GLOBAL YOUNG SCIENTISTS SUMMIT

2020 HIGHLIGHTS

GYSS@one-north
GLOBAL YOUNG SCIENTISTS SUMMIT
SINGAPORE

GYSS 2020

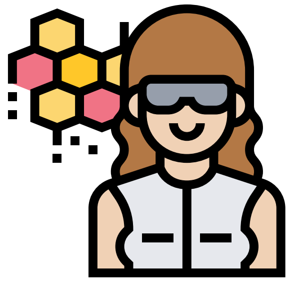
// An international gathering of bright young researchers from all over the world in Singapore, who are mentored by award-winning scientists

// Sparking conversations on the latest advances in science and technology, and how research can develop solutions to address major global challenges

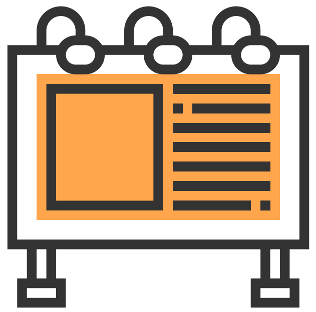
// Multi-disciplinary event covering the disciplines of chemistry, physics, biology, mathematics, computer science and engineering

// Held from 14-17 January 2020

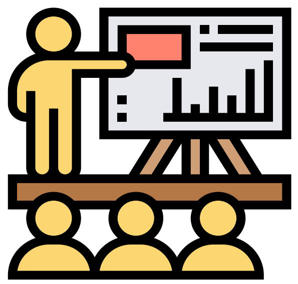
16
EMINENT SPEAKERS



320
YOUNG SCIENTISTS



100
POSTERS PRESENTED



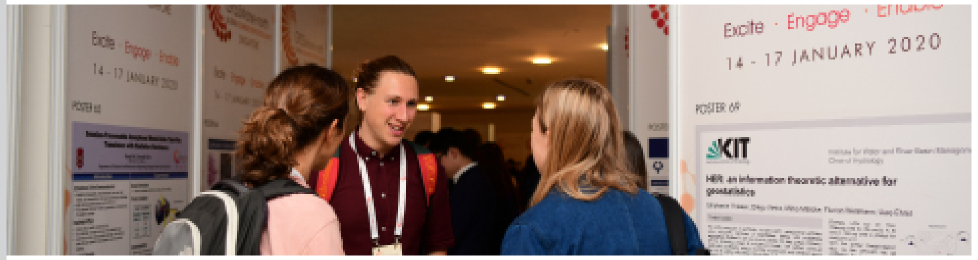
2
PUBLIC LECTURES

PROGRAMME

PLENARY LECTURES //
Speakers shared stories of their prize-winning discoveries

PANEL DISCUSSIONS //
Scientific leaders discussed thought-provoking issues of today, such as the future of medicine and science and society

SMALL GROUP SESSIONS //
Young scientists had the opportunity to be mentored by eminent scientists on more personal topics, such as their scientific careers



POSTER SESSION //
Participants showcased their research projects, sparking interactions and conversations with peers on potential collaborations

SITE VISITS //
Visits to local universities and research institutes offered insight into Singapore's research landscape

PUBLIC LECTURES //
Held all around Singapore, these lectures gave students and members of the public the chance to hear from eminent scientists

PLENARY LECTURES

- **AARON CIECHANOVER //** The Revolution of Personalised Medicine: Are We Going to Cure All Diseases and at What Price?
- **BEN FERINGA //** The Art of Building Small
- **KURT WÜTHRICH //** The Role of the Physics Principle of Nuclear Magnetic Resonance in the Life Sciences
- **KLAUS VON KLITZING //** The New International System of Units
- **KONSTANTIN NOVOSELOV //** Materials for the Future
- **TIM HUNT //** Lessons from a Life in Science - Stumbling on the Secret of Cell Division
- **EFIM ZELMANOV //** Basic Structures of Algebra
- **NGÔ BẢO CHÂU //** Prime Numbers
- **WENDELIN WERNER //** Randomness and Stability
- **MICHAEL GRÄTZEL //** Molecular Photovoltaics and the Stunning Rise of Perovskite Solar Cells
- **JOHN HOPCROFT //** An Introduction to AI and Deep Learning
- **LESLIE LAMPORT //** How to Think About Programes
- **LESLIE VALIANT //** How to Increase the Reach of Machine Learning
- **KEES IMMINK //** Evolution of Mass Data Storage Systems
- **ALAIN FISCHER //** Primary Immunodeficiencies (PID) from Genes to (Patho) Physiology and Gene Therapy

VIEW LECTURE RECORDINGS ON THE NRF YOUTUBE CHANNEL

THE REVOLUTION OF PERSONALISED MEDICINE: ARE WE GOING TO CURE ALL DISEASES AND AT WHAT PRICE?

AARON CIECHANOVER // NOBEL PRIZE IN CHEMISTRY (2004)

Medicine will become more targeted and personalised, improving patient outcomes, but this will also thrust thorny issues such as genetic privacy, editing and ethics to the forefront, said Professor Aaron Ciechanover in his opening plenary lecture for Day Three.

He stated that there have been three broad eras of medicine to date. In the first era, medicines were discovered incidentally. Thousands of years ago, for example, ancient Egyptians noticed that willow bark had pain alleviating properties. This eventually led to the creation of aspirin. In the second era, scientists deployed brute force screening to identify chemicals and compounds that could serve as the basis for various drugs.

Scientific advances including the sequencing of the human genome kickstarted the third and ongoing era of personalised medicine. "We are moving from one-size-fits-all medicine to medicine that fits us exactly. We are also starting to stratify diseases at the molecular level," he said. "The more information we can get about a person's genetics, however, the more questions will arise. If I get information about my genetics and vulnerabilities to certain diseases, do I have an obligation to tell my employer or insurance agent? Do I tell my children? Knowing the future is something we have never had to deal with."

THE ART OF BUILDING SMALL

BEN FERINGA // NOBEL PRIZE IN CHEMISTRY (2016)

Within 50 years, doctors will be able to inject nanorobots into patients to repair wounds and deliver drugs to precise locations in the human body, all because of molecular motors that are being invented and developed today, predicted Professor Ben Feringa in his plenary lecture. “Once you know how to make molecular machines move, and how to control their motion, you can think of many applications,” he said.

He added that scientists are already hard at work on futuristic nanotechnologies driven by molecular motors. These include self-cleaning windows and solar panels, and self-repairing materials. “With such responsive surfaces, if you scratch your car, you won’t have to go to the garage because the material will repair itself,” he said. Researchers are also delving deep into ways to activate the tiny motors, such as by using light, electrical signals or even sugar water.

While such groundbreaking research may be diffcult, scientists should persevere, he said, sharing that it took his research group eight years to successfully create a nanocar. He further advised young scientists: “Think about which scientific question in your discipline you want to tackle. Follow your intuition. Work on an important problem that will make a difference, and, most importantly, be adventurous.”

RANDOMNESS AND STABILITY

WENDELIN WERNER // FIELDS MEDAL (2006)

In some complex systems, changing the input of a few pivotal factors can lead to completely different outcomes. This could have implications for some emerging technologies such as quantum computers, said Professor Wendelin Werner in his plenary lecture.

He gave the example of a pool of voters asked to choose between black and white. The voters are then divided into groups of three, and the majority choice of each group is used for the final vote. In a close vote, changing a single person’s vote could change his or her group’s vote and alter the ultimate decision. “If one wants to modify the outcome, one can just find and target these pivotal individuals,” said Professor Werner. He added that this is a key theoretical issue in quantum computing, where errors in the process can affect its outcome.

Professor Werner said that he is motivated to study such phenomena because of the “beautiful mathematical structures” involved in them. He recommended that young scientists pursue their interests: “I’m doing abstract mathematics, but you can recognise the themes that I’m interested in through my mathematics. You have to build on your own identity and ask your own questions. Think about what makes you different from others.”

EVOLUTION OF MASS DATA STORAGE SYSTEMS

KEES IMMINK // IEEE MEDAL OF HONOR (2017)

Reading and writing were the greatest inventions by humans as, for the first time, they could learn directly from a book, standing on the shoulders of knowledge gathered by others, said Dr Kees Immink during his plenary lecture on the second day of the Global Young Scientists Summit 2020.

He noted that the early books – in the form of clay tablets written in the cuneiform script – were the first instance of data storage. Outlining the evolution of the industry over the years, Dr Immink said one of the biggest breakthroughs in data storage was made in 1956 when IBM developed the IBM 350 disk system, which was the first hard disk drive in the world.

He observed that data storage has evolved through various stages since then and the storage capacity has increased dramatically. And yet, it is struggling to keep up with the storage requirements due to the information explosion. He added that DNA-based systems could potentially provide a solution to data storage problems.

However, there are major technical challenges that need to be overcome. DNA, equivalent to a pint of beer, could store all the information that resides in the Internet today. Writing the data and reading it is still a very slow and expensive process. At the moment, the cost is also very prohibitively high. Dr Immink, however, was optimistic that all these challenges could be overcome with time and suffcient c ommercial interest in developing the technology.

AN INTRODUCTION TO AI AND DEEP LEARNING

JOHN HOPCROFT // TURING AWARD (1986)

The information revolution will be similar in impact to the human race as was the agricultural and industrial revolutions, said Professor John Hopcroft during his plenary lecture.

During his lecture, he gave a broad overview and introduction of artificial intelligence (AI) and machine learning (ML). Using mathematical equations and concepts, Professor Hopcroft explained how machine learning works and its advantages as well as limitations.

Giving an example of image classification, he noted that computers can classify images with better accuracy than humans and this was a major advance in deep learning technologies. One of the techniques has been used for automatic online translations from one language to another.

Dwelling on the fundamental question about whether AI is real, Professor Hopcroft noted that the current state of AI is pattern recognition in a high dimension space. “AI programs do not extract the essence of an object and understand its function or other important aspects. Another revolution in 40 years may accomplish that,” he noted.

He added that not all intelligent-like tasks need AI. Some just need computing power and access to large data. A good example, he added, was chess programs that could easily beat human players. “Computers are doing more and more things that one thought required intelligence,” he added.

MOLECULAR PHOTOVOLTAICS AND THE STUNNING RISE OF PEROVSKITE SOLAR CELLS

MICHAEL GRÄTZEL // MILLENNIUM TECHNOLOGY PRIZE (2010)

Meeting world energy consumption needs using traditional fuel sources like oil and gas was not environmentally sustainable, and clean energy sources were required, said Professor Grätzel during his plenary address. He noted that installed photovoltaic (PV) power, a green energy source, needed to increase 200 times to meet the requirement of the Paris climate change agreement.

Professor Grätzel observed that nature has evolved an elegant solution to the problem of clean energy generation through photosynthesis. Inspired by photosynthesis, dye-sensitised solar cells can provide green power required to meet the rapid growth of energy consumption worldwide.

Talking about these types of solar cells, a variation of which are known as Grätzel cells since he helped to pioneer them, the professor noted that when he started working on the project, a lot of people told him that they would not work. Grätzel cells use a sensitiser dye and nano particles of the semiconductor titanium dioxide, a cheap and widely available material. These cells have now become commercially viable and are used to make vertical panels, balustrades and flexible cells for ambient lighting.

Professor Grätzel also noted that perovskite solar cells, while still in their infancy, are a stunning development because they require several hundred times less materials to manufacture than traditional silicon cells. He added that within the next five years largescale commercialisation of the technology would be possible. He concluded his presentation with a call: “Let’s work to conserve our beautiful world”.

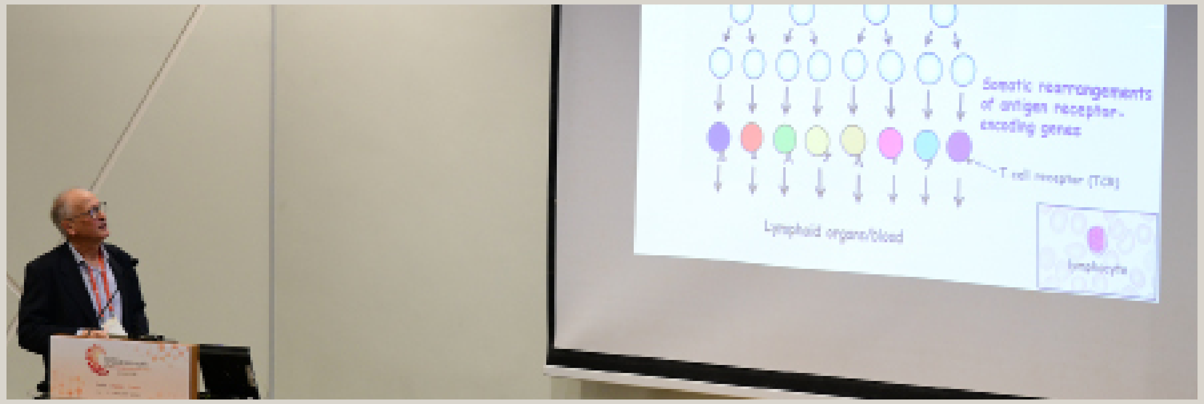
PRIMARY IMMUNODEFICIENCIES (PID) FROM GENES TO (PATHO) PHYSIOLOGY AND GENE THERAPY

ALAIN FISCHER // CHAIR OF EXPERIMENTAL MEDICINE, COLLÈGE DE FRANCE (GUEST SPEAKER)

Around 8000 diseases have been classified as inherited and though they are relatively rare, they still affect 2-3 per cent of the global population, said Professor Alain Fischer during his plenary address.

Some of these diseases include sickle cell disease, cystic fibrosis, myopathies, haemophilia and primary immunodeficiencies. Professor Fischer said that gene therapy has proved to be a promising treatment for these diseases. He noted that gene therapy could provide a normal copy of an affect gene in a cell. It could also be used to inhibit or modify the expression of a mutated gene or fix a mutation. Gene therapy could also provide a synthetic gene for the implementation of a new function.

Professor Fischer added that the idea of using gene therapy to treat genetic diseases is not new as the first paper on this subject was published in Science magazine way back in 1972. However, it is only since 2000 that effective treatment regimens using gene therapy have started.



During his talk, Professor Fischer shared some examples of the use of gene therapy in the treatment of severe combined immunodeficiencies (SCID) using stem cells. He noted that genome editing can also provide treatment to several types of severe diseases.

Professor Fischer said that mastering this treatment technique has been a long journey "full of serendipitous findings". Proof of principle of effcacy and safety of the process has been a lengthy and painful process, he noted.

PRIME NUMBERS

NGÔ BẢO CHÂU // FIELDS MEDAL (2010)

Mathematicians have always built on one another's work, with the history of prime numbers in particular going back thousands of years, said Professor Ngô Bảo Châu in his plenary lecture which outlined the history of the subject and zeroed in on some of its more well-known proofs, theorems and hypotheses.

He noted that the mathematical proof that there are infinitely many prime numbers was produced by Euclid of Alexandria more than 2,000 years ago. Euclid had arrived at this conclusion by demonstrating, through an equation, that it is impossible for there to be only a finite number of prime numbers. Later, Georg Friedrich Bernhard Riemann observed that the frequency of prime numbers is very closely related to the behaviour of an elaborate function.

Even Professor Ngô's breakthrough, for which he won the Fields Medal, involved prime numbers. As a young mathematician, Robert Langlands had formulated an ambitious programme that united two branches of mathematics, namely number theory, which involved prime numbers, and representation theory. His programme, however, relied on an assumption, called the fundamental lemma, which was unproven for 30 years until Professor Ngô showed it was correct. "People have been coming up with elaborate logics for thousands of years," Professor Ngô said, adding that there are still many mysteries waiting to be solved.

LESSONS FROM A LIFE IN SCIENCE: STUMBLING ON THE SECRET OF CELL DIVISION

TIM HUNT // NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE (2001)

Professional advice shared the stage with personal anecdotes in Sir Tim Hunt's lively plenary lecture about his life in science, and how he came to make the seminal discovery that a group of proteins controls cells' growth, duplication and division. "The first problem for any young scientist is to find a problem to solve. When I was starting out, my supervisor told me to go to the library to look for a problem, and so I did," Sir Tim shared.

He also recounted how going to conferences and making friends with fellow researchers had prepared him for his later discoveries and opened up new opportunities. It was at his first conference that he heard two talks that would both play a role in his later Nobel Prize-winning breakthrough. It was also through lending a bicycle to a fellow scientist that he made a friend and was invited to work at the latter's prestigious research institute. "I cannot emphasise enough the importance of personal interactions in the progress of science," he said.

Sir Tim further advised young scientists: "Work with people who are cleverer than you are, try to question your own prejudices, even though it may be diffcult, and, most importantly, follow your nose, wherever it may lead."

HOW TO INCREASE THE REACH OF MACHINE LEARNING

LESLIE VALIANT // TURING AWARD (2010)

The ability to reason is the major component of cognition that needs to be added to machine learning to achieve the goals of artificial intelligence, said Professor Leslie Valiant in his closing plenary lecture for Day Three. In supervised learning, machines are given well-labelled data to teach them how to process similar data in future. This has been useful for various technologies but is not enough. To achieve true artificial intelligence, machines should also be able to examine datasets, reason and come up with rules to process further information.

Professor Valiant outlined several features of such reasoning, which he called robust logic. "If the machine develops two rules that contradict each other in some situations, it should be able to learn its way out of the situation by getting more samples," he said. He noted that some experiments had underlined the superiority of machines that are able to reason. In one experiment, machines were tasked to fill in missing words in sentences drawn from the Wall Street Journal. Those that were able to derive rules from the sentences were more successful.

Professor Valiant said that attaining such robust logic would be diffcult: "One of the challenges will be developing good teaching materials. But it will be worth it."

HOW TO THINK ABOUT PROGRAMS

LESLIE LAMPORT // TURING AWARD (2013)

Dr Leslie Lamport commenced his plenary lecture with an elegant exposition about Euclid's Algorithm, noting that it computes the greatest common divisor (GCD) of two positive integers.

Giving several examples of how this algorithm and others can be used, Dr Lamport observed that in order to execute an algorithm effciently on a computer, one must implement it in code.

Yet programming languages are much more complicated and less expressive than math, so "you don't want to debug an algorithm in the code".

He said that most programmers do not think about the algorithm their program implements. "They design the algorithm as they code. They think about algorithms in terms of code. They should think about them in terms of math."

Dr Lamport added that it is very expensive to fix fundamental design flaws after the code is written because it requires extensive recoding, and often these flaws are not found until the code has been released to users.

BASIC STRUCTURES IN ALGEBRA

EFIM ZELMANOV // FIELDS MEDAL (1994)

Stating there is drama in mathematics, Professor Efim Zelmanov noted that mathematicians want understanding and hence are sceptical of proofs to mathematical problems solved by machines.

Talking about some of the great mathematicians and their seminal contributions, he noted that Évariste Galois, while still in his teens, was able to solve a 350-year-old mathematical problem.

Galois, in a letter to his friend the night before he died in a gun duel, provided a solution to the long-standing question of determining when an algebraic equation can be solved using radicals, which are solutions containing square roots, cube roots and others (but no trigonometric or other non-algebraic functions). Galois' solution contributed immensely to Group Theory in algebra.

Professor Zelmanov noted that Hermann Weyl, another great mathematician, stated that Galois' solution was the most influential paper in the history of mathematics. He also dwelt on the contributions of other famous mathematicians like Émile Léonard Mathieu.

Obliquely referring to the debate over the use of axioms in mathematics, Professor Zelmanov concluded his plenary by observing that mathematicians formulate the most important properties of an object that are relevant to their study, and then take these properties as axioms and study all objects that satisfy these axioms.

"Since the time of Emmy Noether, mathematics speaks the language of axioms. Even the critics of axiomatics write their papers in this way. It is like complaining about the exceeding predominance of English… in English," he concluded.

THE ROLE OF THE PHYSICS PRINCIPLE OF NUCLEAR MAGNETIC RESONANCE IN THE LIFE SCIENCES

KURT WÜTHRICH // NOBEL PRIZE IN CHEMISTRY (2002)

Nuclear magnetic resonance (NMR) will continue to play a crucial role in drug development, declared Professor Kurt Wüthrich in his plenary lecture outlining the history and modern applications of the observation technique which he helped to advance significantly.

The first NMR machines were created in the 1940s using radar technology developed during World War Two to detect enemy planes. "Today, it is used in many ways, including in structural biology," said Professor Wüthrich. "We use it to study the structure of molecules in solution, which means that we can look at the molecules of life in an environment very close to their natural environment." The brain, for instance, is surrounded by cerebrospinal fluid.

By mapping molecules' structure, scientists can identify targets for drugs. "When a chemist makes a new compound, you can use NMR in experiments to see if it is effective," Professor Wüthrich added. He said that he is studying G protein-coupled receptors, which support major human physiological functions and are therefore important drug targets. The receptors are also linked to how pain-relieving opioids work, so better understanding of them could lead to new chemical compounds that are as effective but have fewer or no side effects. He summarised: "NMR can provide the basis for drug development, which is very exciting."

THE NEW INTERNATIONAL SYSTEM OF UNITS

KLAUS VON KLITZING // NOBEL PRIZE IN PHYSICS (1985)

2020 is the first year for the new international system of measurement units, observed Dr Klaus von Klitzing at the start of his plenary lecture, which was the final one of the Global Young Scientists Summit 2020.

On 20 May 2019, the world adopted new definitions for the seven units used to express all measurements: the second for time, metre for length, kilogram for mass, kelvin for temperature, ampere for electric current, candela for luminous intensity and mole for the amount of substance. The latest definitions are based on constant fundamentals of nature, such as the speed of light in vacuum. In his lecture, Dr von Klitzing summarised how the definitions had changed over centuries.

The kilogram, for example, was originally defined in 1799 as the mass of a decimetre cube of water at the temperature of melting ice, before nations agreed in 1875 to use a physical cylinder, subsequently stored in France, and its copies worldwide as the reference. Dr von Klitzing said that the latest definitions for the seven units are better because they are based on the laws of nature, and not physical objects, and thus will not change from country to country or over time: "The constants of nature are the most stable basis for a universal system of units, for all time, and for all people."

MATERIALS FOR THE FUTURE

KONSTANTIN NOVOSELOV // NOBEL PRIZE IN PHYSICS (2010)

Materials have been so important to human life that ages have been named after them, such as the Stone Age, Bronze Age and Iron Age. Now, a new generation of two-dimensional materials and their composites are opening up new possibilities for people, said Sir Konstantin Novoselov in his opening plenary lecture for the Global Young Scientists Summit 2020.

He noted that since he and fellow scientist Sir Andre Geim isolated graphene – a wonder material made up of a single layer of carbon atoms – and mapped its properties in 2004, researchers have been racing to develop other two-dimensional materials, mix and match them to achieve specific properties, and create applications for them.

"In general, we have tended to bet on only a few materials, such as silicon in electronics, steel in construction engineering and aluminium in aircraft. This has limited our invention. Now, we can create new materials atom by atom or layer by layer, and assign properties and functions to the materials and layers. We can design new materials to achieve specific applications," said Sir Konstantin. He urged scientists to think out of the box and make use of the expanding toolbox of materials: "We can create novel applications not possible before."

SMALL GROUP SESSIONS

- **AARON CIECHANOVER //** Development of Personal Career in Science
- **ADA YONATH //** The Everest Beyond the Everest
- **KURT WÜTHRICH //** Being a Scientist in the 21st Century
- **KLAUS VON KLITZING //** 40 Years of Quantum Hall Effect from Basic Science to New Physics and Applications
- **TIM HUNT //** Small Scale Systems Biology: Biological Switches
- **EFIM ZELMANOV //** Career Opportunities for Mathematicians
- **NGÔ BẢO CHÂU //** On the Relation between Number Theory, Algebraic Geometry and Representation Theory
- **WENDELIN WERNER //** Critical Phenomena
- **MICHAEL GRÄTZEL //** The Generation of Chemical Fuels from Sunlight
- **JOHN HOPCROFT //** Preparing One's Career
- **LESLIE VALIANT //** What should a Theory of Machine Learning offer?
- **KEES IMMINK //** How to Bridge the Not-Invented-Here Gap

PANEL DISCUSSIONS

- **ADA YONATH, ALAIN FISCHER, KURT WÜTHRICH //**
- Future of Medicine

- **EFIM ZELMANOV, JOHN HOPCROFT, KEES IMMINK, MICHAEL GRÄTZEL //**
- Science and Society

PUBLIC LECTURES

- **KLAUS VON KLITZING //** 40 Years of Quantum Hall Effect from Basic Science to New Physics and Applications

- **LESLIE LAMPORT //** If you're Not Writing a Program, Don't Use a Programming Language

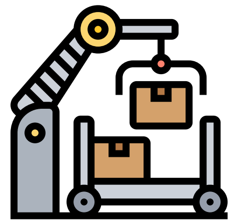
YOUNG SCIENTISTS

// Over 300 promising young scientists from around the world had the opportunity to interact with and be mentored by scientific leaders

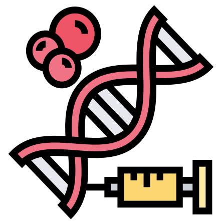
39
COUNTRIES

21-35
YEARS OLD

RESEARCH AREAS

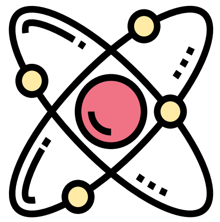


ENGINEERING

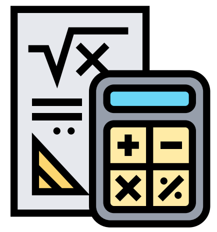


BIOMEDICAL SCIENCES

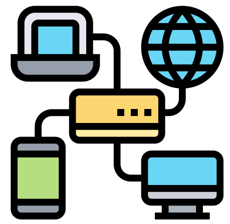
ENVIRONMENT



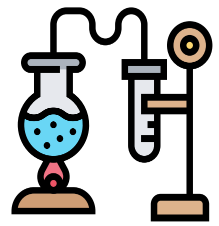
PHYSICS



MATHEMATICS



COMPUTING



CHEMISTRY

PARTICIPATING COUNTRIES

Australia
Belarus
Bhutan
Brunei Darussalam
Cambodia
China
Denmark
Estonia
Finland
France
Germany
Hong Kong
India
Indonesia
Ireland
Israel
Japan
Kazakhstan
Laos
Luxembourg
Malaysia
Myanmar
Netherlands
New Zealand
Norway
Pakistan
Philippines
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South Korea
Sweden
Switzerland
Taiwan
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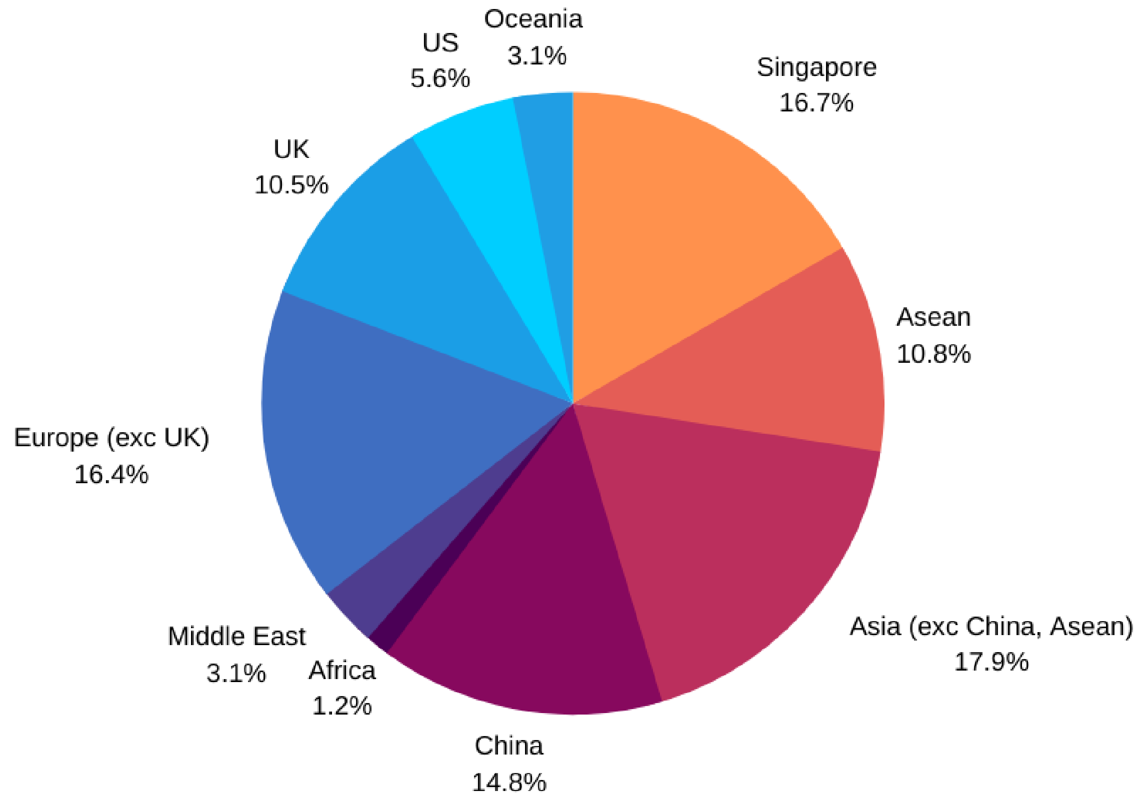
United States of America
Vietnam

BREAKDOWN BY PARTICIPATION



*Total number of registrations: 324

SPEAKERS

// Headlined by some of the world's most distinguished names in science and technology, the 2020 Summit saw award-winning scientists coming together to share the stories behind their revolutionary discoveries

SPEAKERS

AARON CIECHANOVER
NOBEL PRIZE IN CHEMISTRY (2004)

ADA YONATH
NOBEL PRIZE IN CHEMISTRY (2009)

ALAIN FISCHER
CHAIR, EXPERIMENTAL MEDICINE
COLLÈGE DE FRANCE

BEN FERINGA
NOBEL PRIZE IN CHEMISTRY (2016)

EFIM ZELMANOV
FIELDS MEDAL (1994)

JOHN HOPCROFT
TURING AWARD (1986)

KEES IMMINK
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KLAUS VON KLITZING
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NOBEL PRIZE IN PHYSICS (2010)

KURT WÜTHRICH
NOBEL PRIZE IN CHEMISTRY (2002)

LESLIE LAMPORT
TURING AWARD (2013)

LESLIE VALIANT
TURING AWARD (2010)

MICHAEL GRÄTZEL
MILLENNIUM TECHNOLOGY PRIZE (2010)

NGÔ BẢO CHÂU
FIELDS MEDAL (2010)

TIM HUNT
NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE (2001)

WENDELIN WERNER
FIELDS MEDAL (2006)

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