive variant which could be detected because of differences in the genomic sequence between humans and mice as HAMA (Human Genome Aligned Mouse Allele). If this HAMA is found during the process of human genome mutation analysis, it may be falsely regarded as a significant disease-related genetic mutation. As such, the team has prepared and distributed a blacklist so that it could be eliminated during the analysis process in advance. Further, the team has revealed that a significant proportion of information in the already disclosed database of cancer-relating-mutations was in fact false information due to HAMA. They have also proposed a method of estimating the proportion of mice genome included in the PDM sequencing data, by utilizing the number of HAMA found through the sequencing data.

Lastly, the research team has generated 180 artifical contamination data to carry out a performance analysis of mice genome filtering tools which are currently developed. Through this, they have revealed the optimal contamination elimination method including the HAMA filtering. As a result of applying the optimal genome analysis as suggested by the research team, the mice genome sequences can be eliminated with the accuracy of 99.65%, which is 58% improvement to the conventional human genome anlaysis method.

Jo, S. Kim, E. & Kim, S. Impact of mouse contamination in genomic profiling of patient-derived models and best practice for robust analysis Genome Biol 20, 231 (2019). https://doi.org/10.1186/s13059-019-1849-2



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Basic Science

Prof. Yeon-jin Yi's team

Shedding light on Black Phosphorus Degradation in the dark

Black Phosphorus
Electron transfer from black phosphorus (BP) to oxygen molecules is an essential step in the degradation of BP

Phosphorus is a reactive non-metal extracted from phosphate rock. Different environmental conditions and extraction methods result in the formulation of different types of phosphorus. The most thermodynamic one is black phosphorus, which is receiving significant interest in materials engineering at present. Even though its benefits were overlooked for over a century, today, engineers utilize it in electronic devices like tunable photodetectors and memory devices.

Its use boils down to the fact that black phosphorus has high carrier mobility, i.e., electric charges can be carried through easily, and tunable band gap, i.e., the electronic properties can be precisely controlled, but there are limitations as well. The 2D material is liable to undergo rapid degradation in ambient conditions, greatly restricting the range of electrical devices it is used in. To combat this, it is necessary to have a better understanding of the degradation processes.

Previous studies showed a link between water molecules and black phosphorus degradation in normal light settings. Degradation processes in the dark, by comparison, are not so well understood.

A group of researchers, led by Prof. Yeonjin Yi from Yonsei University, set out to further explore this process. Prof Yi and the team conducted a study where observations on degradation of black phosphorus in dark conditions were made. It was found that the topography and surface potential, i.e., the difference between the voltage at the surface and that in the bulk, changed by degradation of the material surface. The team measured the changing characteristics of black phosphorus flakes over 48 hours in dark conditions, to avoid the effects of light-driven degradation. Images taken via atomic force microscopy showed visible changes to the surface over 48 hours of air exposure.

The researchers measured the topography and surface potential of bulk and few-layered black phosphorus in dark conditions. Studying the layered sample could throw light on the relationship between black phosphorus layering and the degradation process in the dark. Over 48 hours, a phosphate layer formed on the surface due to oxygen-driven chemical interactions with the top layer. The few-layered sample had lower electron concentration than did the bulk.

Prof Yi commented, “this low carrier concentration of few-layered black phosphorus limits the oxidation rate”, where the sample with layering was less prone to degradation. This implied connections between degradation and the carrier concentration. It appeared that layering, and notably, the carrier concentration, determine the degradation rate of black phosphorus in the dark. Based on this insight, improved designs and applications of the material can be realized for black phosphorus-based products.

This work can help improve the designs of future electronic devices using black phosphorus by shedding light on black phosphorus degradation in the dark, and enable the further development of techniques to improve black phosphorus stability.

Basic Science

Highly efficient and stable eco-friendly QLED:

A giant step towards the Next-Generation Display

The TV display market is evolving rapidly with the research development of the display technology. A recent trend in the field is the race heated up between the OLED (organic light-emitting diode) and QLED (quantum dot light-emitting diode) display. Especially, the next move of the QLED display technology is drawing much attention as its relative strength point – high color purity and bright luminescence – makes it a potential candidate which can overcome the current limitations that OLED is facing. On the other hand, some are still doubtful about the future of the QLED since the commercialized QLED TVs are making use of the backlight, which means that the quantum dot units are not self-luminescing. This is a critical task to be solved because the use of the backlight limits not only the slimness of the TV product but also the flexibility of the display screen.

Very recently, a research team of Prof. Dongho Kim in Yonsei University and Dr. Eunjoo Jang in Inorganic Materials Lab of Samsung Electronics provided a breakthrough to this problem by introducing the self-luminescing quantum dot light-emitting diodes which are both bright and stable. The QLED devices developed in this study achieved the theoretical maximum efficiency of 21.4% and lifetime of a million hours (at 100 cd/m2). This performance is an all-time high for the nontoxic quantum dot materials and is comparable to that of the state-of-art toxic Cd-containing QLEDs. These results were published in “Nature”, the most renowned academic journal among all.

Quantum dots are nanometer-sized semiconductor particles, of which the emission light color can be tuned by the size of the particle. In this research, quantum dots were designed in core/shell/shell structure in order to improve the brightness and robustness. Indium phosphide (InP), an environmentally benign material, is used for the light-emitting core part of the particle. Highly symmetric and uniform shell encapsulation reduced the structural defects and the thick layer of the ZnSe and ZnS shell minimized the energy loss between each quantum dot particles, leading to an improved LED device efficiency. The QLED efficiency was further optimized by shortening the ligand chain length at the shell surface, thus facilitating the charge transport to the transport layer.

The energy loss mechanism and their relationship to the quantum dot structure were elucidated by spectroscopic technique. Time-resolved spectroscopy is a powerful tool to study quantum dots since it allows the monitoring of the specific photophysical processes occurring in quantum dots under light illumination. It turned out that the light energy loss through a process called Auger recombination was responsible for the luminescence efficiency of the quantum dot under intense illumination and that the extent of energy loss was dependent on the ZnSe shell thickness.

The research team demonstrates the feasibility of the commercialization of self-luminescing QLED by overcoming the current limitations of quantum dot materials. Furthermore, the disclosure of the photophysical mechanism governing the QLED performance is presenting a milestone for the future development of the QLED display. “Quantum dots, with their extraordinary color purity regardless of the brightness, will provide the display that’s highly close to the natural beauty itself. The self-luminescing QLED TV will enable people to experience the real world at home.” concludes Prof. Kim. The findings of this research herald a new era of eco-friendly display technology, of which will likely be seen at the home appliances stall of department stores in the near future.

Prof. Dongho Kim

Basic Science

Prof. Sukyoung K. Yi and his team

Revealed the Formation History of Milky Way-like Galaxies

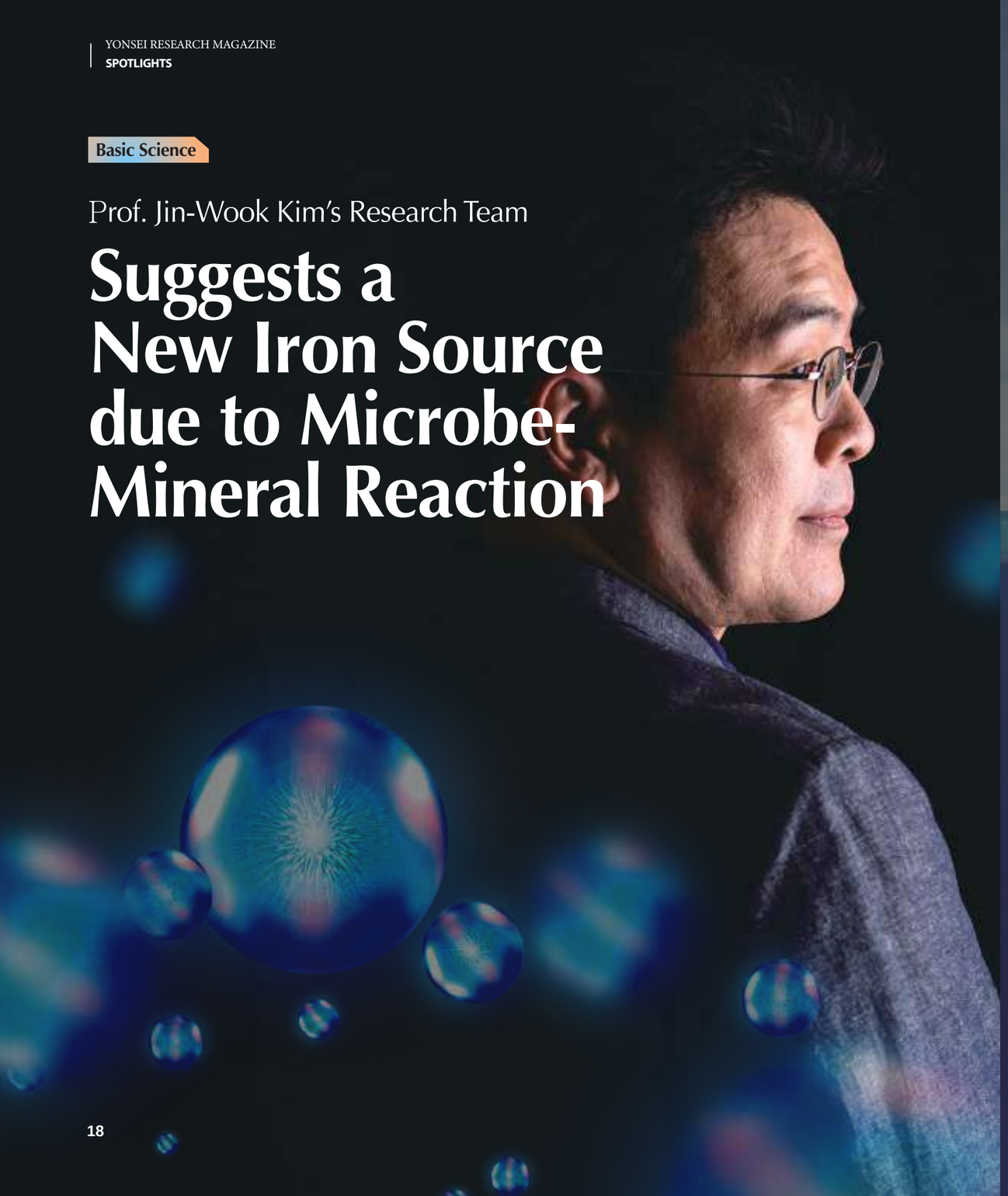
Galaxies are the most complicated stellar objects in the universe, consisting of more than 100 billion stars like the Sun. Spiral galaxies, which account for more than 70% of the galaxies in the local universe, including our Milky Way galaxy (MW), consist of a disc with spiral arms and a spheroid that looks distinct from each other. In particular, the disc structure is the most distinct morphological characteristic of the galaxies. There have been several scenarios regarding the origin of the spiral galaxies, including the MW, but none has yet clearly explained their formation history. To find out a clue to this problem, Professor Sukyoung K. Yi's team has conducted a numerical simulation that includes gravity calculation, hydrodynamics, and all the astrophysical processes like star formation and black hole activities, in a sphere of 60 million light-years in diameter and succeeded in reproducing the formation and evolution of roughly 200 galaxies. This simulation uses supercomputers in Korea and France, and it is run with about 30 million CPU hours over 3 years by connecting 4800 computer cores in parallel. The most up-to-date input physical assumptions including radiative gas cooling, star formation, supernovae, and black hole feedback, are employed in this simulation. In particular, the spatial resolution has been improved by more than 20 times than before, revealing the galaxy formation processes in greater detail than ever before. Professor Yi's team analyzed the model galaxies and quantitatively revealed how the disc and spheroidal structures of spiral galaxies like the MW are formed. In addition, they found that a galaxy mysteriously needs to have a stellar mass of about 10 billion solar masses in order to form a disc, and once such critical conditions are met, the disc is formed surprisingly quickly. Min-Jung Park, who has performed most of the data analysis, has become the first lucky person to witness the detailed formation history of spiral galaxies.

This study is the first paper published from the New Horizon project, conducted by the international collaborative research team that includes the Institute d'Astrophysique de Paris (Yohan Dubois, Christophe Pichon) and the University of Oxford (Julien Devriendt) as well as Yonsei University. The results of this study were published in the September 2019 issue of The Astrophysical Journal, which was selected by AAS Nova (American Astronomical Society) as one of the most interesting results published in the month.

Basic Science

Prof. Jin-Wook Kim's Research Team

Suggests a New Iron Source due to Microbe-Mineral Reaction



Analysis of Marine Sediments from Larsen Ice Shelf C in Antarctica

The joint research team comprising Professor Jin-Wook Kim's research team (Biogeochemistry Lab, Department of Earth System Sciences) and the Division of Polar Paleoenvironment at the Korea Polar Research Institute (KOPRI) published a study suggesting a new iron source due to microbe-mineral reaction on December 19, 2019, in the renowned international science journal Nature Communications. In recognition of its originality, the study was also selected for the Nature Index, through which high-quality studies are selected and shared on a yearly basis by the journal Nature.

The joint research team presented a new source of iron in marine sediments collected from Larsen Ice Shelf C in the Antarctic region. This source is due to iron-reducing action by psychrophilic microbes (i.e., microbes living even in low temperatures such as in Antarctica) related to the retreat of ice shelves in the region since the last ice age.

This field has been attracting the interest of researchers since about 40 years ago. In 2004, Professor Jin-Wook Kim suggested in the international journal Science that microbes can produce changes in minerals even when high-temperature, high-pressure conditions that usually produce such changes are absent. This presented a new paradigm in the academia of that time, as it proposed microbial iron reduction, that is, the phase transition of minerals by organically induced reaction. After continuous research, Kim was invited as a keynote speaker at the Chikyu+10 International Workshop in 2013, where he revealed that such mineral phase transitions due to organically induced reactions can occur not just in the laboratory but also in the natural world. This research finding was published under the title "Naturally occurring, microbially induced smectite-to-illite reaction" (April 15, 2019) in Geology, a top-ranking journal in the field of geology for the past 12 years (IF 5.006/98.94%).

In line with this research trend, KOPRI's Division of Polar Paleoenvironment collected marine sediments from Larsen Ice Shelf C for the first time in the world in 2013. Until recently, the Yonsei-KOPRI joint research team conducted research on microbe-mineral reactions in extreme settings, in relation to changes in sedimentary environments due to glacial-interglacial climate change.

In particular, the joint team examined whether microbe-mineral reaction can provide a potential source of iron in the Southern Ocean, which is deficient in the iron that is required for primary production. The marine sediments from the Antarctic ice shelf region collected by KOPRI has preserved the changes in the sedimentary environment that had been made from the last glacial age to this interglacial age, and the clay minerals in the sediments were analyzed to find clues about the correlations between them.

Professor Jin-Wook Kim's research team has been participating continuously in the Antarctic exploration project with the support of KOPRI's Division of Polar Paleoenvironment. Professor Kim said, "We are conducting follow-up studies through exploration of the Antarctic region, and our overarching aim is to thereby expand the biosphere and find the answer to the origin of life."

"Microbial Fe(III) reduction as a potential iron source from Holocene sediments beneath Larsen Ice Shelf" (Dec. 19, 2019) in Nature Communications

Engineering

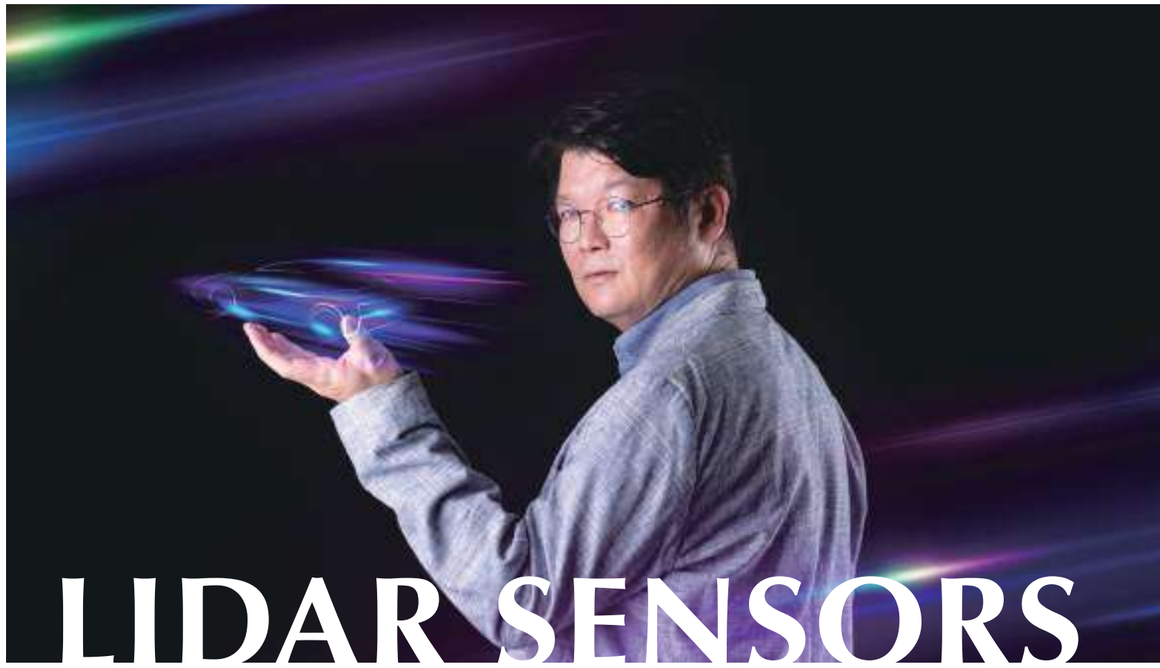
Prof. Jong-Hyun Ahn's research team

developed a special Si photosensor by breaking the absorption limit of Si semiconductor towards SWIR wavelength range via strain engineering.

The development of photodetector that can detect the spectral range of short-wavelength infrared (SWIR) (1300–2000 nm) is in high demand for the lidar sensors used in self-driving vehicles. The lidar device installed on an autonomous vehicle provides a 360-degree view of the surrounding objects and work as an eye of the driverless vehicle. The use of SWIR light is essential for the lidar system used in self driving vehicles because high power light of ultraviolet (UV)-NIR wavelength (250–1000 nm) can caus e irreparable harm to the retina of the human eye. InGaAs based sensors, which have been currently used to detect this range of wavelength, have the disadvantages of expensive production cost and incompatibility with Si CMOS platform. Si has been widely used in the microelectronics industry. However, its photonic applications are restricted to visible and partial near-infrared spectral range owing to its fundamental optical band gap(1.12 eV).

Prof. Jong-Hyun Ahn's research team successfully achieved the significant photoresponse from Si well beyond its optical band-gap limit by applying biaxial tensile strain into Si nanomembrane with ultrathin thickness of < 10nm. The Si photodetector pixels were mechanically stretched by a maximum strain of ~3.5% through pneumatic pressure-induced bulging, enhancing photoresponsivity and extending the Si absorption limit up to 1550 nm, which is the essential wavelength range of the lidar sensors for obstacle detection in self-driving vehicles. Moreover, the development of deformable three-dimensional optoelectronics via gas-pressure-induced bulging facilitated the realization of novel device designs with concave and convex hemispherical architectures, which mimics the electronic prototypes of biological eyes. His team expect to contribute to the development of wearable sensors with new and various functions.

Based on his excellent research achievements, Professor Jong-hyun Ahn was selected as the 'World's Most Influential Researcher' in 2018 and 2019 by Clarivate Analytics, which selects the author of the top 1% Highly Cited Research based on the Web of Science (WoS).



Engineering

Prof. Jong-Souk Yeo's research team

Major International Grant Demonstrates Yonsei's excellence in Nanostructure research

Professor Jong-Souk Yeo of the School of Integrated Technology & Nano Convergence Systems Group in Yonsei Institute of Convergence Technology at Yonsei University and his international research team has been awarded the prestigious Human Frontiers Science Program (HFSP) Research Grant to elucidate the development of biological optical nanostructures.

In March 2019, the International Human Frontier Science Program Organization (HFSPO) announced the 34 winning teams of the 2019 competition for its high-profile research grants which will collectively total $35 million over three years. Out of 814 applications from more than 60 countries, 9 Young Investigator Grants and 25 Program Grants were selected for funding – a success rate of only four percent.

Along with his colleagues Matthew Shawkey (Evolution and Optics of Nanostructures Research Group, Ghent University, Belgium) and Marie Manceau (Center for Interdisciplinary Research in Biology, College de France, France), Professor Yeo will investigate how optical nanostructured tissues organize themselves to produce nature's brightest colors in a subsample of birds – a group with incredibly diverse structural colors and mechanisms – in the context of better understanding developmental and evolutionary biology and sparking advances in the biomimetic design and "green" commercial manufacture of self-assembling optical materials. The interdisciplinary research team's international collaboration has attracted $350,000 a year for three years, totaling at $1.05 million, via the HFSP grant.

"This is really exciting as the grant enables us to bring our interdisciplinary expertise to address this long-standing question on how the nanometer-scale tissues are organized in nature," said Professor Yeo.

With his extensive industry experience at Lucent Technologies and HP, Professor Yeo understands the importance of sustainable technologies, currently leading a multidisciplinary research group of "Nano Convergence Systems" that focuses on biomimetic and nature-inspired approaches for low power, highly efficient, and multifunctional nanotechnologies while leveraging biological and ecological inspiration from close collaboration with the National Institute of Ecology in Korea.

The Human Frontier Science Program (HFSP) is an international program of research support, aiming to promote intercontinental collaboration and training in cutting-edge, interdisciplinary research focused on the life sciences. HFSP's Research Grants are awarded for a broad range of novel, cutting-edge collaborative projects among teams of scientists working in different countries and across disciplines under the umbrella theme, "Complex mechanisms of living organisms."

Since the HFSP grants and fellowships were first awarded in 1990, 28 grant awardees have gone on to win Nobel Prizes in the fields of Physiology or Medicine, Chemistry and Physics. For more information on the HFSP 2019 awardees and awarded projects, you may visit HFSP web site, https://www.hfsp.org/.

Engineering

The research team of Prof. Hyun-Seog Roh

Succeeds in Development and Mass Production of Fe-AI-Cu Catalyst

for the core reaction within hydrogen production process, high-temperature water-gas shift reaction

The research team of Prof. ROH Hyun-Seog of the Environmental Engineering Department of the Future Campus of Yonsei University succeedead in mass-producing Fe-AI-Cu catalyst, thus proposed a possibility of commercialization of catalyst for high-temperature water-gas shift reaction which is used for hydrogen production.

The volume of municipal solid waste has been continuously increasing along with fast economic growth and rising GDP. However, a significant amount of wastes are still disposed by the traditional landfill method, thus causing environmental problems such as air pollution, leachate leakage, and lack of landfill space. The "Waste to Energy (WtE)" technology is praised as a way to truncate the downsides of the existing waste disposal methods, for its advantage in effective disposal of waste and regathering of energy.

Especially, waste gasification technology, one of many WtE technologies, completely decomposes toxic elements within flammable wastes at high temperatures to eliminate the harmful substances while simultaneously producing synthesis gas (main ingredient: CO, H2). This is advantageous for maximizing the efficiency in gathering energy resources from wastes. The high-temperature water-gas shift reaction is a technology transforming CO within synthesis gas into an easily detachable CO2 while producing additional H2, simultaneously. Should the high-temperature water-gas shift reaction be introduced to waste gasification process, it is possible to achieve a sustainable and cost-effective hydrogen production.

Prof. ROH proposed the possibility of commercializing hydrogen production using waste-derived synthesis gas by identifying the core factors required for the mass production of Fe-AI-Cu catalyst. He has further commented on the significance of this research that it will contribute to making policies to promote the hydrogen economy via diversification of the way hydrogen and hydrogen vehicles are supplied, along with expanding the use of resource cycle, tackling environmental problems, and improving environment around landfills.

Engineering

Prof. Jong-Moon Chung at Yonsei University

Receives the MOIS Minister's Award for 'Outstanding Achievement in Disaster Safety R&D'

for the Innovative Research and Development Conducted in Creating the AR-Based Integrated Disaster Response Training Simulator

Professor Jong-Moon Chung, Department of Electrical and Electronic Engineering, Yonsei University, received the Ministry of the Interior and Safety (MOIS) Minister's Award at the First Awards Ceremony for Outstanding Achievements in Disaster Safety R&D, held at the K-Safety Expo 2019. It was awarded in recognition of his contribution as the principal investigator for 'Developing an Augmented Reality (AR)-based Integrated Disaster Response Training Simulator.'

Given recent trends in the growing complexity of disasters, there is a demand for new means of training to strengthen disaster response capabilities. Therefore, this project was conducted with the aim of developing a training simulator using AR technology that can build an environment similar to actual situations and heighten the sense of reality.

To develop an integrated disaster response training simulator, actual databases and the disaster response manual from the Ulsan Metropolitan City were taken into account in designing several complex disaster scenarios, such as hazardous chemical spills, dam collapse, collapse of multipurpose facilities, and so on. This simulator was designed to allow multiple participants online to use AR goggles or computers to select and carry out individual roles and collaborative functions (situation management, traffic control, medical support, etc.) in actual response organizations such as the Central Disaster and Safety Countermeasures Headquarters, the Central Accident Investigation Headquarters, and regional disaster and safety countermeasures headquarters. To implement these technologies, AR libraries such as OpenCV, Vuforia, and ARToolkit were used, and the latest AI and big data technologies for tracking and labelling objects in disaster situations were utilized. Various 3D city modelling software engines were used to analyze and apply the geographic information system (GIS) data from the Ulsan Metropolitan City Hall and Ulsan.

This simulator was actually pilot tested in the Ulsan Metropolitan City and the Nam-gu district in Ulsan during the 2018 Safe Korea Disaster Response Drill, the 2019 Disaster Preparedness Constant Drill, and the 2019 Safe Korea Disaster Response Drill. In 2020, it will be incorporated into the official training course (Disaster Preparedness Competency Support Course) at the National Civil Defense and Disaster Management Training Institute, and it will gradually be applied and utilized in disaster preparedness training at various government ministries, local governments, and public institutions. Through this project, it is expected that a large number of trainees including disaster response personnel will be able to strengthen their disaster response competency through realistic training that goes beyond existing forms of large-scale coordinated or individualized training. Further, by modularizing common functions, it will be possible to incorporate training scalability for institutions at each level involving various central agencies and local governments.

Social Science

Prof. M. Jae Moon's contribution

The evolution of E-Governance

Professor M. Jae Moon is a pioneer in digital government research - he was awarded the Mosher Award and the Peter Boorman Award for International Scholar in 2009. More recently, in August 2018 and 2019 he was named consecutively among the world's 100 Most Influential People in Digital Government by the global policy platform Apolitical.

In 2002, Professor Moon reported his findings on how far U.S. municipal governments were embracing electronic government. Using data from a survey of almost 1,500 municipalities, he identified local governments' actual progress toward implementing information technology. "At that early stage, most governments had not progressed beyond using IT for communication," Professor Moon recalls, "and very few had a long-term strategic plan for their e-government initiatives." Prominent challenges included a lack of technical expertise and financial resources, alongside security and privacy issues.

Professor Moon's 2002 paper has received more than 2,600 Google Scholar citations, making it the third-most cited paper on public administration between 1997 and 2015. An unprecedented achievement as no other paper on e-government has received more recognition by social scientists. He has since tracked the subsequent evolution of e-governance in the United States, Korea, and beyond focusing on how e-government relates to citizen satisfaction, trust, efficiency, procurement, bureaucracy, and use of mobile technology.

In 2017 and 2019, Prof Moon extended his seminal work of 2002 with a study exploring the growing role of crowdsourcing and government-citizen collaborations through the web to design and deliver public services.

In particular, "web-based co-production" and "open government" are particularly relevant in Korea, where the government has been pursuing public sector reforms to increase openness, information sharing, and collaboration. Central to effective co-production are the amount of public information available to citizens and the extent of interaction between them and the government. For instance, the Korean government's increasing provision of public data and policy support has enabled tech-savvy individuals and citizen groups to develop more than two thousands public service apps. Recently, several apps on COVID-19 and facial masks have been developed and widely used, which helped the country to mitigate the unprecedented infectious disease.

As the Director of the Institute for Future Government at Yonsei University in Seoul, Korea, he and his colleagues have investigated how the international regime affects the functions and policies of governments. He forecasts further changes in how governments operate, both driven and facilitated by ever-developing-information and communications technologies. "The e-government concept has already advanced to mobile government (m-government), ubiquitous government (u-government), and AI-based government" he explains. "In line with trends in the commercial world, we can expect governments of the future to be data-driven."

Social Science

The research team of Prof. Tae-dong Lee

Sustainable CITY-to-CITY collaborations to help tackle climate change

Highly populated cities leave large environmental footprints and contribute to climate change. Cities often team up in networks, called city-to-city networks, to reach sustainable environmental goals such as targets to reduce emission.

However, some very real challenges hinder the potential of these networks to survive and expand. This was indicated in a study led by Taedong Lee from Yonsei University, South Korea, wherein they assessed the status of different types of city-to-city networks taking action on climate change. As Prof Lee explains, "Interaction and collaboration among cities offer policymakers a chance to understand how other cities are conducting climate mitigation and adaption measures."

Multi-city collaboration can improve the actions and policies related to climate change, but it depends on what activities are undertaken and where the collaborating cities are located. Those in close proximity to each other may share similar cultural norms but be financially competitive to one-another. Across country borders, transaction costs can get expensive. On the global scale, the process is prone to get complex, as not all cities can participate equally; those in developing countries may not be able to bear the transaction costs involved.

In their study published in 2018, the research group led by Prof Lee assessed twenty-four city-to-city networks collaborating on climate action, by using their case studies of websites. They also proposed a framework to classify the different types of city-to-city networks. The first concerns their geographic bases within a nation, regional or global networks. The second is linking modalities, which is about the nature of member organizations, which could be multilateral or institutional-led ones. Thirdly, they considered activities like networking, information sharing, funding, research, and monitoring.

Surprisingly, they discovered that not all city-to-city networks were active. It seemed that those involved in information sharing, networking, and providing climate change updates were prone to fade out. In contrast, those providing research and monitoring information had greater growth and membership reach. Prof Lee says, "These functions also increase the number of contacts with international institutions or national government to change policies." Sharing the progress and outcomes of practical, sustainable initiatives attracts participation by multiple cities and helps stakeholders make important decisions. The findings of this study shed light on the collective actions of cities, through networks, towards climate change.

The researchers devised a framework to explain different types of city-to-city networks and their activities. The team emphasised that for city-to-city networks to survive and grow, well-designed research, lobbying, and monitoring activities absolutely need to be implemented. Providing research and monitoring information, in particular, encourages cities to join city-to-city networks for taking climate change action. The findings of this study could help cities decide what city-to-city networks they should choose and join for climate change initiatives.

Green Infrastructure Technology for Climate Change Research Center (GIT4CC)

The Green Infrastructure Technology for Climate Change Research Center (GIT4CC) at Yonsei University was established in September, 2011, with the aim of securing adaptation technologies for the civil infrastructure to prepare for global climate change. GIT4CC is the first research institute in Korea to specialize in climate change adaptation research for the civil infrastructure. It has taken part in the Engineering Research Center (ERC) program supported by the National Research Foundation of Korea (NSF) from 2011 to 2018, achieving research results that far exceeded the original goals. Since 2018, it has been taking part in the NSF-supported Priority Research Institute Program in the science and engineering fields.

The climate change adaptation technologies involve adapting the civil infrastructure to climate change using more advanced technologies than carbon emissions reduction, disaster prevention and other previous measures used to address climate change. In the future, super typhoons, abnormally high temperatures, cold waves, and heavy snow due to climate change are expected to inflict enormous damages to the civil infrastructure. A key task of research at GIT4CC is to provide preemptive adaptation strategies for the infrastructure to cope with such extreme weather conditions. At present, GIT4CC is conducting research on developing the following: (1) a smart response system to improve adaptability to urban disasters and climate change, (2) technologies providing smart solutions to reduce human health vulnerabilities caused by climate change in urban areas, and (3) a deep learning-based system to diagnose the impact of climate change and generate adaptation scenarios. In order to conduct effective research, GIT4C is relying on an interdisciplinary approach that integrates civil engineering, environmental engineering, and computer science.

In order to come up with an effective climate change adaptation strategy, it is necessary to obtain abundant and diverse data accumulated over a long period of time, and suitable techniques to analyze such data. First, to obtain such data, GIT4CC built a landslide stability monitoring system on Ansan Mountain near the Sinchon Campus and a fine dust monitoring system within the Sinchon Campus in 2019. The landslide stability monitoring system periodically measures the moisture content of the soil through soil-moisture sensors installed at four major points on Ansan Mountain, and the fine dust monitoring system measures local concentrations of fine dust through fine dust sensors installed at two different locations within the Sinchon Campus. The measurement data obtained from these two systems are regularly uploaded to a cloud server. These two sets of data are being used in the research on real-time landslide analysis models and on human health vulnerabilities, respectively. By building these monitoring systems, GIT4CC has laid the foundation for obtaining its own real-time environmental information sensing data that is essential for coming up with a climate change adaptation strategy.

Research on climate change adaptation technologies requires techniques for analyzing not just the existing structured data in digital form, but also unstructured data such as images and text. Accordingly, GIT4CC is actively utilizing the latest ICT techniques, including deep learning, text mining, and natural language processing. For example, in the case of image analysis, research is being conducted on automatically detecting the flood damage level by analyzing images of vehicles photographed on roads. In the case of text data, there is ongoing research on using the contents of construction accident reports that are already available in large quantities to analyze the relationship between weather and construction accidents, and also on using the massive amount of text data generated in real time by many unspecified SNS users to analyze and respond to climate disasters.

In these ways, GIT4CC is obtaining the data and studying the core techniques of analysis required for climate change adaptation technologies. It also plans to build a living lab that applies these adaptation technologies to the Sinchon Campus of Yonsei University. From the very beginning of its existence, GIT4CC has taken active part in addressing social problems related to climate disasters, for instance by participating in the public hearing on the Umyeonsan Mountain Landslide in 2011. Through its living lab project, GIT4CC will endeavor to yield empirical research findings that can protect people's safety and property from the ravages of climate change.

The Yonsei Institute of Pharmaceutical Sciences(YIPS)

The Yonsei Institute of Pharmaceutical Sciences (YIPS), currently directed by Dr. Sung-Joo Hwang PharmD-Ph.D, aims to develop innovative novel pharmaceutics and improve the overall quality of public healthcare. Established in 2011 as a research institute affiliated with the Yonsei College of Pharmacy, YIPS is now a comprehensive institute consisting of the Center for Innovative Drug Research, the Clinical and Social Pharmacy Center, and the Instrumental Analysis Lab. In addition, numerous researchers whose expertise covers the entirety of drug production, from the drug development to its use, are contributing to YIPS. To play a leading role in the pharmaceutical sciences, YIPS is also actively conducting multidisciplinary convergence research, consisting of basic, translational, and interdisciplinary research related to numerous pathophysiologies and relevant pharmaceutical development, also through collaboration with other researchers within and outside the Yonsei University. Currently, YIPS is recognized by many as a first class research institute in the pharmaceutical field.

In 2018, the Center for Innovative Drug Research embarked on a project titled “Developing Transportome Modulation Technologies for Treating Intractable Diseases”, supported by the science and engineering division of the Priority Research Institute Program managed by the Ministry of Education and the National Research Foundation of Korea. This project will receive a total funding of KRW 6.8 billion over the next 9 years. The goals of this project are: to (1) build a stronger research foundation in the Yonsei University through strengthening infrastructure for university-affiliated research institutes, (2) establish the foundation for developing new innovative drugs that can treat intractable diseases, and (3) train outstanding researchers to enhance staff’s international competitiveness in the medical life science field.

Research performance at YIPS has been steadily improving both in quantity and quality. Manuscripts published by top 10% journals increased from just ten in 2016 to 31 in 2019. Those published by top 3% journals increased from only one in 2016 to four in 2019. Over the last five years, YIPS researchers have published more than 400 papers in famous journals, such as Science, Cell Metabolism, Nature Communications, PNAS, Journal of Experimental Medicine, Cancer Research, Nature Chemistry, Journal of Allergy and Clinical Immunology, Journal of the American Chemical Society, Science Advances, Nature Medicine, Progress in Lipid Research, Phytomedicine, and others, including over 70 papers with JCR scores in the top 10%. The institute has also obtained 90 patent registrations and made 24 technology transfers in and out of Korea. Furthermore, the research members of this institute founded three startups: 1) S2Cbio (Wan Namkung), 2) Smart Bio Pharm (Jin Hyeon Jeong), and 3) Stemore (Jong Hyuk Sung). Through such startups, research results are funneled into the industry, new jobs are created, and the profits are reinvested back into research, thus fashioning a cycle of research development.

YIPS plans to achieve the highest level of research excellence, foster outstanding researchers with international competitiveness, and serve as the vanguard for the technology transfer and commercialization of scientific achievements, with a vision to become the most premiere research institute in Korea, with international stature in the field of medical life sciences.

Digital Therapeutics
that Take Looks After People's Minds, Feelings,
and Actions through User Experience

YONSEI HCI LAB

Human-computer interaction (HCI) is a discipline that deals with the principles and methods for developing systems that are convenient and enjoyable for people to use. More specifically, HCI involves studying the interactions between human users and computer systems with a view to developing interfaces that afford more harmonious interactions. HCI may be defined as a field of study in which methods and procedures for the interaction between users and systems are designed, evaluated and implemented, such that systems designed for interaction with users can work smoothly with them to achieve given goals.

At the Yonsei HCI Lab, researchers from various fields such as cognitive science, computer science, management, technology management, and design have gathered together to gain an in-depth understanding of new principles and methods by which the quality of our lives can be improved through digital systems, and to apply this understanding to our actual lives.

Currently, the HCI Lab is conducting joint research with Human-AI Interaction Co. Ltd. (HAII) on digital therapeutics that is more convenient to use, achieves better therapeutic effects through steady use, and provides good user experience. Digital therapeutics is based on software rather than drugs, and refers to a system that prevents, treats, and manages chronic diseases such as diabetes and psychological disorders such as depression.

The study "Fribo: A Social Networking Robot" was conducted as part of this research on digital therapeutics, and it won the Best Paper award at the 2018 ACM/IEEE International Conference on Human Robot Interaction (HRI), thus demonstrating the positive user experience effects of conversational agents.

At present, the HCI Lab is conducting four studies, including voice-based digital therapeutics for elementary school children, digital therapeutics for older persons with Alzheimer's disease or depression, and digital therapeutics for alleviating the symptoms of depression and anxiety disorder among young people. The studies are as follows.

First, the Lacion project is designed for children in the lower grades of elementary school, and aims to help them acquire healthy life habits by reminding them of things to be done after school through AI speakers, and possibly for treating ADHD symptoms they might have.

Second, the Alzguard project aims to treat mild cognitive impairment and also to prevent Alzheimer's disease by enabling older persons aged 50 and above to engage in 20-minute conversations daily on KakaoTalk Plus Friend, an app that even older users are familiar with and can use easily.

Third, the Serene project is designed to treat depression and anxiety in adults in their 20s and 30s, and involves an AI agent that synthesizes the user's voice to conduct daily meditation and self-reflection with the user.

Fourth, the Cheme project aims to treat depression in older persons by allowing them to recollect their past experiences three times a day, and connecting them with other users that have similar memories.

Going forward, the HCI Lab will use conversational agents and user data analysis to build a framework for digital therapy platforms that help maintain the psychological health of users, and conduct empirical studies to provide concrete and practical a ssistance to many people.

YONSEI CONNECT-AI RESEARCH CENTER

FOR THE DEVELOPMENT OF A DIAGNOSE TREATMENT SYSTEM BASED ON MULTI-DIMENSIONAL MEDICAL DATA

Yonsei CONNECT-AI Research Center is a subsidiary research institute of Yonsei University established in 2019, for the development of a diagnose treatment system based on multi-dimensional medical data with the goal of developing technologies for cardiocerebrovascular diagnosis and optimal treatment. Cardiovascular diseases are the number one cause of death globally. With aging population of our modern society and change of diet, the occurrence of diseases relating to the cardiovascular system, the demand for treatment for such diseases is growing higher than ever.

Especially, auxiliary technologies for medical diagnosis based on the recent integration and use of multi-dimensional data, which is the source of the 4th Industrialization, is urgently required. As such, CONNNECT-AI Research Center is conducting researches to develop diagnosis treatment system to provide optimal medical service while minimizing medical complication by conducting virtual mock tests before the treatment of cardiocerebrovascular diseases. These tests are enabled by integration and use of multi-dimensional data gathered from medical institutions.

In order to achieve the above goals, Yonsei CONNECT-AI Research Center is conducting a research according to the 5C's below:
C1 (Continuity) studies 'data integration' solutions throughout all stages of emergency treatment in order to provide an efficient emergency medical service.
C2 (Completeness) studies methods for 'accurate gathering' of real-time on-site data and 'prompt sharing of information' via the use of Cloud.
C3 (Complement) studies the development of 'AI emergency medical service' supporting the best emergency treatment
C4 (Community) has a purpose to achieve a 'demonstration in local communities' within the duration of the project through the development of system securing commercialization.
C5 (Consensus) refers to efforts in establishing 'social consensus' which includes structuring of laws and infrastructure for the distribution of AI emergency medical service.

So far, CONNECT-AI Research Center has been contributing to the development of the medical industry by participating in AI-based medical ICT researches and various government-led research projects as well as winning projects (developing a precision medicine emergency system) of ICT Promotion Fund of the Department of Science and Technology in the scale of total amount of KRW 231 billion since April 2019 until today. We have further published 367 journal papers in medical IT and medical AI including first aid, and we're continuously completing a minimum number of 10 papers and 5 patents every year, as well as actively practicing research activities such as hosting international research conferences and providing practical trainings for international academic accreditation.

Based on outstanding research outcomes and resources, CONNECT-AI Research Center in near future will successfully undertake large-scale government-led projects along with the advancement of medical ICT researches we have been running from the past. We, as a university-subsidiary equivalent research institute of Yonsei Medical School, aim to undertake the tasks of developing AI-based medical ICT technologies by closely cooperating with Yonsei University Health System.

2nd Global Sustainable Development Forum

World Leaders and Sustainable Development Experts Gather to Discuss Global Issues

On February 14–15, 2019, Yonsei University hosted a forum to explore the future of "sustainable development".

Together with Honorary Chairman Ban Ki-moon (former UN Secretary-General) of the Institute for Global Engagement & Empowerment, Yonsei University prepared a forum to discuss and seek solutions to various problems facing our society and the global community. The two-day Global Engagement & Empowerment Forum on Sustainable Development (GEEF) was held at the Centennial Hall and Baekyang Nuri, Yonsei University. Over 100 experts in the field of sustainable development participated in this event, and discussed various topics such as advancing women's rights, equal access to healthcare, economic cooperation between North and South Korea, sustainable cities, and development resources. GEEF is an international forum officially launched by Yonsei University in February 2018 to raise public awareness on the importance of sustainable development.

Speakers from various fields participated in this year's forum, including the Chancellor of Austria Sebastian Kurz, the former President of Austria Heinz Fischer, the former Prime Minister of New Zealand Helen Clark, the Executive Secretary of UNESCAP Armida Alisjahbana, the Executive Director of UNFPA Natalia Kanem, the President of SenseTime Michael Wen Zhang, the Mayor of Seoul Park Won-soon, the President of KOICA Lee Mi-kyung, the former Director-General of UNESCO Irina Bokova, and television personality Sam Okyere.

Asia's Top Educational Institution

Recognized for Innovative Teaching and Learning Strategy at the THE Awards Asia 2019

Yonsei University was honored as Asia's top educational institution by winning at an awards competition for Asian universities held by Times Higher Education (THE), a UK magazine that rates and ranks universities all over the world.

THE hosted the Awards Asia 2019 to select and award Asian universities that have shown outstanding performance and exceptional leadership. Among these, Yonsei University was recognized for its distinctive and innovative strategy, and thus selected as Asia's top university in the Teaching and Learning Strategy of the Year category. It also reached the position of finalist in the Technological Innovation of the Year category, thereby solidifying its position as a prestigious Asian university.

In particular, Yonsei University was lauded for taking the lead in cultivating global digital leaders to serve as the vanguard of the Fourth Industrial Revolution by implementing a campus-wide digital literacy revolution.

Gold Winner in the QS-APPLE 2019 Creative Awards

Yonsei University received the Gold Award at the Creative Awards ceremony organized by Quacquarelli Symonds (QS), a global higher education assessment company based in the UK. In order to emphasize the importance of university brand building and effective communication between universities and education consumers, QS bestows the Creative Awards in five categories, i.e., Most Creative Corporate Institution Video, Best International Print Advertisement, Best International Student Recruitment Brochure, Best International Website Page, and Most Creative Booth Design. Since the beginning of 2018, Yonsei University has been reorganizing the layout and content of its English website page and fixing technical problems for the benefit of international students, thereby stepping up its digital marketing efforts in line with its reputation as Asia's top university.

Yonsei Hosts "ACS Publications & IBS Forum"

World's Top Scholars in Nano Field Discuss its Future at Yonsei University

The ACS Publications & IBS Forum, an international research forum on energy and nanomaterials, was held at the Grand Ballroom, Baekyang Nuri, on September 30 – October 1, 2019. Co-hosted by the Yonsei-IBS Institute and the American Chemical Society (ACS), this forum was attended by more than 700 participants from 11 countries including China, Japan, and the Philippines, and from domestic and foreign chemical research institutes, life science institutes, and corporations, along with students from Yonsei University. In this forum, in-depth lectures were delivered on three themes, "Nano for Energy", "Nano for Bioscience", and "Nano for Medicine". 15 speakers were invited, including the world's leading scholars in nanoscience and nanomedicine such as Professor Joanna Aizenberg (Harvard University), Professor Peidong Yang, and Professor Yi Cui (Stanford University). The scholars that participated in the forum plan to share developments and research achievements in nanoscience and nanomedicine, and explore joint research areas.

Yonsei's Global MBA Program Listed Korea's only in The Economist's Ranking of Top 100 Full-time MBAs

The Global MBA program at Yonsei University's Graduate School of Business (Dean Kil-soo Suh) was included in the world's top 100 full-time MBA ranking published by the UK weekly newspaper The Economist on November 1, 2019.

The Yonsei Global MBA program is a full-time MBA course that is conducted entirely in English for one year and six months. The program rose to the 95th place in this year's world ranking of full-time MBA programs compiled by The Economist. At the top of the ranking was the University of Chicago at No. 1, followed by MBA programs at Harvard University, HEC Paris Business School, Northwestern University, and University of Pennsylvania. In Asia, only seven programs including Yonsei Global MBA were listed in the top 100 MBA ranking, and the Yonsei program was the only one in Korea to be named in the ranking.

The Global MBA program at Yonsei's Graduate School of Business runs a Career Development Center, and provides students with a systematic career development program following their admission, including one-on-one career coaching, career workshops, and career development-related courses. Moreover, the program has endeavored to facilitate networking and bonding through its Global MBA alumni invitation events held twice each year, various exchange events with part-time MBA students, and special lectures with alumni as invited speakers.

'Peace' Symposium to Celebrate Gandhi's 150th Birth Anniversary

To celebrate the birth of Mahatma Gandhi, Yonsei University co-hosted an international symposium on the theme "Gandhi's 150-Year Legacy: Peacebuilding in Asia and the West" for two days from October 1 to 2, 2019, with George Mason University Korea, the East-West Theological Forum, and the Embassy of India to the Republic of Korea.

First day events were held at Yonsei University's International Campus in Songdo. The Senior Presidential Secretary for Civic and Social Affairs, Geo-sung Kim, delivered his congratulatory address, saying, "I am grateful for this meaningful occasion on which we can reflect together on Gandhi's nonviolence movement and Korea's March 1st independence movement." In the subsequent opening event, a video containing President Moon Jae-in's speech to the UN General Assembly was shown. Referring to Gandhi's statement on peace, President Moon emphasized the importance of "dreaming about peace and achieving it together". The Indian Ambassador to Korea, Sripriya Ranganathan, said, "I am glad that we have this meaningful opportunity to reflect on Gandhi's spirit of sacrifice and leadership, and the legacy of his campaign for peace." The opening ceremony was followed by a ceremony dedicating the bust of Gandhi on the ground floor of Veritas Hall B on the International Campus. This bust was donated to Yonsei University by the Indian government on February 21 to mark Gandhi's 150th birth anniversary.

Yonsei Cancer Center Joins International Advanced Clinical Research Consortium

Becoming the First in Asia to Join Guardant Connect Consortium

The Yonsei Cancer Center has recently become the only institution in Asia to join the Guardant Connect Consortium. Through partnership between Guardant Health AMEA, a US-based global diagnostic company, and multinational pharmaceutical companies, this consortium brings together advanced clinical research institutions across the world.

The Yonsei Cancer Center and Guardant Health AMEA signed an agreement on the center's participation in the consortium on July 17, 2019.

Under this agreement, the center's patients can be assayed with Guardant360, a plasma next-generation sequencing test that was proven to be effective in trials conducted by multinational pharmaceutical companies on various targeted therapies.

A noninvasive genomic profiling test for cancer, Guardian360 is used in the diagnosis of all cancer patients in the US. In Korea, however, health insurance does not cover it yet so the patient has to pay the full cost of the test.

Mirae Campus Certified as the World's First Accredited Educational Institution for Medical Physicists

The Department of Radiation Convergence Engineering, Graduate School, located at the Mirae Campus of Yonsei University, was certified as an internationally accredited postgraduate medical physics program by the International Organization for Medical Physics (IOMP). The Catholic University of Korea and the Korea Advanced Institute of Science and Technology (KAIST) also received the same accreditation.

Yonsei University at the Mirae Campus, the Catholic University, and KAIST were the three universities accredited as educational institutions for medical physicists on this occasion. These educational institutions are the first in the world beside IOMP's own International Centre for Theoretical Physics to receive the accreditation.

The accreditation of postgraduate medical physics programs granted in accordance with strict assessment criteria adhering to the guidelines laid down by the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO).

Mirae Campus to Participate in Establishing a University in Ghana

Contributing to Greater Exchanges with Africa

On December 18, 2019, Yonsei University and the Government of Ghana signed a contract to establish a university in Bunso, Ghana. With the financial support provided to the Government of Ghana by the Export-Import Bank of Korea, the university is scheduled to open in 2023. By establishing this university, the Ghanaian government aims to cultivate leaders who will lead the industrial development of Ghana as well as the entire West Africa.

Around KRW 120 billion will be invested over a span of three years starting from 2020 in this project, which involves establishing two colleges, a college of engineering and a college of agriculture, and eight academic departments that will accommodate approximately 1,100 students. The Mirae Campus will set up the university's educational curriculum, administrative system, experiment facilities, and industry-university cooperation system, and train the operating personnel. Selected as an SW-centered University in 2019 and slated to establish Korea's first "digital healthcare convergence university", the Mirae Campus will convey its knowhow on establishing and operating advanced ICT-integrated academic departments.

Yonsei University Library Receives Korea Digital Management Innovation Award

Yonsei University Library was honored with the Minister of Culture, Sports and Tourism's Award in the Contents sector at the 19th Korea Digital Management Innovation Awards, held at the Millennium Hilton Seoul, on August 29, 2019.

Now in its 19th year, the Korea Digital Management Innovation Awards is an event that recogni□zes corporations that are spearheading the Fourth Industrial Revolution and creating high value-added products and services in the domestic digital knowledge industry. Yonsei University Library was selected as an award recipient for its achievement in spearheading innovations in higher education by swiftly integrating research and education with cutting-edge ICT technologies.

In particular, Yonsei University Library was praised for building the world's first 5G commercial network and an R&D platform on campus in December 2018, and actively undertaking its 5G-based educational innovation project. By responding proactively to the changes that ultra-connected, ultra-low-latency, cutting edge 5G technologies would bring to universities, the library's efforts laid the foundation for gaining a global competitive edge in education.

Yonsei's CPRC Hosts the '2019 Korea-Indonesia 5G Smart Space Collaboration Workshop'

Yonsei University's Communications Policy Research Center (CPRC) cohosted the Korea–Indonesia 5G Smart Space Collaboration Workshop with the Global System for Mobile Communications Association (GSMA) and Inha University's Smart Spectrum Engineering Research Center (SSE-ITRC). It was held at the Sheraton Seoul Palace Gangnam Hotel on November 15, 2019.

This event was organized by Yonsei University and GSMA. It was attended by a total of 33 delegates from the Indonesian Ministry of Communication and Information Technology (KOMINFO) led by Director General Basuki Yusuf Iskandar, along with over 100 Korean experts in ICT and Smart Space.

At this workshop, there were multifaceted discussions on the 5G-based Smart City that will be introduced during the relocation of Indonesia's capital, as well as ways for Korean ICT companies to enter overseas markets by applying ICT technologies to various fields. Then, the attendees continued the discussion on 5G-based ICT and Smart Space while they were visiting the NEFS Smart Office Showroom on the 15th, Busan's Eco Delta Smart City (EDC) and the Busan IT Promotion Agency on the 16th, the Ministry of Science and ICT on the 18th, and the National Agency for Administrative City Construction in Sejong City on the 19th.

AI Learning Space to Serve as Wellspring to a Rich Variety of Ideas

Yonsei University Library has built Y-Smart Space on the ground floor of the Yonsei-Samsung Library. The 330 square meter space is the first and only university smart space available in Korea.

Y-Smart Space is an assemblage of 5G-era convergent services, a smart space that combines cutting-edge technologies such as IoT, immersive media, and artificial intelligence. Implemented with students' ideas, the space had drawn a lot of attention even before it was started. This experimental and innovative space is expected to actively support creative collaboration among students, as well as startups and joint industry-university research linked to high value-added industries. Yonsei University Library announced that it also plans to showcase an exhibition space for experiencing immersive media and an immersive media education platform, both linked to Y-Smart Space.

At the smart space opening ceremony held at the Yonsei-Samsung Library on January 14, 2020, the Yonsei University Library Director Bong Gyou Lee said, "Through Y-Smart Space, we will increase access to cutting-edge ICT such as IoT, immersive media, and AI, and implement various services and functions to enhance smart literacy capabilities."

Wins 2019 CubeSat Contest

Yonsei University Will Launch Satellite via the Nuri Rocket in 2021

Yonsei University's CubeSat Yonsei team won with the best entry at the 2019 CubeSat Contest, hosted by the Ministry of Science and ICT and organized by the Korea Aerospace Research Institute.

This contest provides Korean graduate and undergraduate students with the opportunity to make their own CubeSats, with a view to improving our understanding of nanosatellites, cultivating experts in space development, and expanding the base of space technology. The CubeSat Yonsei team consists of astronomy students (led by Sungmin Jin) and science and engineering students guided by Professor Sang-Young Park (Department of Astronomy). Previously, the team's entries were also selected at the 2012 and 2017 CubeSat Contests.

As the contest winner, the CubeSat Yonsei team will receive funding for its Multi-spectral Imaging for Monitoring Aerosol by Nanosatellite (MIMAN) project, thus enabling the team to build the nanosatellite it has designed (Figure). Intended to demonstrate fine dust monitoring, the MIMAN satellite will be launched as a payload on the space launch vehicle Nuri, which is being developed independently in Korea.

Graduate School of Public Health and AI Startup 2BKO Develop AI-based Data Analysis Tool

Key Infrastructure for Obtaining Innovative Results Such as New Drug Development through Big Data and AI

Professor Sun-Ha Jee's team at the Graduate School of Public Health and the AI startup 2BKO collaborated to develop an AI-based analysis tool. This tool is web-based (https://yonsei.2bko.com/#) and does not require installation.

The data analysis tool can perform not just basic statistical analysis, but also AI analysis such as machine learning and deep learning. Currently, the prototype version of the tool is available to researchers.

In designing this tool, priority was given to enhancing data security and accessibility of analysis in order to supplement the flaws in the programs used by researchers. In particular, blockchain technology was used to minimize risks in data management that can arise during medical data analysis, joint research, and data transfers, thus preventing any tampering with data.

The tool includes various analysis techniques including AI analysis. It thereby increases the accessibility to AI-based analysis for students and researchers who are not well-versed in statistics. Therefore, healthcare researchers can use the tool to conduct statistical analysis in a safe environment without having to master other statistical programs.

Yonsei Center for Research Facilities Holds Completion Ceremony for New Research Space

The Yonsei Center for Research Facilities (YCRF, Director Won-Gun Koh, Department of Chemical and Biomolecular Engineering) held the completion ceremony for a new research space at the Advanced Science and Technology Center, B1, on January 22, 2020.

YCRF is a state-of-the-art analysis center established in 2010. It has over 60 varieties of cutting-edge research equipment worth about KRW 15 billion that are available to researchers both in and outside the university, enabling them to conduct various kinds of precision analysis.

Currently, there are 15 Master's and PhD level specialists working in a 1,160-square-meter space on 5F, 2F, and B1 floors of the Advanced Science and Technology Center. YCRF has now secured an additional 990 square meters of research space, and it plans to provide more extensive precision analysis services for researchers by acquiring high-priced research equipment such as CS-TEM, confocal microscope, and MALDI-TOF/TOF within this year.

Yonsei Mirae Campus Oversees Smart Medical Ship Project, Ship Launching Ceremony Held in Brazil

On the morning of February 13 (Thursday, local time), a smart medical ship launching ceremony was held in the city of Manaus, Amazonas, Brazil. The event was attended by Professor Young-Ro Yoon from the Department of Biomedical Engineering, Mirae Campus, Ambassador Chan-Woo Kim from the Embassy of the Republic of Korea in Brazil, Governor of Amazonas Wilson Miranda Lima, Mayor of Manacapuru Betanael da Silva D'Ângelo, and Director General Seong-Ryong Kang of the International Cooperation Division, Korea Institute for Advancement of Technology (KIAT), among others.

The smart medical ship development project in Brazil was undertaken on the basis of the "Korea-Brazil Joint Smart Medical Ship R&D Cooperation MOU", which was signed between KIAT and the University of Taubaté on the occasion of the Korea-Brazil summit in 2015. The project went through a one-year planning process, and Yonsei's University-Industry Foundation (Professor Young-Ro Yoon's biomedical engineering research team) was selected as the managing institution for the project with the support of KIAT and the Ministry of Trade, Industry and Energy (MOTIE).

The aim of this project was to develop a smart medical ship with a "mobile integrated medical service support system" by equipping the medical ship provided by Brazil (the State Government of Amazonas) with IT technologies, medical devices, and computer equipment from Korea. The successful completion of the project in 2019 made it all the more significant because it marked the 60th anniversary of the establishment of diplomatic ties between Korea and Brazil.

Article Publication(SCI, SSCI, A&HCI, Etc.)

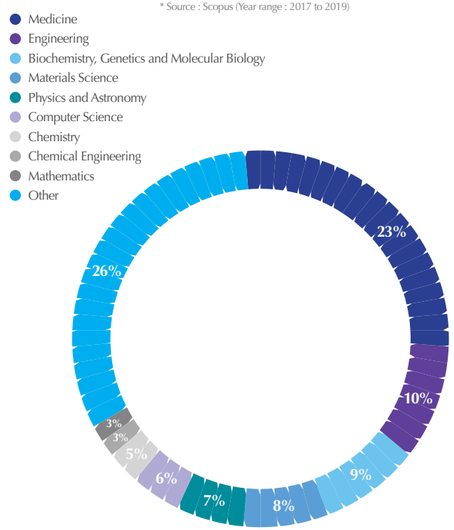
(Unit : Case)

* Source : Scopus (Year range : 2017 to 2019)

Publication by Journal Category(2017-2019)

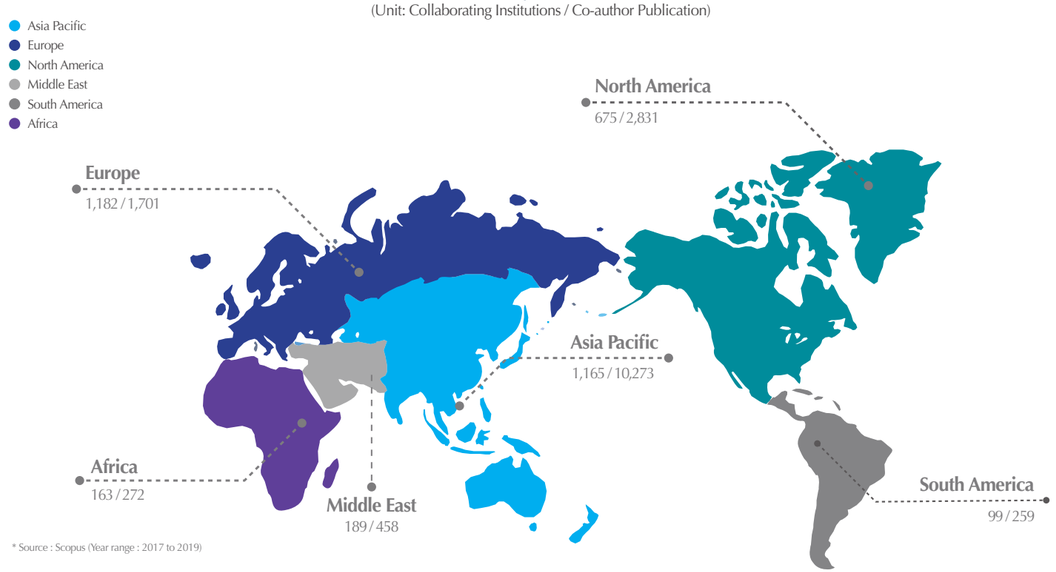
(Unit : %)

* Source : Scopus (Year range : 2017 to 2019)



Institutions Collaborating with Yonsei Univ. (2017-2019)

(Unit: Collaborating Institutions / Co-author Publication)

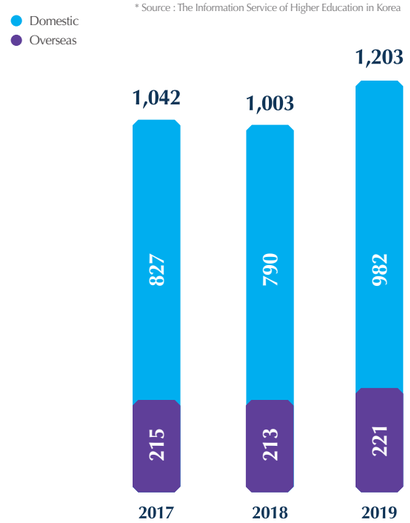


* Source : Scopus (Year range : 2017 to 2019)

Patent Applications

(Unit : Case)

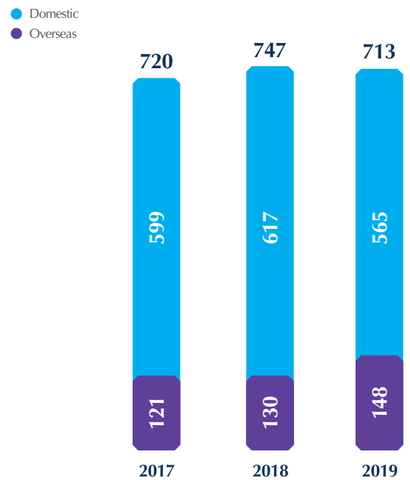
* Source : The Information Service of Higher Education in Korea



Patent Registrations

(Unit : Case)

* Source : The Information Service of Higher Education in Korea



Expenditures

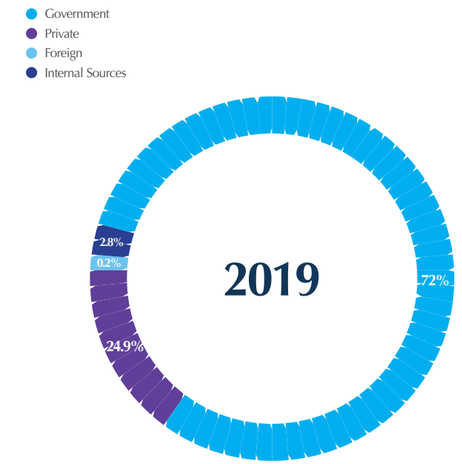
(Unit : million USD)

* Source : The Information Service of Higher Education in Korea

Expenditures by Funding Source

(Unit : %)

* Source : The Information Service of Higher Education in Korea



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03 BI(Pre-BI, BI, Post BI) Centers
Innovation spaces for eligible startups

04 Seoul Startup Cafe in Shinchon
Open Space for growth networking & programs

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