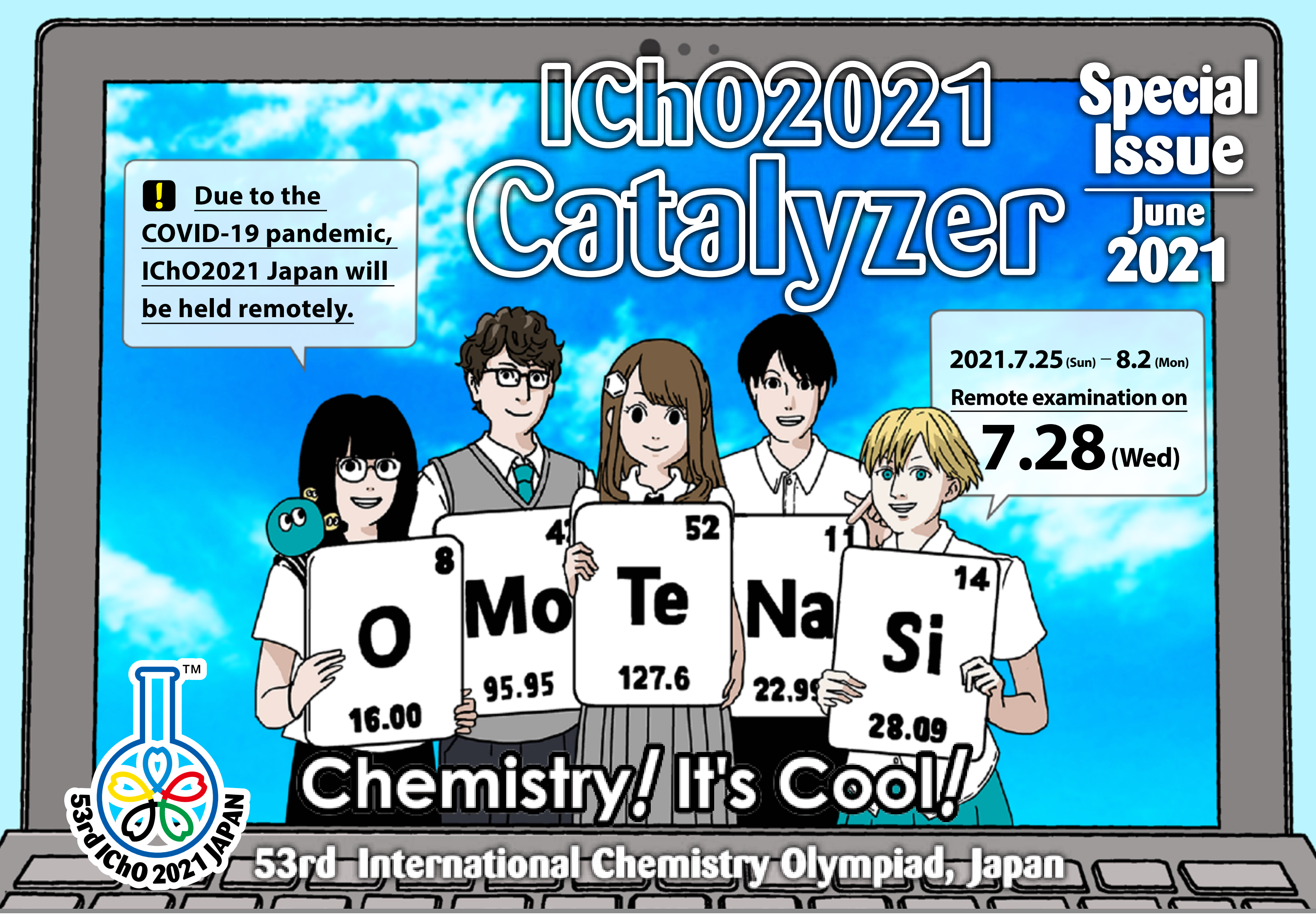


Dear Students, Mentors, Guests, Distinguished Scholars, Observers, SC Members and Colleagues:

Welcome to the IChO2021 Japan 53rd International Chemistry Olympiad. I am delighted to serve as the Chair of the Executive Committee of IChO2021, a very important scientific event especially for students at secondary school level.

This past January, we carefully discussed whether we could hold a real or remote Olympiad in 2021. We eventually decided to hold a remote Olympiad this summer, owing to the ongoing global COVID-19 pandemic. The most important priority was to be able to organize IChO2021 safely and smoothly. Our remote IChO2021 will be held from 25 July to 2 August, 2021. The three key concerns of the Chemistry Olympiad are as follows: (1) The safety of all participants, including secondary school students; (2) Equal opportunity for every student; and (3) International experiences via competition and cooperation, despite the Olympiad being held remotely.

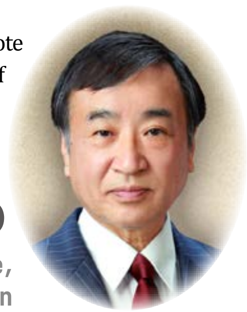
I hope you have already visited our website, https://www.icho2021.org. There you can find our motto for IChO2021, “Chemistry*!* It’s Cool*!*”, as well as our first Catalyzer newsletter. We are sure that you can still enjoy chemistry and experience O-Mo-Te-Na-Si during this remote Olympiad.

The opening ceremony will be held online on our website on 25 July, 2021, and the examination will be conducted in each country on 28 July. Students will be able to take the examination in their home countries. The duration of the examination is five hours. The examination may start at any time between 4:00 pm and 9:00 pm JST, and each country can decide the starting time that suits them.

After grading is complete, an online closing and award ceremony will take place on 2 August. Students may attend the ceremony with their avatars. Medals and the certificates will be sent to participants via surface mail together with commemorative gifts.

Between the opening and closing ceremonies, Olympiad participants can enjoy a series of remote events. These include virtual visits to tourist spots such as Himeji Castle and other famous world-heritage temples and shrines in the Kansai region (Kyoto, Nara, Osaka, and Kobe). Interesting cultural events are also planned, including a visit to a special site at which repair work to an ancient Buddha statue is being carried out. Students can take part in a scientific virtual visit to SPring-8, the world’s largest synchrotron radiation facility. Communications among participating students are also important. Virtual reality avatars will be available for all students to enhance their remote communication experiences. We also plan to make the practical examination available to the general public so they can try their own experiments.

We will make every effort to make our remote IChO2021 Japan a resounding success. On behalf of the executive committee, I sincerely hope you all enjoy the Chemistry Olympiad this summer.



Dr. Yoshiki Chujo
Chair of the Executive Committee,
IChO2021 Japan

Remote Examination FAQ

Due to the COVID-19 pandemic, IChO2021 Japan will be held remotely. The safety of every participant is our first priority. Even though we might be far apart, we still aim to provide special experiences to the participants in July.

Several changes to regulations for the examination are listed below. For more details, please see website.

Q What are the time zones for the remote IChO?

A All dates and times on this document are based on Japan Standard Time (JST), which is Coordinated Universal Time (UTC) +9 hours. Japan does not use daylight saving time during the summer.

Q When is the date for the examination?

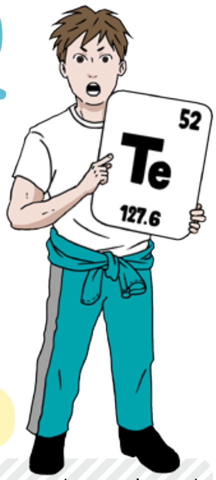
A The theoretical examination will take place on 28 July, 2021.

Q How long is the examination?

A The duration of the examination is 5 hours. The details of the examination must be reported by invigilators. A report form to be completed by invigilators will be provided with the student examination papers.

Q What is the start time of the examination?

A The examination may start at any time between 16:00 and 21:00 JST, and each country can decide its own starting time. However, all competitors in each country must have the same examination timetable to avoid ill-intentioned communication among competitors. Countries with multiple time zones must set their timetable on the basis of one specific time zone and conduct the examination accordingly.



Q How will be the examination conducted remotely?

A The preparation of the examination (discussions, voting, translation, printing) will be done using Oly-Exam software. Mentors will read, comment and vote on, and translate the examination text using the Oly-Exam software.

Q Where should the examination be located?

A The examination location must be a calm and quiet room with electricity, and equipped with a computer or smartphone, web camera, microphone, high quality printer, scanner with PDF-conversion software, and stable internet connection. Each location will be checked via Zoom before the examination.

A single location for the full number of 4 students is highly preferred. If legal travel restrictions in the country forbid a single location, multiple locations for one country are acceptable.

Q What help/tools are allowed for the examination?

A Only a non-programmable calculator, good writing pen and a ruler can be used during the examination. Students should write their answers only using a pen with dark ink.

Q What are the important dates for the IChO2021?

A See the following Table.

Schedule of Remote IChO2021 (Tentative)

J : JST C : CET E : EST

Date	Student	Mentor	Time
Jul 23, Fri		Training of Oly-Exam	J 21:00 C 14:00 E 8:00
Jul 25, Sun	Opening Ceremony (Start time to be determined)		
		Receive the problem	J 21:00 C 14:00 E 8:00
Jul 26, Mon		Deadline of feedback	J 9:00 C 2:00 E 20:00
	Activity (To be announced)	Jury meeting	J 21:00 C 14:00 E 8:00
Jul 27, Tue	Activity (To be announced)	Receive the authorized problem Translation/submission	J 9:00 C 2:00 E 20:00
Jul 28, Wed	Start remote examination at J 16:00 ▼ 21:00 C 9:00 ▼ 14:00 E 3:00 ▼ 8:00	Deadline of translation	J 9:00 C 2:00 E 20:00
		[Invigilator] Receive and print out the problem	J 14:00 C 7:00 E 1:00
		[Invigilator] Submit the solutions (Within one hour after the end of the examination)	
Jul 29, Thu		Receive the solution and the grading scheme	J 9:00 C 2:00 E 20:00
	Activity (To be announced)		
Jul 30, Fri	Activity (To be announced)	Receive grading (from Organizer, Request arbitration)	J 9:00 C 2:00 E 20:00
		Deadline of request, Jury meeting	J 21:00 C 14:00 E 8:00
Jul 31, Sat		Arbitration America(west) ▸▸▸ Asia ▸▸▸ Europe ▸▸▸ America(east)	J 9:00 C 2:00 E 20:00
Aug 1, Sun		Receive final results	J 9:00 C 2:00 E 20:00
	Activity (To be announced)		
Aug 2, Mon	Closing Ceremony		J 21:00 C 14:00 E 8:00

Seimi-kyoku 舎(sei)密(mi)局(kyoku)

the Origins of Modern Chemistry in Japan

During the Edo period (1603 to 1868), when the Tokugawa shoguns ruled the country, Japan adopted a policy of seclusion and closed its borders to the outside world for more than 250 years; international trade was allowed only with China (mainly under the Qing dynasty) and the Netherlands. Any information on the natural sciences that emerged in Europe in the early 18th century came only from the Netherlands through *Dejima*, a small artificial island in the bay of Nagasaki on the west end of Japan.

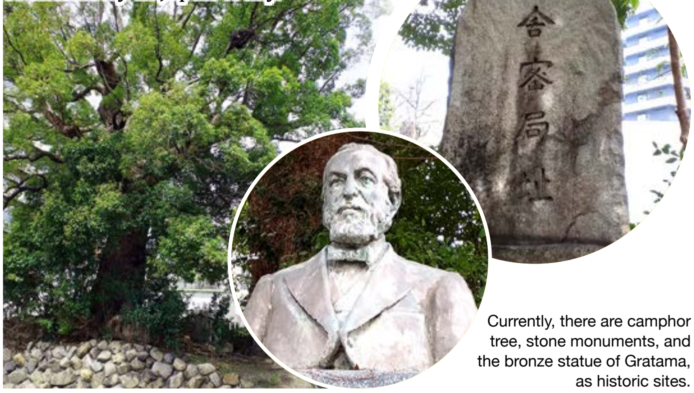
The first systematic chemistry lectures in Japan were given by Johannes Lijdius Catharinus Pompe van Meerdervoort, a physician who came to Japan in 1857. Pompe began teaching Western medicine in Nagasaki, and after he found that the students lacked fundamental knowledge in science, he also started teaching a course in basic science. After Pompe left Japan, Dr Anthonius Franciscus Bauduin was invited to succeed him, and taught chemistry as well as medicine. Following Bauduin, the Dutch chemist Koenraad Wolter Gratama was invited to teach in Japan as a specialist in science and chemistry teaching.

In 1867, Gratama was set to be transferred to the *Kaiseijo*, the shogunate's Western education and research center located in Edo (present-day Tokyo), but this plan was thwarted when the shogunate collapsed during the Meiji Restoration in 1868. The new Meiji government, however, established a college called the *Seimi-kyoku* in Osaka to replace the *Kaiseijo*, and welcomed Gratama as head lecturer there. The word *seimi* was a transliteration of the Dutch word *chemie*, though it is no longer used today. One reason behind the new government's move to establish the *Seimi-kyoku* in Osaka is said to have been their initial intention to move the capital from Kyoto to Osaka, rather than to Tokyo. Ultimately, however, the Emperor moved to Edo Castle where the Tokugawa shogunate was based, after the castle was surrendered bloodlessly to the new government. Eventually, Edo was renamed Tokyo and became the new capital city of Japan.

In 1868, the new *Seimi-kyoku* (also known as the *Osaka Seimi-kyoku*) was completed, and Gratama started teaching physics and chemistry there. Gratama not only taught students, but also initiated training programs for physics and chemistry teachers. The following year, a medical school and hospital were established nearby, where Bauduin also taught. Many students from the medical school also came to attend the lectures at the *Seimi-kyoku*, among them Jokichi Takamine, who later became well-known for his research on adrenaline (Catalyzer, No. 2). Kikunae Ikeda, who discovered the "umami" ingredient *Ajinomoto* (Catalyzer, No. 6), studied chemistry under the tutelage of Jiro Murahashi, Gratama's assistant at the *Seimi-kyoku*. Hiroakira Akashi, who worked at the medical school hospital, deepened his knowledge by listening to Gratama's lectures, and eventually established the *Kyoto Seimi-kyoku* in his home town Kyoto, with the support of the Kyoto prefectural government. Genzo Shimazu, a blacksmith who had been a contractor at the *Kyoto Seimi-kyoku*, was taught by the German teacher there, and later established Shimadzu Corporation, the chemical equipment manufacturer (Catalyzer, No. 5). These are just a few examples of the many students and teachers who received direct or indirect instruction from foreign teachers and who later drove the development of medicine, chemistry, and pharmacy in Japan.

Koenraad Wolter Gratama
(1831-1888)

In 1870, Gratama completed his term of office and returned to the Netherlands the following year. The German chemist Georg Hermann Ritter was invited to replace him. In 1872 however, all the personnel and assets of the *Seimi-kyoku* were transferred to the *Tokyo Kaisei Gakko* school, which later became the University of Tokyo. The *Seimi-kyoku* underwent several organizational and name changes, finally becoming the Third Higher School in 1889, which would later be merged into Kyoto University. At the site of the former *Osaka Seimi-kyoku* near Osaka Castle, there is a large camphor tree in a corner surrounded by a stone wall that appears to block the walkway, and at the base of the tree stands a stone pillar and monument that reads "Site of the Former *Seimi-kyoku*." On the reverse side of the monument is a majestic bust of Gratama. Although the *Seimi-kyoku* disappeared in the turbulent times for Japanese society in the early Meiji era, its legacy lives on as the foundation of chemistry in Japan today.



Currently, there are camphor tree, stone monuments, and the bronze statue of Gratama, as historic sites.

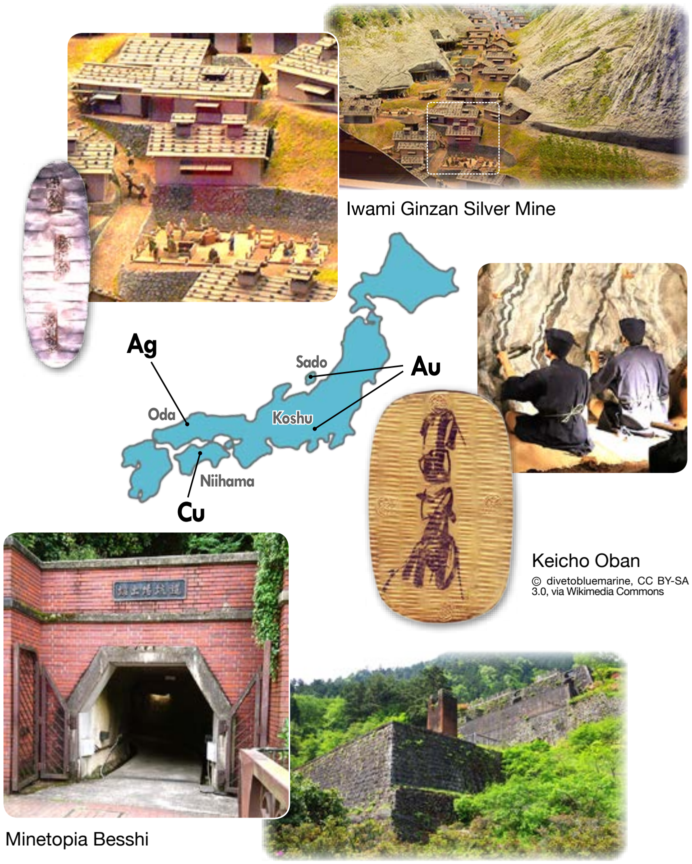
Element #1

Japanese mineral resources
Au, Ag, and Cu

Today, Japan depends mostly on imports of the mineral resources it needs, but in the past it used to produce large amounts of gold, silver, and copper. Marco Polo, the 13th-century merchant and explorer who travelled throughout Asia, introduced Japan to Europe as “Japan, Land of Gold” in his travelogue *The Travels of Marco Polo*, which later became the driving force for adventurous explorers during the Age of Discovery.

Long ago, gold mines such as those on the island of Sado (part of Niigata prefecture today) and in Koshu (Yamanashi prefecture) produced significant amounts of gold. In the Edo era, from the 16th to the 19th centuries, the Tokugawa bakufu (shogunate) established an official gold guild known as the Kin-za, and gold coins called Keicho Koban and Oban were issued.

In terms of silver production, one of the major operations was the *Iwami Ginzan* silver mine, where production of silver continued for approximately 400 years from the 16th century. The *Iwami Ginzan* silver mine was located in what is the city of Oda in Shimane Prefecture today, and production reached its peak during the Edo period, when the mine was directly managed by the *bakufu*. Production then gradually decreased until the mine was closed in 1923. The *Iwami Ginzan* silver mine site was registered as a UNESCO World Heritage (Cultural) Site in 2007, listed as the Iwami Ginzan Silver Mine and its Cultural Landscape, with special mention made of its environmentally friendly operation.

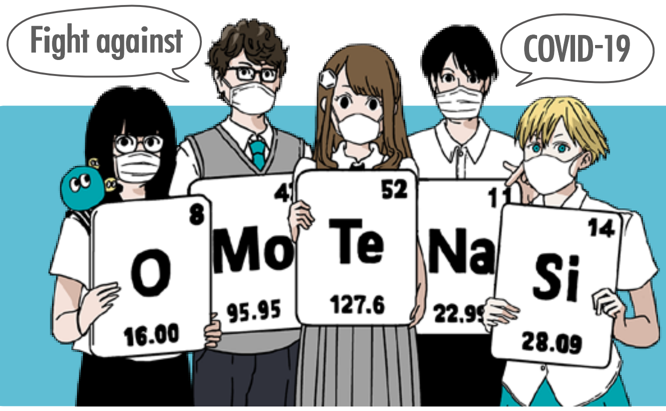


Iwami Ginzan Silver Mine

Keicho Oban

Minetopia Besshi

The Besshi copper mine located in what is the city of Niihama in Ehime Prefecture, discovered in 1690, produced a total of 700,000 tonnes of copper in 283 years until it was closed in 1973. The former mine site is now the location of Minetopia Besshi, a historical theme park where people can learn how the mine operated in the olden days.



These five elements spell “OMoTeNaSi”, the Japanese word for hospitality. It means to wholeheartedly take care of guests without expecting anything in return. Attention is paid to even the smallest details in order to bring guests the best experience possible. As you make your way across Japan, you will find *omotenasi* everywhere.

Chemistry! It’s Cool!

53rd IChO 2021 JAPAN

IChO2021 Special Issue
Catalyzer June 2021

Official Website
https://www.icho2021.org/
icho2021

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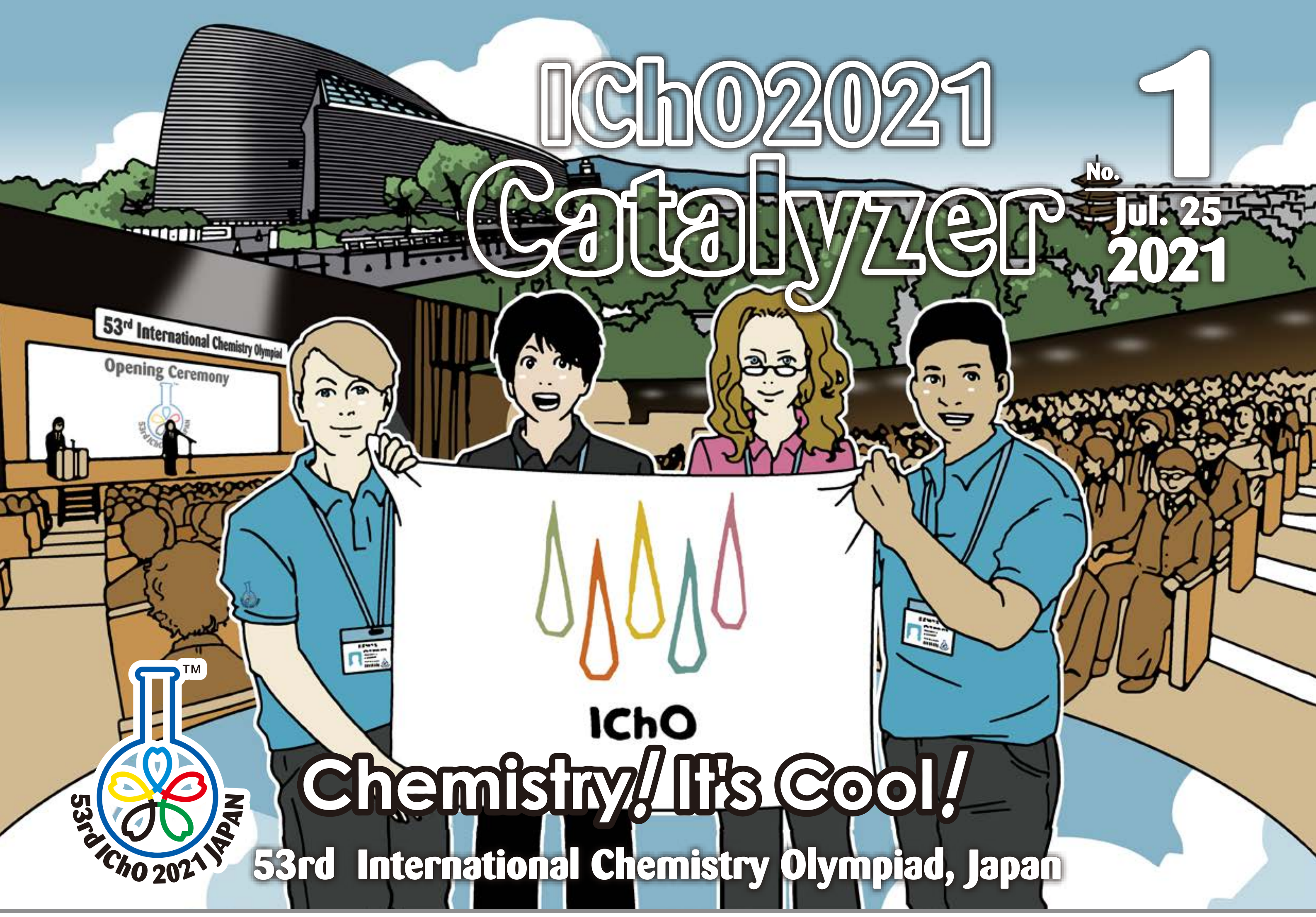


Cover illustration : Opening Celemony

Message

It is our great pleasure to host the 53rd International Chemistry Olympiad (ICh02021), a competition so rich in history since the first one in 1968, and to welcome very talented young students from 79 countries and regions around the world.

As important as it is as an academic subject, chemistry is also the basis for creating materials and substances with a vast range of functions that constantly supports our daily lives.

The COVID-19 pandemic is still plaguing the world. Chemistry is playing a vital role in the fight against COVID-19 by being applied for PCR and antigen testing to detect infection and its history and for the manufacture of COVID-19 treatment drugs.

Moreover, we expect chemistry to greatly contribute to achieving the Sustainable Development Goals, including the stable supply of food, the recycling of waste, and so on.

All the students participating in ICh02021 have the potential to address these various shared problems of the world and to open up a new path for humankind. It is a crucial issue for governments around the world to discover their talents and create an environment to develop fully these capabilities.

The International Science Olympiads, including IChO, have provided various opportunities for talented students to challenge, and contributed to discovering such students and fostering their capabilities. As the host country, Japan will make its utmost efforts to support this mission.

Because of COVID-19, like the previous Olympiad, ICh02021 will be held online. The organizers are planning to make full use of VR technology and avatar technology to provide remote tours to both state-of-the-art and traditional science and technology facilities, which large groups of people cannot usually visit. Unfortunately you will not be able to have direct interaction, however, with the creative use of these technologies, you will be able to overcome the barriers of distance and space to connect with your peers.

We hope that all of you representing your countries at this Olympiad will fully demonstrate your real abilities and the results of your efforts, improve yourselves through competitions, and make lasting friendships with peers.

It is our sincere wish that you all continue your self-improvement and make the most of your experiences to play active roles in leading your countries and the world.

HAGIUDA Koichi

the Minister of Education, Culture, Sports, Science and Technology

IChO2021 Japan Welcome Address at the Opening Ceremony on July 25

I am Kohei Tamao. Thank you for your kind introduction. It is a great pleasure and honor for me to say a few words at the opening ceremony of the 53rd International Chemistry Olympiad, IChO2021 Japan.

Dear talented high school students, mentors, scientific observers, guests, distinguished scholars, invigilators, Steering Committee members, and colleagues from all over the world, welcome to the Opening Ceremony of IChO2021 Japan.

Originally, we had been preparing to hold IChO2021 Japan at Kindai University, one of the biggest private universities in Japan, located in the lively and modern commercial city of Osaka in mid-west Japan, also known as the birthplace of chemical research in this country.

However, in light of the ongoing COVID-19 pandemic, we had no choice but to hold IChO2021 remotely, following the lead of IChO2020 Turkey last year.

This is the result of giving top priority to the safety of our young talented students and all participants, even at the expense of practical examinations and opportunities for in-person international exchange. I would like to thank all the International Steering Committee members led by Dr. Gábor Magyarfalvi for their enthusiastic discussion and acceptance of our decision.

Even under the difficult conditions presented by the COVID-19 pandemic, the good news is that we have accepted registrations from 85 countries and regions of the 89 to which we sent invitations. More than 320 students have been registered. I would like to express my sincere gratitude and respect for the wonderful efforts of mentors, teachers, and all concerned in each country to select talented students and set up the examination sites.

The theoretical examinations will be held on July 28th in each country, and the examination results, including gold, silver and bronze medalists, will be announced in the closing ceremony on August 2nd.

I am confident that the remote examinations on July 28th will be carried out in an atmosphere of justice, fairness, and trust, maintaining the spirit of IChO across space and time. It is my sincere hope that all the participating students will do their very best, showcasing the talents and skills they demonstrate every day.

As we are unable to hold the practical examinations, we have prepared a demonstration video of the practical tasks.

To compensate for the fact that the participants cannot meet in person, we will offer various initiatives for students to create international friendships and become familiar with Japanese culture and the state of art, science, and technology in this country.

For that purpose, VR avatars for all students have been prepared to facilitate remote networking and to give greater realism to virtual visits to sensitive areas such as the restoration site of an ancient Buddha statue and the world's largest synchrotron radiation facility, SPring-8, to which access is normally prohibited.

Dear students, now I would like to ask you to keep the following three things in mind, as you are about to enjoy a once-in-a-lifetime valuable experience.

First, you have been given hope and courage to overcome difficulties through your participation in this remote IChO2021 Japan.

Second, the unprecedented difficulties we have been facing can only be overcome by international friendships and trust. Thus, you should show gratitude and respect to your mentors, teachers, invigilators, and all others who have contributed to make this major international event a reality, despite the obstacles faced.

Third, I want you to remember that chemistry, the central science, is all around us. Chemistry must therefore play a key role in finding solutions for many global challenges, including energy, environmental, and resource-related issues that humanity is now facing.

I hope that IChO2021 Japan helps to foster many talented young people who will go on to play roles as future world leaders. While you do not have the opportunity to meet each other in person this time, I am convinced that one day you may meet each other somewhere in the world when you go to university or graduate school. I sincerely hope that you take the opportunities given to you as participants in this remote IChO2021 to create strong networks of international friendship, with the slogan "Chemistry*!* It's Cool*!*" as your watchword.

Finally, I would like to thank the Ministry of Education, Sports, Science and Technology (MEXT Japan) and the Japan Science and Technology Agency (JST) for their meaningful support, and the more than 180 chemical companies and trading companies in Japan as our sponsors for their substantial financial assistance, as well as numerous personal donations.

My special thanks are also due to all the members of the Japan Committee and Organizing Committee for IChO2021 Japan, as well as our secretariat and KNT Corporate Business Company, Ltd., as represented by the Vice President of the Japan Committee and Chair of the Fundraising Committee Dr. Kyohei Takahashi, Chairs of the Finance Committee the late Dr. Tadao Kondo and Dr. Teiji Koge, Chair of the Executive Committee Professor Yoshiki Chujo, Chair of the Scientific Committee Professor Hiroshi Nishihara, and member of the International Steering Committee Professor Nobuhiro Kihara.

Without their remarkable support and endeavors, this remote IChO2021 Japan would not be possible.

Now, it is my great pleasure to officially declare remote IChO2021 Japan open.

Thank you very much for your kind attention.

Dr. Kohei Tamao

President, IChO2021 Japan Committee
Chairman, Organizing Committee
for the 53rd IChO2021, Japan

Schedule of Remote IChO2021

Date	Student	Mentor	J	C	E
Jul 25, Sun	Opening Ceremony (Virtual Reality Venue)	Opening Ceremony (Virtual Reality Venue)	15:00	08:00	02:00
	VR Closed	Receive the problem	21:00	14:00	08:00
Jul 26, Mon	VR Closed	Deadline of feedback	09:00	02:00	20:00
		Jury meeting	21:00	14:00	08:00
Jul 27, Tue	VR Closed	Receive the authorized problem Translation ▸▸▸ submission	09:00	02:00	20:00
Jul 28, Wed	Examination (5 hours) Start between J 14:00 – 05:00 (Jul 29), C 07:00 – 22:00, E 01:00 – 16:00	Deadline of translation	09:00	02:00	20:00
		[Invigilator] Receive and print out the problem	11:00	04:00	22:00
		[Invigilator] Submit the solutions (Within 2 hours after the end of the examination)			
Jul 29, Thu		Receive the solution and the grading scheme	09:00	02:00	20:00
	Activity (SPring-8 Virtual tour)	Activity (SPring-8 Virtual tour)			
Jul 30, Fri	Video: Practical Examination explanation	Receive grading (from Organizer, Request arbitration)	09:00	02:00	20:00
		Deadline of request, Jury meeting	21:00	14:00	08:00
Jul 31, Sat	Activity Video:History and Culture of Nara	Arbitration America (west) ▸▸▸ Asia ▸▸▸ Europe ▸▸▸ America (east)	09:00	02:00	20:00
Aug 1, Sun	Activity Video:Himeji Castle, Osaka, and Kyoto	Receive final results	09:00	02:00	20:00
		Activity Video:Himeji Castle, Osaka, and Kyoto			
Aug 2, Mon	Closing Ceremony (Virtual Reality Venue)	Closing Ceremony (Virtual Reality Venue)	21:00	14:00	08:00

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time) 00:00 (Brown color letters) : The night before

The VR video programs will be opened at 00:00 JST on each day.

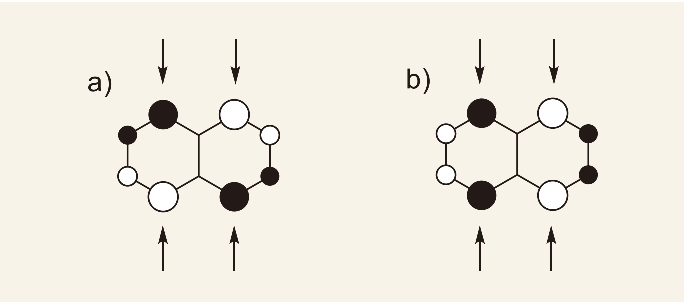
Nobel Prize Research from Japan 01

Frontier Orbital Theory

Kenichi Fukui

Dr. Kenichi Fukui
(1918–1998)

How do chemical reactions occur? For chemistry students, the frontier orbitals called HOMO (Highest Occupied Molecular Orbital) and LUMO (Lowest Unoccupied Molecular Orbital) are extremely important. This concept of frontier orbitals was conceived by Kenichi Fukui, who in 1952 proposed that electrophilic substitution reactions in aromatic hydrocarbons occur at the position with the highest coefficient of HOMO, while nucleophilic reactions are determined by the coefficient of LUMO. This was an epoch-making concept, completely different from the conventional theory of organic electronics, which was based mainly on electron density.

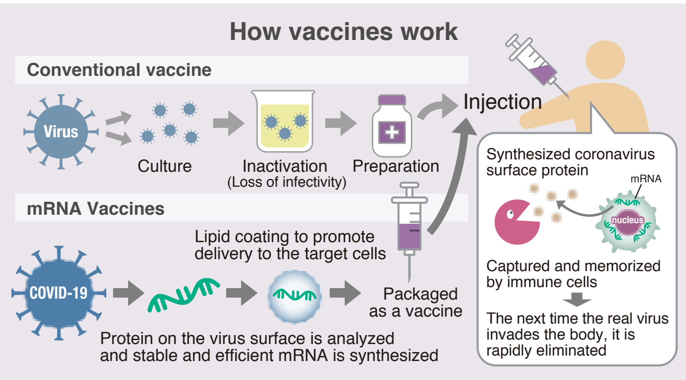


Frontier orbitals of naphthalene. a) HOMO. b) LUMO.
The arrows show locations where reactivity is higher.

In 1964, he further developed this theory by pointing out that the symmetry and phases of the HOMO and LUMO of the reacting molecule play important roles in cycloaddition reactions such as the Diels–Alder reaction. In 1981, he was awarded the Nobel Prize in Chemistry for “the theories concerning the course of chemical reactions,” together with Roald Hoffmann, who separately published the Woodward–Hoffmann rules in 1965. Fukui was the first Japanese chemist and Asian person to be awarded the prize, which had until then been won by researchers from Europe and the United States. Today, the concept of HOMO–LUMO is widely used not only in chemical reactions and physical properties of molecules themselves, but also in molecular electronics, organic electroluminescence, enzymatic reactions, and electron transfer in interactions in biomolecules such as proteins.

COVID-19 and mRNA Vaccines

For certain infectious diseases, it is empirically known that once a person is infected they will not contract the disease again. This is due to the function of the immune system, which remembers the disease they have been infected with and can quickly eliminate the pathogen on the second infection. Vaccines make use of this biological function. Less virulent viruses or bacteria, as well as a portion of the pathogen (protein or polysaccharide), can be administered as a vaccine. This allows the immune system to remember the pathogen and prevent infection. Vaccines against COVID-19, a new type of coronavirus, which has had a major impact on our lives since 2020, are being vigorously developed around the world, resulting in the development of mRNA vaccines. Unlike conventional vaccines, mRNA vaccines deliver mRNA, the gene for the pathogen protein, into the human body. Although mRNA vaccines have been studied since the 1990s, they have not been put to practical use due to a number of drawbacks, including the following: 1) mRNA is not stable in vivo, 2) mRNA is not very efficient in the production of proteins, and 3) it is not easy to deliver mRNA into cells. Development of effective mRNA vaccines proceeded by solving these issues one by one. This was done through introducing artificial structures into the mRNA to prevent degradation by metabolism, and optimizing the RNA sequence to increase the efficiency of conversion into protein. Furthermore, by encapsulating the mRNA in lipid nanoparticles, researchers succeeded in efficiently delivering it into the cell. As a result, an extremely effective vaccine against coronaviruses has been developed.



Doshomachi

Kansai Scenes 1

"Medicine Town" and Sukunahikona Shrine

In the era of Toyotomi Hideyoshi (1537 to 1598), drug wholesalers were concentrated in the Doshomachi area of Osaka in accordance with the government's commercial policy. During the isolationist period of the Tokugawa shogunate (1603 to 1867), exchange with foreign nations was restricted to China and Holland. Drug wholesalers who imported drugs from those two countries established their businesses in Doshomachi, forming an officially approved guild, or *Kabunakama*, called the *Yakushunakagainakama.* In 1721, the Tokugawa government established an agency in Doshomachi for checking the quality of medicinal products made in Japan (*Wayakushu aratame kaisho*). Hence, all medicines commercially traded throughout Japan passed through Doshomachi first. All these historical connections led to Doshomachi being home to many pharmaceutical companies, making it Japan's first "medicine town," followed later by Nihonbashi Honcho in Tokyo.

The Doshomachi Pharmaceutical and Historical Museum (*Kusurinomachi Doshomachi Shiryokan*) is a great place to see exhibits of prescription medicines, instruments, equipments, and other related items used by medical wholesalers. The Sukunahikona Shrine, a Shinto shrine that is dedicated to medical deities, can also be found in Doshomachi.

Participating Teams

1 Armenia
2 Australia
3 Austria
4 Azerbaijan
5 Bangladesh
6 Belarus
7 Belgium
8 Brazil
9 Bulgaria
10 Canada
11 China
12 Chinese Taipei
13 Costa Rica
14 Croatia
15 Cyprus
16 Czech Republic
17 Denmark
18 El Salvador
19 Estonia
20 Finland
21 France
22 Georgia
23 Germany
24 Greece
25 Hungary
26 Iceland
27 India
28 Indonesia
29 Iran
30 Ireland
31 Israel
32 Japan
33 Kazakhstan
34 Korea
35 Kyrgyzstan
36 Latvia
37 Lithuania
38 Luxembourg
39 Malaysia
40 Mexico
41 Moldova
42 Mongolia
43 Montenegro
44 Netherlands
45 New Zealand
46 Nigeria
47 North Macedonia
48 Norway
49 Oman
50 Pakistan
51 Philippines
52 Poland
53 Portugal
54 Qatar
55 Romania
56 Russian Federation
57 Saudi Arabia
58 Serbia
59 Singapore
60 Slovakia
61 Slovenia
62 South Africa
63 Sri Lanka
64 Sweden
65 Switzerland
66 Syria
67 Tajikistan
68 Thailand
69 Trinidad and Tobago
70 Turkey
71 Turkmenistan
72 Ukraine
73 United Arab Emirates
74 United Kingdom
75 United States of America
76 Uruguay
77 Uzbekistan
78 Venezuela
79 Vietnam

Observer Teams

- Afghanistan
- Ecuador
- Egypt
- Kuwait
- Nepal
- Paraguay

Early Bird Communication

To Catalyzer

United Arab Emirates

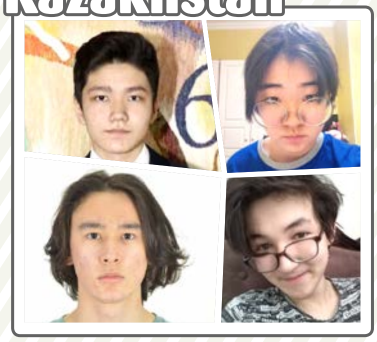
Georgia

The Swedish team with the elements. Good luck with the Catalyser!

Vietnam

Sweden (Sverige)

Kazakhstan



Students doing experiments in the lab and standing in front of the chemistry department gate.

Croatia

Bulgaria

This picture was taken during the IChO training session on July 5 2021.

Indonesia

Nigeria

We are glad to participate in 2021 Remote IChO competition. Regards from Nigeria.

Today's schedule Jul. 25

Student

- **Opening Ceremony at VR Venue** J 15:00 C 08:00 E 02:00

Participants of IChO2021 can attend the opening ceremony from VR space.
Non-participants can also watch the opening ceremony from the IChO2021 website.

Mentor

- **Opening Ceremony at VR Venue** J 15:00 C 08:00 E 02:00
- **Receive the problem** (Oly-Exam) J 21:00 C 14:00 E 08:00

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time)

Short short from Kansai | A Papier-mâché Tiger

In ancient Asia, tigers were considered to be messengers from the Gods, and their bones were used as a medicine and in lucky charms. In 1822, when Osaka was hit by the cholera epidemic that was sweeping the world at the time, an apothecary in Doshomachi, Osaka, created a Japanese herbal medicine containing tiger skulls and distributed it with a tiger-shaped charm made of paper called *Hariko-no-tora*, meaning a papier-mâché tiger. Although the medicine itself became obsolete, *Hariko-no-tora* are still handmade as traditional crafts. They are popular in the Kansai region as lucky charms that protect people from disease and express the wish for healthy growth of children.

Useful Japanese Phrases +α
the Kansai dialect

Following on from the useful Japanese phrases introduced in Catalyzer No. 0, this edition features *Kansai-ben*, a dialect spoken in the Kansai region, where we had originally planned to hold the in-person IChO2021. Let's all try speaking *Kansai-ben!*

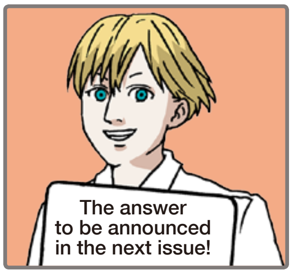
English	Standard Japanese	Kansai Dialect	
Good bye	Sayounara	Sainara	さいなら
I'm sorry.	Gomennasai	Sunmahen	すんまへん
My bad.	Gomen	Suman	すまん
Thank you!	Arigatou	Ohkini	おおきに
Yes	Hai	Soya	そや
No	Iie	Chau	ちゃう
foolish	bakamitai	ahokusa	あほくさ
nonsense	kudaranai	shoumona	しょうもな
strange	okashina	kettaina	けったいな
because	～ nanode	～ yasakai	～やさかい
tired	tsukareru	shindoi	しんどい
How about?	Dou?	Donai?	どない？
McDonald's	Mac	Makudo	まくど
Father	Tousan	Oton	おとん
Mother	Kasan	Okan	おかん

＊ These words are just some examples.

ELEMENT QUIZ Q1

A neodymium magnet, known as the world's strongest permanent magnet, is made of three elements. Which of the following is the correct combination?

1 (Nd, Pb, B) 2 (Nd, Pd, Fe)
3 (Nd, Fe, Co) 4 (Nd, Fe, B)



Chemistry! It's Cool!

53rd IChO 2021 JAPAN ™

IChO2021 Catalyzer No. 1

Official Website
https://www.icho2021.org/
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Jul. 25
1908
Patented!
Production method of Umami flavor
(AJINOMOTO)

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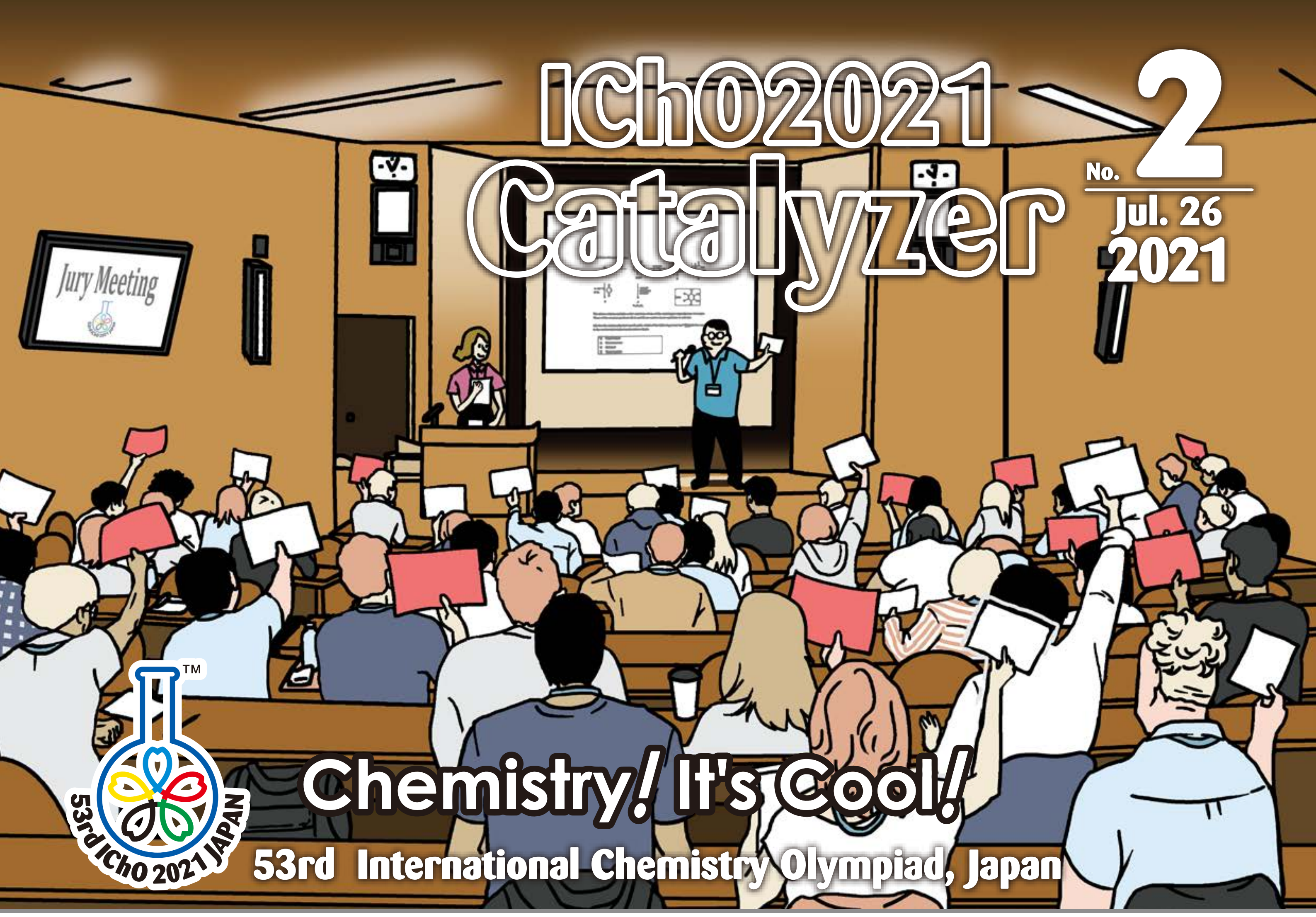
English Editor: Maiko Katayama
Illustration: Science Manga Studio



Cover illustration : Jury Meeting

Nobel Prize Research from Japan 02

Asymmetric Reactions

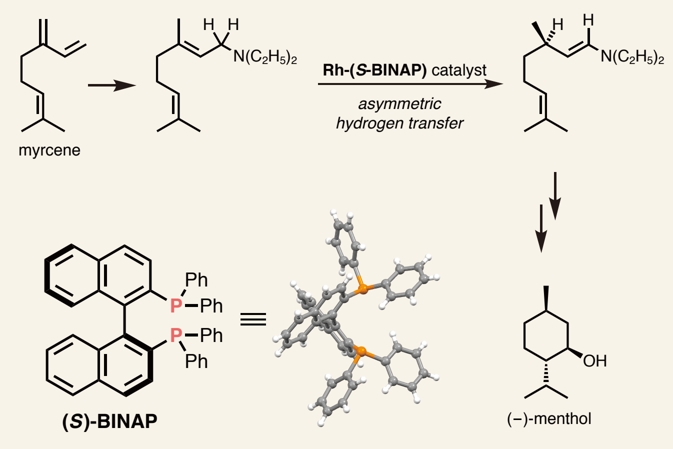
Ryoji Noyori

Photo by Kagaku-Dojin

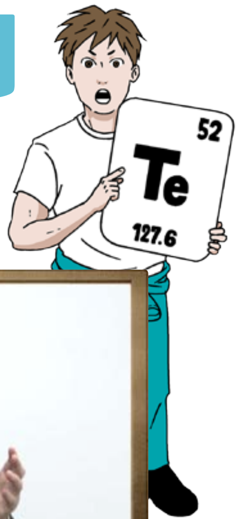
Dr. Ryoji Noyori
(1938–)

Some organic compounds exist as two stereoisomers that are mirror images of each other (chiral molecules); the relationship resembles that of a person's right hand and left hand. Many chiral molecules are found in nature, typical examples of which are the amino acids that make up proteins in living organisms. Interestingly, proteins in living organisms are composed of only one of the mirror-image isomers (L-type amino acids). Since living organisms distinguish chiral molecules, asymmetric synthesis is extremely important in the development of pharmaceuticals, flavors, and food additives. Ryoji Noyori developed unique chiral phosphorus ligand BINAP as a source of chirality essential for the synthesis of chiral compounds. BINAP has a beautiful structure with C_2 symmetry, and its metal complexes enable various catalytic asymmetric reactions. One of the best known applications of BINAP is the Rh-BINAP-catalyzed asymmetric hydrogen transfer reaction, a key step in the synthesis of (−)-menthol used in flavors and pharmaceuticals. This technology has been commercialized by Takasago International Corporation (Japan), a world leader in the fragrance and flavor industry. For developing such a truly practical method for catalytic asymmetric synthesis, Ryoji Noyori was awarded the Nobel Prize in Chemistry in 2001, together with William S. Knowles and Karl Barry Sharpless.

Industrial synthesis of (−)-menthol

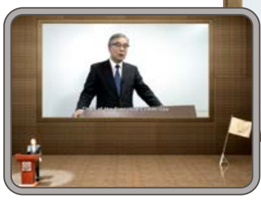


The Opening Ceremony held at the Virtual Reality Venue



Program of Opening Ceremony

- Opening Movie
- Introduction of Sponsors
- Opening Address by Dr. Kohei Tamao
  President, IChO2021 Japan Committee
- Welcome Message from HAGIUDA Koichi
  the Minister of Education, Culture, Sports, Science and Technology
- Message from Dr. Akira Yoshino
- Introduction of Participating Teams



Dr. Kohei Tamao
President, IChO2021 Japan Committee
Chairman, Organizing Committee for the 53rd IChO2021, Japan

HAGIUDA Koichi
the Minister of Education, Culture, Sports, Science and Technology

Dr. Akira Yoshino
Honorary Fellow, Asahi Kasei Corp. 2019 Nobel Laureate in Chemistry

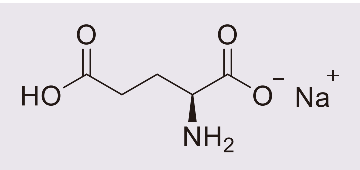
Chemistry! It's Japan!

The Discovery of Umami Component

Kikunae Ikeda

Our sense of taste includes sweetness, sourness, saltiness, and bitterness as well as umami. The umami component was discovered by Kikunae Ikeda. Back then, the taste was thought to consist of a combination of four tastes: sweet, sour, salty, and bitter. Ikeda believed that dashi or broth made of dried bonito flakes and kelp, contained ingredients that made people feel that a food was delicious. Motivated by this somewhat unique Japanese sensibility, he attempted to identify the source of umami from kelp, and in 1908, determined that monosodium glutamate was indeed the umami component. Although glutamate itself had already been described as a chemical compound, Ikeda was the first to formulate the concept of glutamate as a component of umami. Based on this discovery, the company Ajinomoto was established, which has grown to become one of Japan's leading food companies. Ikeda also discovered the umami component of bonito, and together with his student Shintaro Kodama, discovered inosinic acid as the second umami component. Whether umami is a taste or not has been debated for a long time, but the discovery that the taste buds on the tongue contain sensors (glutamate receptors) that sense umami as well as the other four tastes has scientifically proven that humans can actually sense umami as a taste. The Japanese word umami has now gained currency in English and has become internationally recognized.

Dr. Kikunae Ikeda
(1864–1936)



Structure of monosodium glutamate

Tenjin Festival and Gion Festival

Kansai Scenes 2

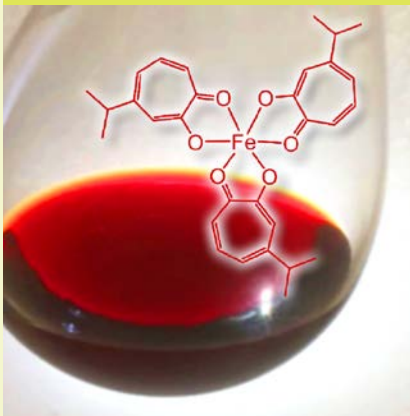
Held throughout the country, many of Japan's festivals are religious events. The Tenjin Festival in Osaka, the Gion Festival in Kyoto, and the Kanda Festival in Tokyo are known as Japan's three top festivals; two of them in the Kansai region of western Japan. The Tenjin Festival is held at the Osaka Tenmangu Shrine, which enshrines Sugawara no Michizane, a 9th century scholar and politician. On the night of July 25, the anniversary of Michizane's death, a boat procession is held on the Okawa River, accompanied by a fireworks display. It is known as the festival of fire and water because of the splendid sight of bonfires, lanterns, and fireworks reflected on the Okawa River. Aside from the festival, the Osaka Tenmangu Shrine also attracts students who come to pray for success in their entrance exams, as Michizane is worshipped as the god of learning. The Gion Festival has been held at Yasaka Shrine since the 9th century. Thirty-two large floats called *Yamahoko* are paraded through the center of Kyoto on July 17 each year.

Tenjin Festival

Gion Festival

Tale related to Preparatory Problem

Plactical Task 4



Hinokitin : Let a Deep-red Natural Pigment Inspire Your Curiosity

Practical Task 4 of the preparatory problems deals with nonbenzenoid aromatic compounds, a collection of which is designated in Japan as Certified Chemical Heritage No. 036. Reading the related literature, we found an article containing a comment by Tetsuo Nozoe*, looking back on his research into a seven-membered ring compound named hinokitiol, which reads: "I was attracted by the red pigment hinokitin in the wood of the Formosan Hinoki Cypress tree (*Chamaecyparis obtuse var. formosana*) derived by Nenokichi Hirao". Hirao had published a paper on hinokitin in 1926 (*Nihon Kagakukaishi*, vol. 47, pp. 666–671). Nozoe unexpectedly discovered that hinokitin contained iron, and obtained hinokitiol by removing the iron content, leading to the discovery of a new family of chemical compounds, the nonbenzenoid aromatic compounds. Hinokitin is an iron trivalent complex with hinokitiol as a ligand. In Practical Task 4, you are to synthesize hinokitin from hinokitiol and iron (III) nitrate nonahydrate. Watch in awe as the reaction produces a compound with an impressively deep-red color (see photo). I hope that the red color of hinokitin will catalyze the curiosity and passionate spirit of inquiry of young people who will create the future of chemistry.

*Tetsuo Nozoe (1902–1996) : Japanese Chemist, Professor of National Taiwan University (1936–1948) and Tohoku University (1948–1966)

Today's schedule Jul. 26

Student

- VR Closed

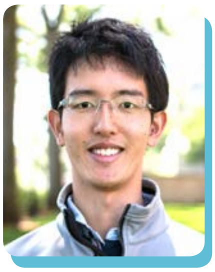
Mentor

- **Deadline of The Problem Feedback** (Oly-Exam)
  J 09:00 C 02:00 E 20:00 (Jul. 25)
- **1st Jury meeting** (zoom) J 21:00 C 14:00 E 08:00

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time)

CHEER UP! Participants!

Welcome to IChO! I hope you are enjoying your virtual stay in Japan and getting ready for the exam. More than anything, however, enjoy your time with participants from other countries. I made many lasting friendships in IChO and I am sure you will too! When you hesitate to talk with someone because they speak a different language or come from a different culture, remember your passion for chemistry will be the bond that connects you together. Have fun!



from **Tomohiro Soejima** (Japan)
University of California, Berkeley
Department of Physics
PhD student

IChO 43rd in Ankara, Turkey Gold medal
IChO 44th in Washington D.C., USA Gold medal

ELEMENT QUIZ Q2

Stainless steel is an alloy made by adding two metals to iron. Which of the following is the correct combination of the two non-iron metal elements?

1 (Co, Mn) 2 (Zn, Ni)
3 (Ca, Mn) 4 (Cr, Ni)

Short short from Kansai

Illumination of Tsutenkaku Tower

As the COVID-19 pandemic continues to rage around the world, Japan too is battling waves of cases and new variants, and has started vaccinating its population in stages. Tsutenkaku Tower, the symbolic tower of Osaka, lights up in different colors to call on the local citizens to help prevent the spread of the disease. In accordance with the model adopted by the Osaka prefectural government in its countermeasures against COVID-19, the color is red during a state of emergency, yellow when an alert is issued, and green when the alert is lifted. The tower has also been illuminated with blue lights to express gratitude to the medical personnel who are struggling on the front lines.

Answer for Q1

4 (Nd, Fe, B)

A neodymium magnet contains iron and boron in addition to neodymium, as shown by the chemical formula $Nd_2Fe_{14}B$.

The iron generates magnetization and the neodymium directs the magnetization in one direction.

The boron keeps the distance between the iron and the neodymium atoms at an optimum level.

Chemistry! It's Cool!

53rd IChO 2021 JAPAN

IChO2021 Catalyzer No. 2

Official Website
https://www.icho2021.org/
icho2021

Jul. 26
1885
Got married!
Marie & Pierre Curie

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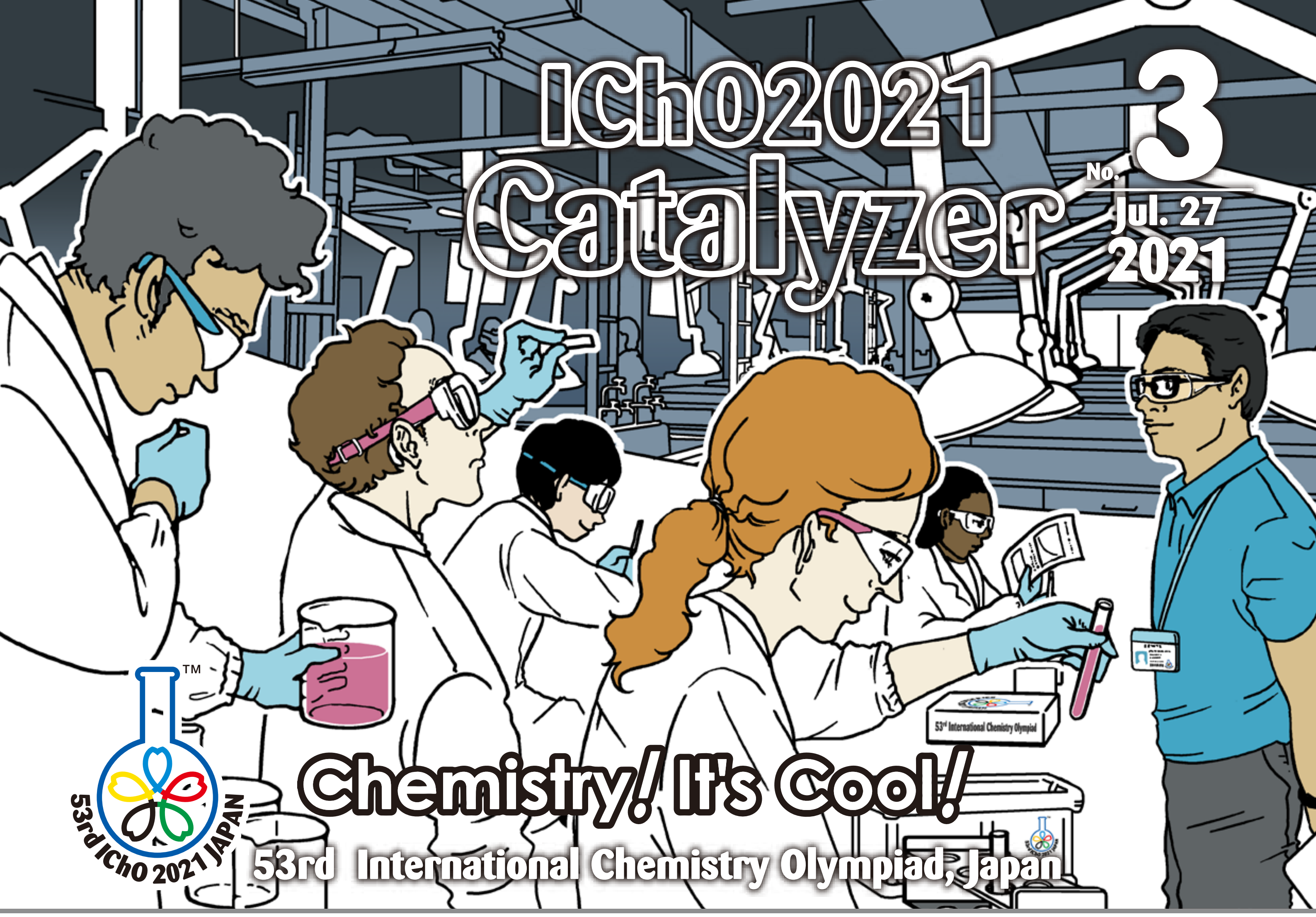
English Editor: Maiko Katayama
Illustration: Science Manga Studio

IChO2021 Catalyzer

No. 3

Jul. 27 2021



Cover illustration : Practical Exam

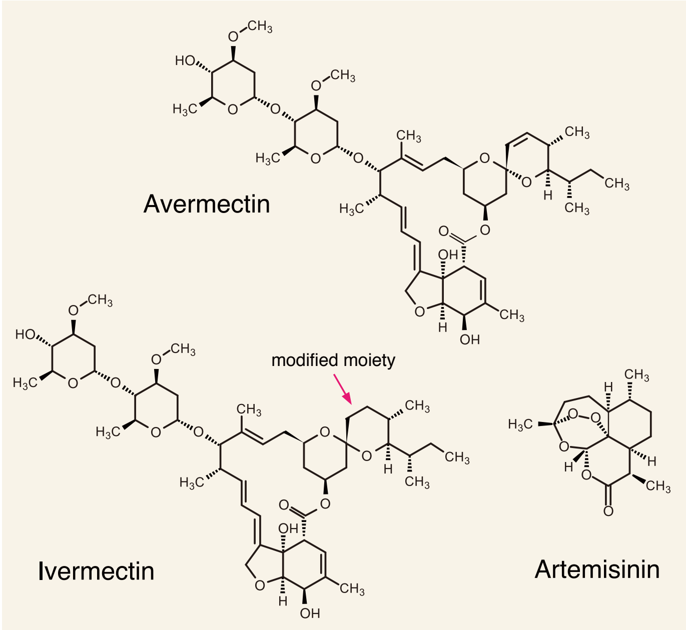
Nobel Prize Research from Japan 03

Natural Product Chemistry that Leads to Medicines ······· Satoshi Ōmura

Nature is host to countless compounds that can be used as medicines and yet remain undiscovered by humans. Satoshi Ōmura has isolated and determined the structures of many useful natural organic compounds produced by microorganisms in soil, many of which have been put to practical use. One such compound is avermectin, a substance produced by the bacterium Actinomycetes that was isolated from the soil of a golf course in Shizuoka Prefecture. Ōmura's research in collaboration with William C. Campbell showed it has strong activity as an anthelmintic, a treatment for parasitic diseases. Subsequently, a structurally modified version of this compound, ivermectin, was developed as an anthelmintic for livestock. Furthermore, ivermectin has been shown to be effective against onchocerciasis, a disease which may lead to loss of sight, caused by filarial nematodes transmitted by mosquitoes in Africa and other tropical regions, and is now widely used as an anthelmintic. The 2015 Nobel Prize in Physiology or Medicine was awarded to Satoshi Ōmura, William C. Campbell, and Youyou Tu for "their discoveries concerning a novel therapy against infections caused by roundworm parasites." Youyou Tu also discovered artemisinin, which is the basis of a group of drugs used to treat malaria.

Photo by Satoshi Ōmura

Dr. Satoshi Ōmura
(1935–)



Chemistry! It's Japan!

Studies on Urushiol

••• Rikō Majima

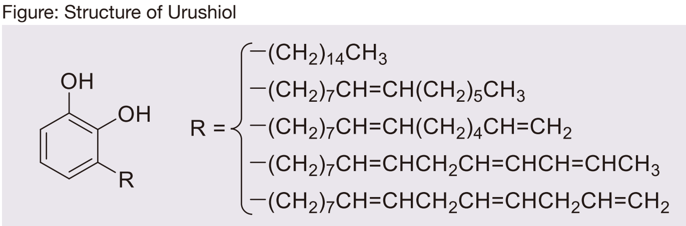
Urushi lacquerware is one of Japan's well-known traditional crafts. Urushi, which has a beautiful black luster, is a natural resin obtained from the sap of the lacquer tree and consists mainly of a catechol derivative called urushiol. The structure of urushiol was determined by Rikō Majima, and the research process became the starting point for the development of organic chemistry in Japan. When Majima started his research around 1900, chemistry in Japan was still in its infancy, and there was a serious shortage of skilled chemists to guide experimental research. Majima studied organic chemistry almost entirely on his own and became acutely aware of the gap in ability between Japan and the Western countries; at the same time he came to the conclusion that if he could conduct research on lacquer, which is native to the Orient, he would be able to develop his own original research without being outdone by researchers from other countries.

Urushiol: originally a light-yellow resin, it turned blackish after 100 years

After studying in Germany, Majima began to determine the structure of urushiol in earnest at Tohoku Imperial University. With the latest European methods such as advanced vacuum distillation, ozonolysis, and catalytic reduction, he tried to determine the structure of urushiol. After several steps, he finally determined that urushiol exists as a mixture of the compounds shown in the figure. Majima began to determine the structures of many other natural products found only in the Orient such as indole and aconite alkaloids, in addition to urushiol, and trained many of his students as organic chemists. His students eventually established organic chemistry laboratories at universities around the country and laid the foundation for modern organic chemistry in Japan.

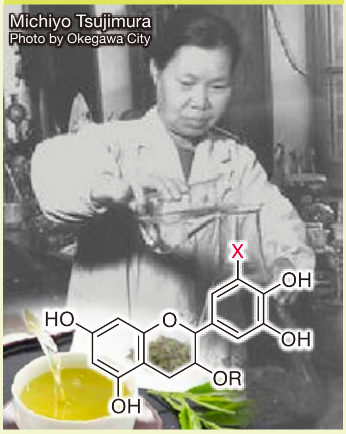
Dr. Rikō Majima
(1874–1962)

Figure: Structure of Urushiol



Tale related to Preparatory Problem

Theoretical Task 23



Michiyo Tsujimura
Photo by Okegawa City

Green tea, a part of Japanese culture

What would you drink when you are thirsty? Water, juice, soda, or tea? Tea, particularly green tea, is very popular in Japan among other countries. Tea is classified into three major types: green tea (unfermented), black tea (fermented), and the rest such as oolong tea (semi-fermented). As introduced in preparatory problem 23, green-tea culture in Japan started in the early 1200s. The most famous form is the traditional ‘tea ceremony’, during which *matcha* is prepared and drunk. In addition, green tea is largely consumed as a regular beverage on a daily basis and has been associated with a variety of health benefits. Tea leaves contain several catechins such as epicatechin, epigallocatechin, epicatechin gallate, and epigallocatechin gallate, which are responsible for the characteristic taste (*shibumi*) of green tea. Japan also made significant contributions to green-tea chemistry. For instance, Michiyo Tsujimura, the first Japanese female doctor of agriculture, isolated catechin from green tea for the first time in 1929. Green tea also contains caffeine, which has a bitter taste (nigami), and theanine, which adds a savory (*umami*) flavor. While green tea is produced by suppressing the oxidation of tea leaves, black tea is produced by fermentation of the tea leaves, promoting oxidative dimerization of catechins to give theaflavins, which have a benzotropolone core structure and are characteristic pigments of black tea.

Himeji Castle

Kansai Scenes 3

Himeji Castle (or *Himeji-jo* in Japanese) is an excellent surviving example of a modern Japanese castle. Described as a *Hirayama Jo* in Japanese, meaning a hilltop castle, it is located in the north of present-day Himeji. It is one of the original 12 castle towers (*tenshu*) which were built in the Edo period (1603 to 1868), and is designated as one of the 100 Great Castles in Japan. Himeji Castle was designated as a National Treasure in 1951, and a UNESCO World Heritage Site (Cultural) in 1993; so becoming Japan’s first cultural World Heritage Site. The present castle tower was built in 1609 by Ikeda Terumasa, a warlord who married Tokuhime, the second daughter of Tokugawa Ieyasu, the founder of the Edo bakufu (shogunate). The castle is also known fondly as *Shirasagi-jo* (White Egret Castle), as its elegant figure resembles an egret with its wings outstretched. The castle is characterized by brilliant white stucco exterior walls and features a huge *tenshu* (main tower) with five layered roofs and seven stories (one underground and six above ground), which is interconnected with smaller towers (the East, the West, and the Northwest) by *watari-yagura* roofed passages. The *tenshu* was restored to its current beautiful condition after five-and-a-half years of restoration work that stretched from 2009 to 2015.

Early Bird Communication

Saudi Arabia

Mexico

Iceland

Poland

Today's schedule Jul. 27

Student

- VR Closed

Mentor

- Translation ››› submission J 09:00 C 09:00 E 20:00 (Jul. 26)

Have a nice day!

J: JST = UTC + 9 C: CET = UTC + 2 (summer time) E: EST = UTC - 4 (summer time)

CHEER UP! Participants!

Not just IChO, but even the months leading up to it, are like a dream come true. Not only are you stimulated intellectually but you get to meet remarkable people at truly amazing places in the world. The knowledge, the drive, and encouragement you take away are unparalleled and stay with you for life.

from **Maaha Ayub** (Pakistan)

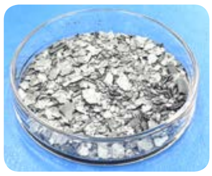
IChO 49th in Nakhon Pathom, Thailand
Bronze Medal

Answer for Q2

4 (Cr, Ni)

Stainless steel was developed to strengthen iron's rust resistance, and a number of researchers contributed to its improvement during the 19th and 20th centuries. The metals added to iron are typically chromium and nickel, which form a passive layer on the surface, preventing rust caused by air or water. Today, stainless steel is widely used, for example, in cooking utensils, vehicles, and machine parts.

Element #2 Japanese mineral resources Iodine



Iodine, with atomic number 53 and an atomic weight of 126.9, is represented by the symbol I. It belongs to Group 17, the halogen group, together with elements such as bromine, chlorine, and fluorine. Although Japan is usually characterized as a country poor in natural resources, it is placed second in the world after Chile in the production of iodine. Eighty percent of iodine is produced from sodium iodide dissolved in ancient seawater in natural gas wells in Chiba Prefecture. Japan even exports iodine to other countries around the world.

Iodine is a dark purple solid at room temperature and ^{127}I is its only stable isotope, with a natural abundance of almost 100%. The isotope ^{131}I is a fission product of uranium and other radioactive elements, and it has a half-life of around 8 days transforming ^{131}Xe with beta and gamma emissions. Therefore, stable ^{127}I can be used to protect people from health hazards caused by a nuclear accident. Iodine as an element has a variety of uses in our lives such as X-ray contrast agents, bactericidal disinfectants, and polarizers used in screens of LCD TVs, PCs, and smartphones.

Since iodine is a component of thyroid hormones, a shortage of iodine in the body may lead to the condition known as hypothyroidism. However, such shortages are rare in Japanese because the country is surrounded by sea and sufficient iodine can be obtained from a diet rich in seaweed and a variety of seafoods. By contrast, many people living in other parts of the world are exposed to the risk of iodine deficiency. Thus, potassium iodide or potassium iodate is added to the table salt to prevent it.

ELEMENT QUIZ Q3

Which element is produced as a result of nuclear fission of uranium-235, apart from krypton?

1 Ba **2** Ra

3 Po **4** Pu

Chemistry! It's Cool!

53rd IChO 2021 JAPAN

IChO2021 Catalyzer No. 3

Official Website
https://www.icho2021.org/
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Jul. 27
1921
Succeeded!
Insulin extraction

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English Editor: Maiko Katayama
Illustration: Science Manga Studio

Cover illustration : Theoretical Exam

Message from Dr. Akira Yoshino

Hello, everyone. This is Akira Yoshino.

Congratulations to all the representatives from all over the world who participated in the 2021 International Chemistry Olympiad in Japan. I congratulate you on your daily interest in chemistry and the fruits of your enthusiastic learning. We would also like to extend our congratulations and respect to the mentors from each country who have nurtured such wonderful athletes.

The International Chemistry Olympiad is an international event in which high school students from all over the world compete for their chemistry skills. Not only that, but it also builds a human resources network for young people through international exchange and deepens their understanding of Japanese culture. It will be of great significance to develop human resources who will be in a leadership position in the future.

Unfortunately, due to the influence of the new coronavirus pandemic, it has become a remote competition, but even in such a difficult situation, it is the relationship of international trust that has been built up so far. I would like to once again recognize with you that it is supported by the depth of friendship, and I would like to express my sincere gratitude to all the people concerned and the executive committees of each country for their efforts.

Chemistry is central science. It plays an important role in creating new substances by making full use of the properties of elements. I received the Nobel Prize in Chemistry in 2019 for developing a lithium-ion secondary battery and leading it to practical use. In this development, after a long basic research based on the properties of lithium, cobalt, carbon, etc., it was put into practical use. In this way, the results of basic research in chemistry have the power to change the social system. Chemistry must play a leading role in solving various problems such as environment, resources, energy, and health that are currently facing on a global scale. And they are entrusted to a younger generation like you.

You are the leaders of each country and the world in the future. Please take pride in participating in the International Chemistry Olympiad, and remind yourself of the importance of these roles in chemistry for further development.

Please do your best in the written test and enjoy the VR videos of various research facilities and cultural activities that are prepared to deepen your exchange.

This is my greeting.

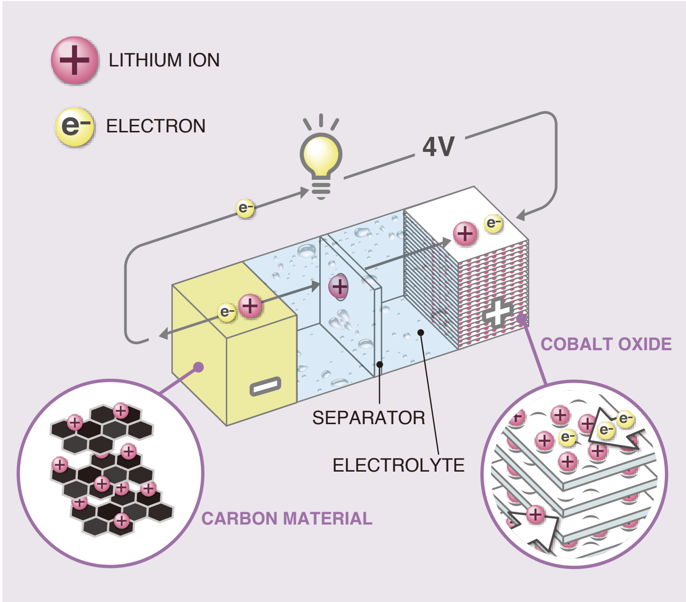
Dr. Akira Yoshino

Honorary Fellow, Asahi Kasei Corp.
2019 Nobel Laureate in Chemistry

Nobel Prize Research from Japan 04

Development of Lithium-ion Secondary Batteries ····· Akira Yoshino

Lithium-ion batteries (Li-ion batteries) are used in all aspects of modern life, from small smartphones and notebook computers to electric vehicles, due to their features such as light weight, rechargeability, and high capacity. It would not be an exaggeration to say that Li-ion batteries enable us to freely carry electricity around. It all started in 1976 when Stanley Whittingham developed a revolutionary rechargeable battery using metallic lithium for the anode and titanium disulfide for the cathode, which intercalates lithium ions. Later, John B. Goodenough developed a battery using lithium-cobalt oxide ($LiCoO_2$) as the cathode, but the practicality of this battery was challenged by the fact that it used metallic lithium as the anode, which posed the risk of explosion and ignition. Akira Yoshino(photo: previous page) overcame these safety and stability issues by using carbon materials for the anode, and laid the foundation for practical Li-ion batteries. For these achievements, Akira Yoshino, John Goodenough, and Stanley Whittingham were awarded the Nobel Prize in Chemistry in 2019. Akira Yoshino was born and raised in Osaka, where IChO2021 was to be held. He says he was inspired to pursue chemistry by the book “THE CHEMICAL HISTORY OF A CANDLE”, written by Michael Faraday, which his homeroom teacher in elementary school recommended he read.

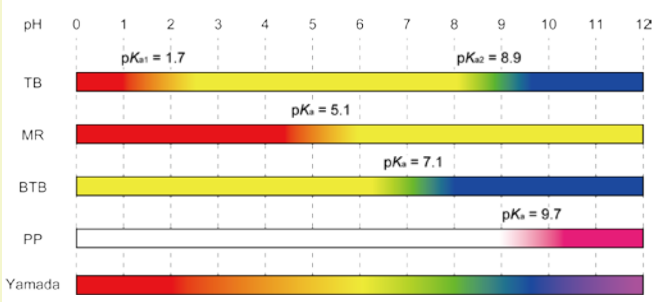


Tale related to Preparatory Problem

Theoretical Task 10

How to make rainbow indicator

Universal indicators are widely used to check the pH values of aqueous solutions. Nowadays, the most popular universal indicator shows red in acidic conditions and blue in basic conditions, the same color variation as that of the rainbow and therefore easy to remember. Is there a suitable molecule that will show such a drastic color change alone? The answer is no: universal indicator is a mixture of several indicators. The original recipe was proposed by a Japanese researcher, Shinobu Yamada, in 1933. Let’s see how he cleverly mixed the individual indicators to achieve a rainbow of colors. Thymol blue (TB) changes from red to blue via yellow. To generate the color orange, methyl red (MR) is added. Because of the pKa gap between TB and MR, we can generate an orange color, which is the mixture of red (MR) and yellow (TB), around a pH of 3 to 4. Bromothymol blue (BTB) is used to generate a green color. Using the pKa gap between TB and BTB, we can generate green, which is a mixture of yellow (BTB) and blue (TB), around a pH of 7 to 8. Note that MR in basic conditions and BTB in acidic conditions are yellow. Therefore, too much MR makes the solution green in basic conditions, and too much BTB makes the solution orange in acidic conditions. Fortunately, phenolphthalein (PP) is colorless in acidic and neutral conditions, and therefore the purple color in basic conditions can be adjusted relatively easily. The appropriate constituent ratio is determined by human eyes with a trial-and-error process. We are thankful for Yamada’s keen eyes that gave us this universal indicator today.



Color chart of indicators used for Yamada universal indicator (note that the colors and their variations are qualitative).

Chemistry! It's Japan!

Spectrochemical Series ••• Ryutaro Tsuchida

Gems and pigments have attracted human beings with their beautiful colors since ancient times. Such colors are mainly caused by transition metal ions: the colors depend on not only types of metal, but also the ligands attached to the metal, and the coordination structures. However, the colors we see are mere sensory expression, which differs from individual to individual. Thus, quantifying the colors derived from inorganic compounds as energy and understanding the causes of these colors has been a major challenge for complex chemistry.

Complex chemistry was first brought to Japan by Yuji Shibata (1882–1980), who learned from Alfred Werner, the founding father of modern complex chemistry, and later taught at Tokyo Imperial University and Nagoya Imperial University as a Professor. His student Ryutaro Tsuchida, who later taught as professor at Osaka Imperial University, became interested in the relationship between color and ligands in metal complexes. After conducting measurement of the electronic absorption spectra of a numerous kind of metal complexes, he discovered a quantitative relationship between the wavelength of the absorption band and the ligand. Based on this finding, he proposed the spectrochemical series (1938), in which ligands and metal ions are arranged in the order of the energy difference of the d-d transition of octahedral metal complexes. Later, it was theoretically supported by ligand field theory, which considers the covalent nature of the metal–ligand bond, and it became clear that the spectrochemical series is an order of ligand field splitting energies. In addition to colors, Tsuchida was also strongly interested in the steric structure. He assumed the coordination bonds in complexes to be in the same bonding state as the covalent bonds in organic compounds, and the most stable molecular structure is the one that minimizes the repulsion between all electron pairs. This model that Tsuchida conceived was actually almost the same as the model known as the VSEPR rule today; however, this would not be known globally, since Japan was at midst of war. This achievement is very typical of Tsuchida, we may say, who was always conscious of correlations between “structure and properties” of complexes.

Dr. Ryutaro Tsuchida
(1903–1962)

In addition to his chemical research, Tsuchida also devoted himself to the expansion of chemical education as well as his own research. He was involved in producing teaching guidelines for high school chemistry and handbooks to chemical experiments, and he was also involved in launching and publishing chemical magazines for general public. In particular, he was a long-time member of the editorial board of the monthly magazine “*Kagaku* (Chemistry)” (first published in 1951) : this periodical is still published today, and the logo he designed for the magazine is still used as company logo of Kagaku-Dojin.

Complexes synthesized and organized by Tsuchida in the order of the spectrochemical series. Source: *Kinzoku Sakutaino Iro To Kozo* (*The color and structure of metal complexes*), 1944, Zoshinsha.

Company logo of Kagaku-Dojin.

Kansai Scenes 4

Fushimi Inari Taisha Shrine

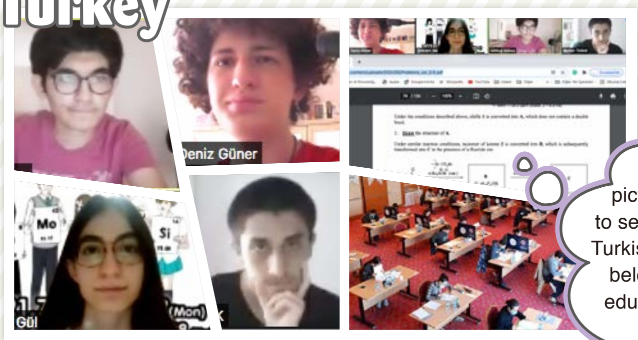
Fushimi Inari Taisha, also known as *Oinari-san*, is the most important of the *Inari* shrines that are dotted throughout Japan, and is located in Fushimi-ku, Kyoto. Since the shrine was established in 711, it has been worshipped as a god of good harvest, prosperous business, safety in the home, and fulfillment of wishes. The foxes that serve as messengers of the shrine are also cherished by the people. From the first *torii* gate on the main approach to the shrine, the outer hall of worship (*maiden*), inner hall of worship, and main hall of worship are arranged in a straight line. It is said that there are about 10,000 *torii* contributed by followers, including the beautiful vermilion *senbon torii* (one thousand gates) that line the mountain. *Fushimi Inari Taisha* is one of the most popular tourist spots among people visiting Japan.

Early Bird Communication

Slovenia

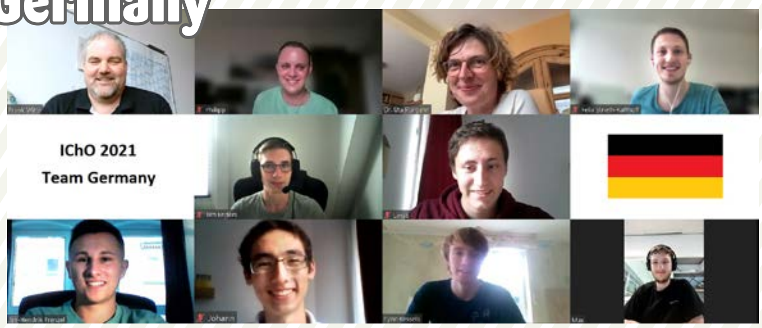
We printed the T-shirts ourselves!

Turkey



One of the pictures belongs to selection exam of Turkish team. Others belong to remote education lessons of team.

Germany



The screenshot is from the conclusion of our virtual study camp on June 11 with selected student representatives for the USA as well as mentors.

Azerbaijan

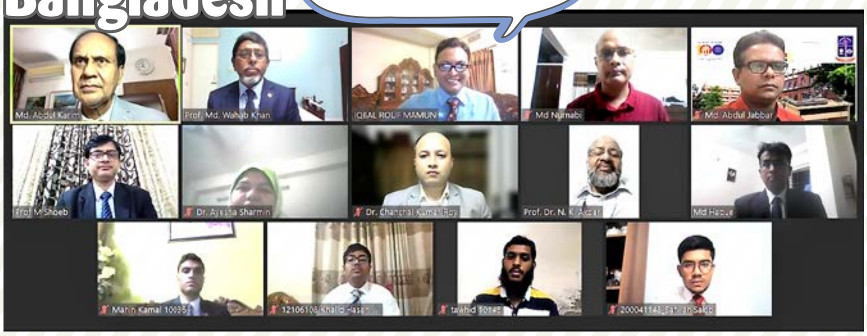
United States of America

Pakistan

Pics of Team Members for Catalyzer.

Bangladesh

Wish great success of 53rd IChO.



Today's schedule Jul. 28

Student

Start between

- **Examination** (5 h) J 14:00▸05:00 (Jul. 27) C 07:00▸22:00 E 01:00▸16:00

Mentor

- **Deadline of translation** J 09:00 C 02:00 E 20:00 (Jul. 27)

Invigilator

- **Receive and print out the problem** J 11:00 C 04:00 E 22:00 (Jul. 27)
- **Submit the solutions** (Within 2 hours after the end of the examination)

Have a nice day!

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time)

CHEER UP! Participants!

Hello, dear Olympians! My name is Edith Leal and I represented the mexican delegation in the 45th and 46th IChO and now I'm studying my PhD in Chemistry. Looking back from the future, the best advice I can give to you is to give your personal best. Meeting so many young people, who are very intelligent and who seem better prepared for the tasks than you can be very overwhelming, however, remember that just by being here, you have already won a lot of knowledge, from the fundamentals of Chemistry, beyond your usual high school program, to the very specialized Preparatory Problems, which some of them are so specialized, they can be difficult to encounter, even as an undergraduate Chemist. So, stop worrying about anything else and focus into putting everything you know on the questions in the exam, so that when you finish, you feel satisfied and happy with yourself.

Greetings and my very best wishes!

from **Edith Leal** (Mexico)

IChO 45th in Moscow, Russian Federation
Participant

IChO 46th in Hanoi, Vietnam
Bronze medal

Element #3 Japanese mineral resources Lithium

Basic Information

Origin of the name: Greek word *lithos* (stone)
Discovered by: J. A. Arfvedson (Sweden) [1817].
Global reserves: 21 million tons
Major reserve countries: Chile, Australia, Argentina
Global production: 82,000 tons
Major producers: Australia, Chile, China

Lithium-ion batteries are widely used in smartphones and notebook computers today. The applications of these light-weight and high-performance secondary batteries in electric vehicles have grown, in part due to a shift towards a decarbonized society. Akira Yoshino, a Nobel laureate in chemistry in 2019, developed a new battery using a lithium oxide compound as the cathode and a carbon material as the anode (See page 2 of this issue).

© The Courtyard of our Minerals

Answer for Q3

1 Ba

In 1938, German Chemists Otto Hahn and Fritz Strassmann discovered that when uranium-235 is bombarded with neutrons, radioactive barium, krypton, neutrons, and an enormous amount of energy are released. This discovery led to the development of nuclear energy.

ELEMENT QUIZ Q4

Assume you have the same volume of gold, silver, copper, and mercury, and they are all at the same temperature. Which of these metals is the heaviest among them?

1 Gold **2** Silver **3** Copper **4** Mercury

Chemistry! It's Cool!

53rd IChO 2021 JAPAN

IChO2021 Catalyzer No. 4

Official Website
https://www.icho2021.org/
icho2021

Jul. 28
1919
Succeeded!
Transatlantic by R34 airship

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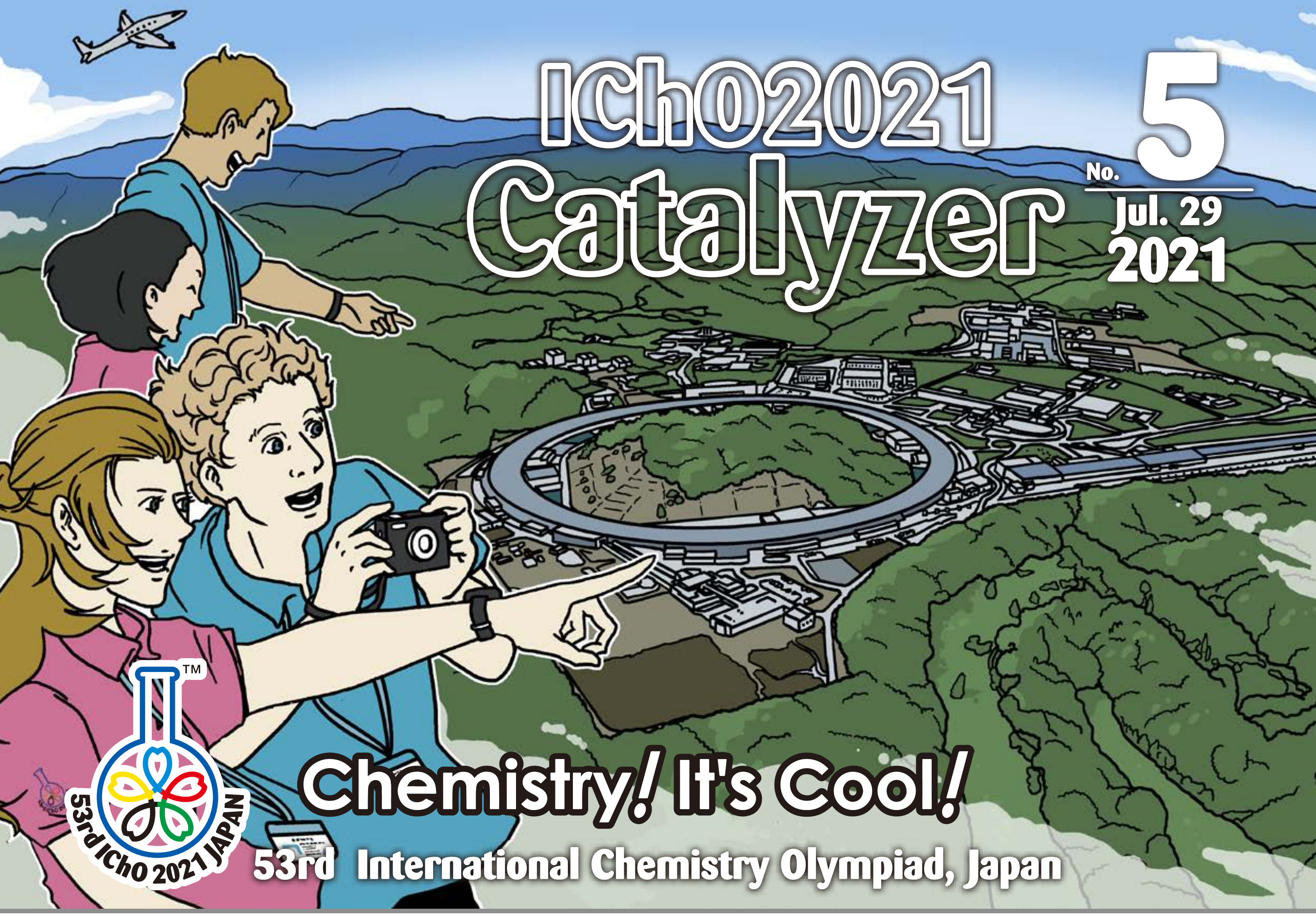
Edited by the Team Catalyzer IChO2021
English Editor: Maiko Katayama
Illustration: Science Manga Studio

IChO2021 Catalyzer

No. 5

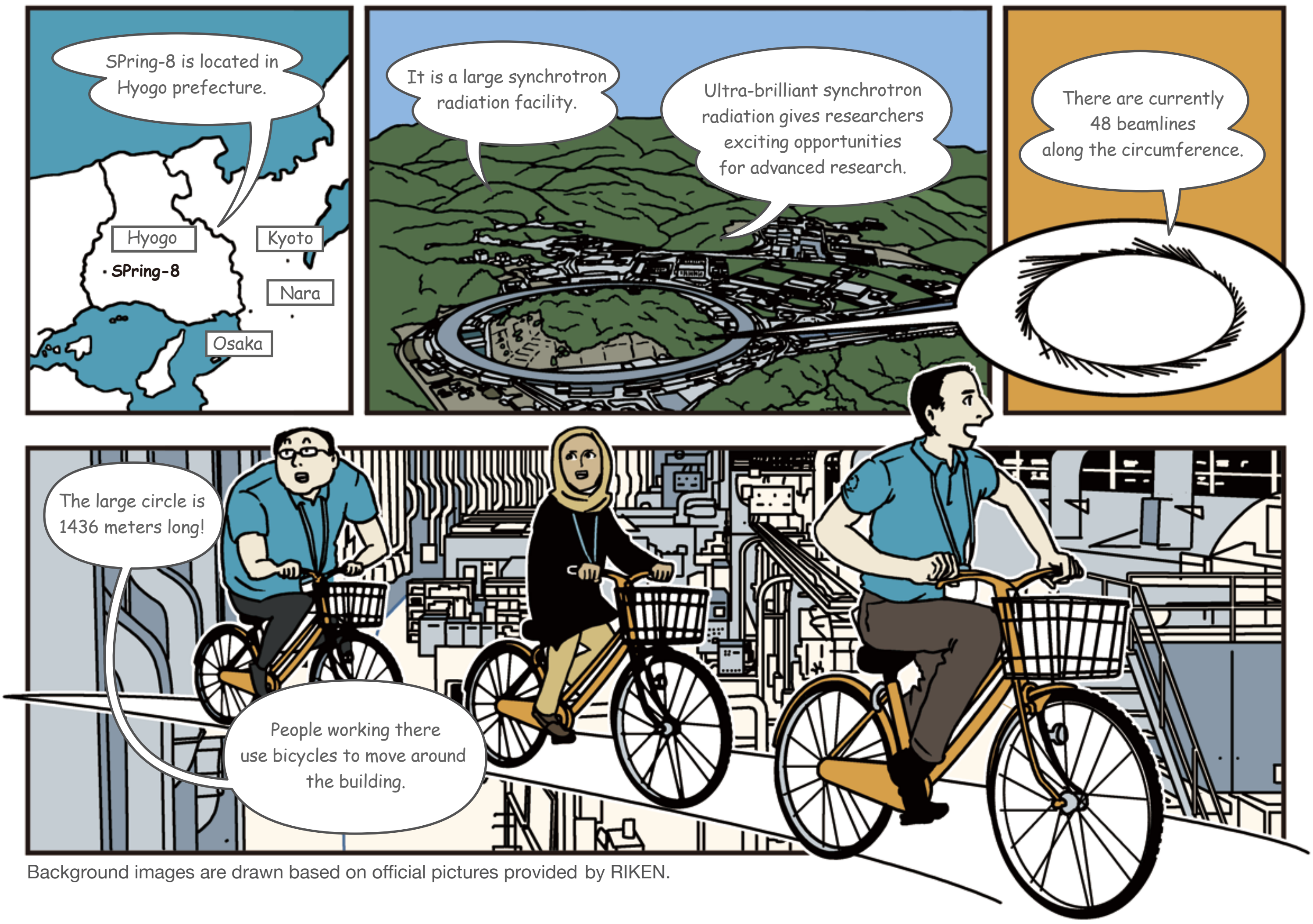
Jul. 29 2021



Chemistry! It's Cool!

53rd International Chemistry Olympiad, Japan

Cover illustration : Scientific Program (SPring-8)



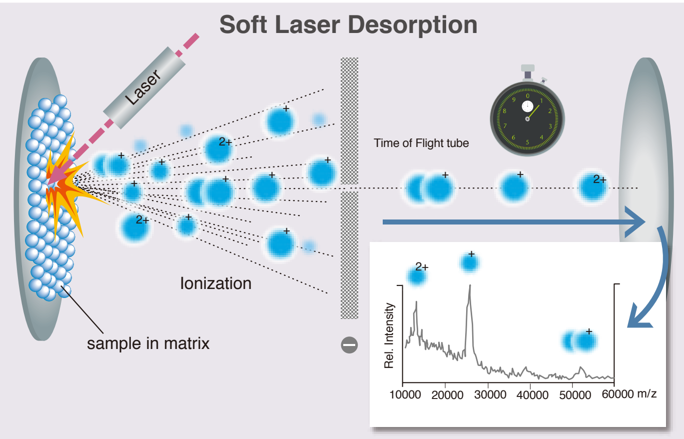
Background images are drawn based on official pictures provided by RIKEN.

Nobel Prize Research from Japan 05

Soft Laser Desorption for Mass Spectrometry ………………… Koichi Tanaka

Recent years have seen a growing need for methods to determine the structure of biomolecules such as proteins, carbohydrates, and lipids. Koichi Tanaka, an engineer at Shimadzu Corporation, has developed an innovative method to enable mass spectrometry of such large biomolecules. Mass spectrometry (MS) is an analytical method for measuring the mass of a material in its ionic state, based on its mass-to-charge ratio, and to do this, the sample (analyte) must first be ionized. Previously, electron ionization (EI), in which the sample is irradiated with thermal electrons, was mainly used for this process, but this did not provide useful information on the mass of biological macromolecules with high molecular weights such as proteins, because they are hard to volatilize and are easily decomposed by heat. On the other hand, in the soft laser ionization method such as the matrix-assisted laser desorption/ionization (MALDI) method, the analyte is mixed with a viscous liquid known as a matrix and irradiated with an ultraviolet laser beam, which causes rapid heating and ablation of the matrix as well as vaporization and ionization of the sample, enabling a soft ionization of the analyte. It is said that this method was conceived when a sample was mistakenly prepared using glycerin instead of acetone, and the sample was analyzed so as not to waste it. This method becomes a particularly powerful tool when analyzing compounds with large molecular weights, making it possible to measure compounds with molecular weights of 100,000 or more. MALDI, and another method known as electrospray ionization (ESI), developed by John B. Fenn, are currently the main methods used for ionizing organic compounds for mass spectrometry. The 2002 Nobel Prize in Chemistry was awarded "for the development of methods for identification and structure analyses of biological macromolecules" to Koichi Tanaka, John B. Fenn, and Kurt Wüthrich for their achievements in protein structure analysis. This particular year's Nobel Prize in Chemistry was unique in that it was awarded for the development of fundamental technologies that support advanced research.

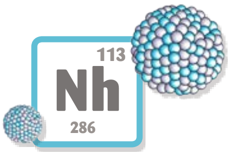
Dr. Koichi Tanaka
(1959–)



Remote Examination on Jul. 28

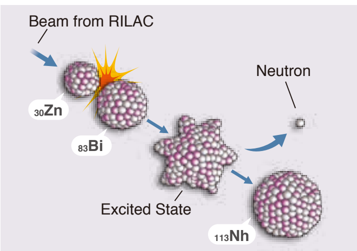
Chemistry! It's Japan!

New Nomination to Periodic Table



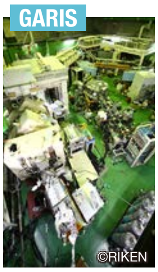
Nihonium is the 113th element (symbol: Nh) of the periodic table. This element was first discovered in July 2004 by Kosuke Morita and his group at RIKEN, Japan's largest multidisciplinary research institution. After two successful follow-up tests and certification of the element's discovery at the end of December 2015, the name nihonium and the symbol Nh were officially ratified in November 2016. This became the first element to be named in the Asian region, as all the elements identified until then had been found in Western countries. Nihonium (^{278}Nh), was artificially synthesized by fusing two types of nuclei: a thin film of bismuth (^{209}Bi) with atomic number 83 and mass number 209 was irradiated with a beam of zinc (^{70}Zn) with atomic number 30 and mass number 70 that had been accelerated to about 10% of the speed of light. In this experiment, a large linear accelerator (RILAC) with the world's highest beam intensity and a gas-filled recoil separator (GARIS), which extracts only the 113th element from the countless particles produced by irradiation, played a major role. The probability of nuclei fusing is extremely small, and only three atoms of nihonium were obtained after 400 trillion collisions. It was also revealed that the lifetime of nihonium is only 344 microseconds.

Elements up to the 118th, oganesson (Og), have now been reported, completing the 7th period of the periodic table.



RILAC

GARIS



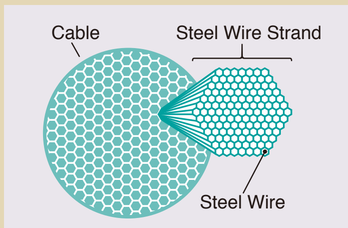
Akashi Kaikyo Bridge

Kansai Scenes 5

the longest suspension bridge in the world

The Akashi Kaikyo Bridge is one of the world's longest bridges. It crosses the Akashi Strait (or Akashi Kaikyo in Japanese), linking Kobe on the mainland of Honshu with Iwaya on Awaji Island, and has a total length of 3,911 meters and central span of 1,991 meters. Awaji is then linked with the island of Shikoku by another suspension bridge called the Onaruto Bridge that crosses the Naruto Strait, well-known for the massive Naruto Whirlpools. Together, these two great bridges provide a seamless route for people travelling between the islands of Honshu and Shikoku.

The suspension cables of the Akashi Kaikyo Bridge are supported by two main towers, which rise 288.3 meters above the sea. The main cables of the supporting towers consist of 290 strands (wire bundles with regular hexagonal cross sections), each of which is made of 127 high-tensile galvanized steel wires. Each cable has a diameter of 112.2 centimeters and can support a load of up to 60,000 tonnes. To protect the wires from wind and rain and to prevent corrosion, their surfaces are coated with rubber, and the cable interiors are protected with desalted and dehumidified air, maintaining the strength and durability of this marvelous suspension bridge.



Early Bird Communication

Montenegro

Oman

Malaysia

This is the picture of the final selection test which was conducted online. The best four candidates from this test are representing Malaysia for IChO 2021.

Today's schedule Jul. 29

Student

- Activity (SPring-8 Virtual tour)

Mentor

- Receive the solution and the grading scheme

J 09:00 C 09:00 E 20:00 (Jul. 28)

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time)

Early Bird Communication

Thailand

Philippines

ELEMENT QUIZ Q5

Which chemist discovered the most elements from nature in history?

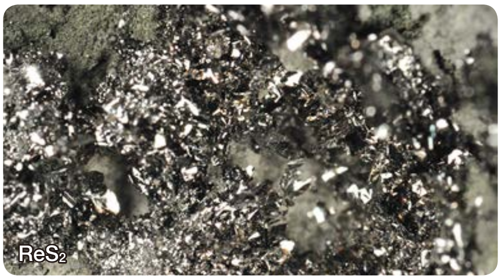
1. Marie Curie
2. Davy
3. Lavoisier
4. Humboldt

Element #4 Japanese mineral resources Rhenium

Basic Information

Origin of the name: the Latin name of the River Rhine, *Rhenus*
Discovered by: W. Nodak, I. Tacke, and O. Berke (Germany) [1925]
Global reserves: 2,400 tons
Major reserve countries: Chile, the USA, Russia
Global production: 53 tons
Major producers: Chile, Poland, the USA

In 1908, Masataka Ogawa, who was studying at the University of London at the time, reported his discovery of element 43, which he named nipponium (Np), in the mineral trianite produced in Sri Lanka (then Ceylon). Unfortunately, his analysis was later found to be inaccurate, and the element Ogawa had discovered was actually element 75, rhenium, which is one row down on the periodic table. If his analysis had been accurate, there might have been an element named after Japan more than 100 years before nihonium (Nh).



© Crystal Museum

Answer for Q4

1 Gold

Density (weight per cubic centimeter = g/cm^3) is used to compare the weights of substances. The density of water is defined as 1.0 g/cm^3. The densities of the four metals are 19.3, 10.5, 8.96, and 13.6 g/cm^3 for gold, silver, copper, and mercury, respectively; thus, gold is the heaviest of the four. The heaviest of all known metals is osmium, with a density of 22.6 g/cm^3.

Chemistry! It's Cool!

IChO2021 Catalyzer No. 5

Official Website
https://www.icho2021.org/
icho2021

Jul. 29
1836
Completed!
Triumphal arch in Paris

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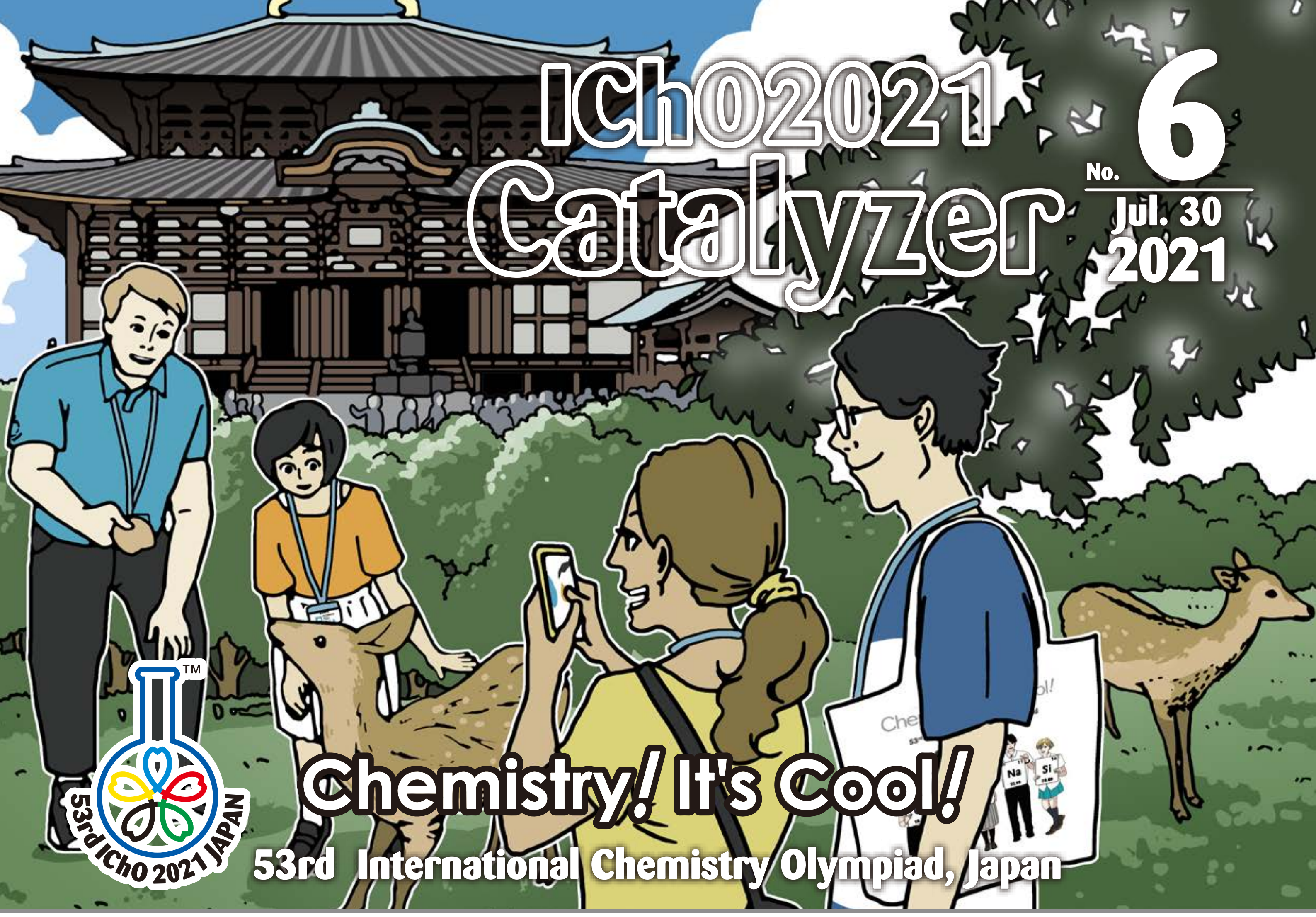
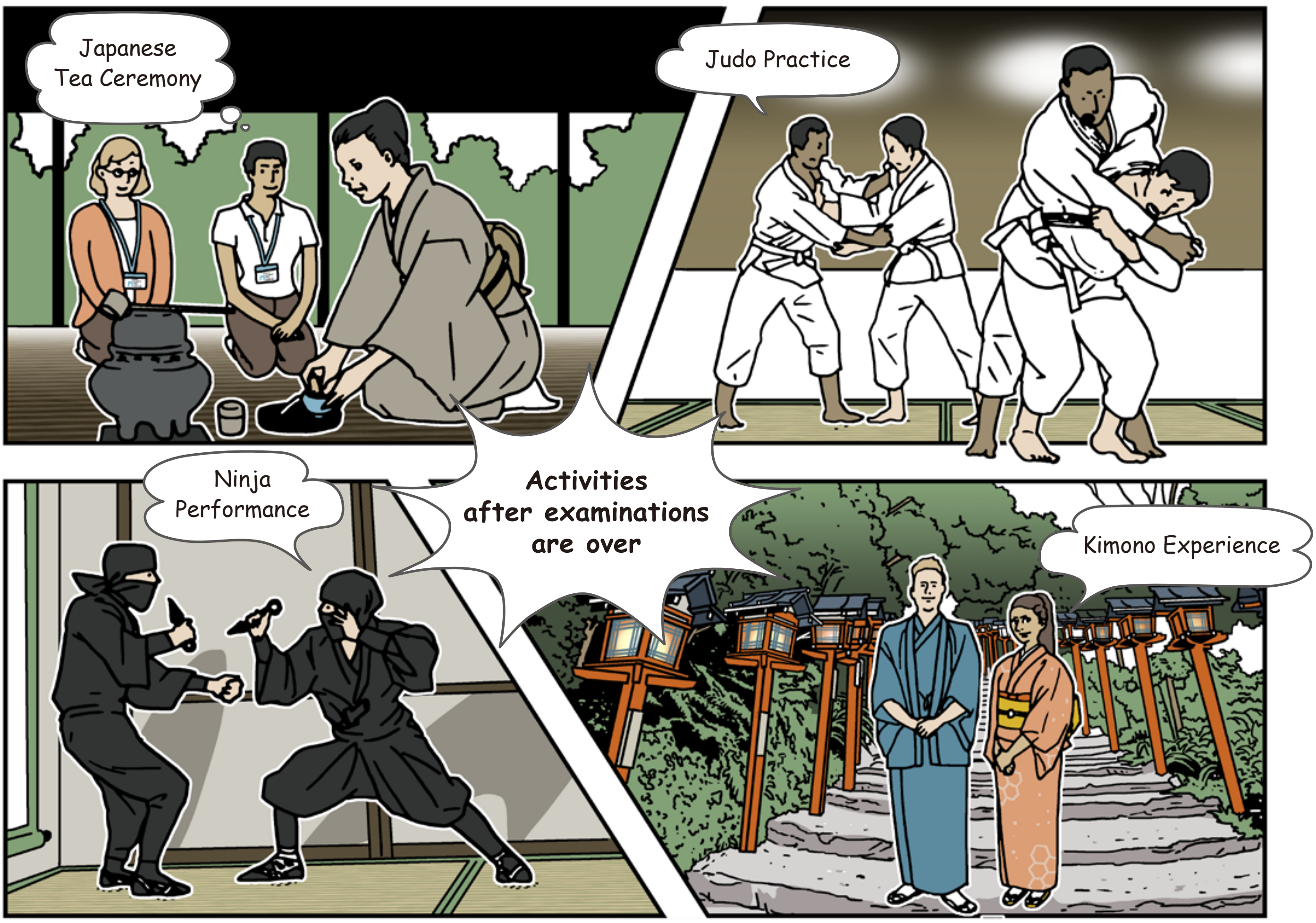


Cover illustration : Excursion to Nara



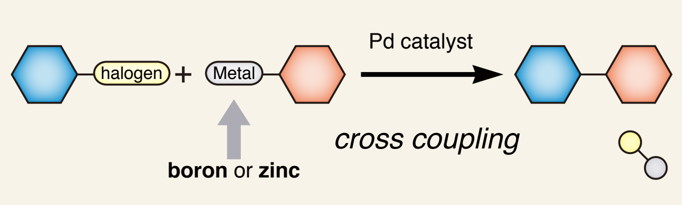
Nobel Prize Research from Japan 06

Development of Palladium-Catalyzed Cross Coupling ····· Akira Suzuki / Ei-ichi Negishi

Many of the functional materials and pharmaceuticals that are indispensable to modern life are created by organic synthetic reactions. In order to synthesize such useful materials, carbon–carbon bond formation reactions are indispensable to link the carbon atoms of organic molecules. A typical example of such a cross-coupling reaction is the chemical transformation of benzene rings. This reaction is difficult to achieve by traditional methods using carbocations and carbanions, but was found to be more easily accomplished by using transition-metal catalysts. It is no exaggeration to say that the field of cross-coupling reactions has been led by Japanese researchers, and in particular, the palladium-catalyzed cross-coupling reactions of aryl halides with arylmetal (boron or zinc) reagents developed by Akira Suzuki and Ei-ichi Negishi in the 1970s are extremely versatile. They have a wide range of applications, and are currently being used in the synthesis of numerous pharmaceuticals and organic electroluminescent materials. In 2010, Akira Suzuki and Ei-ichi Negishi were awarded the Nobel Prize in Chemistry, together with Richard F. Heck, for the development of such a truly practical synthetic reaction.

Dr. Akira Suzuki (1930–)

Dr. Ei-ichi Negishi (1935–2021)

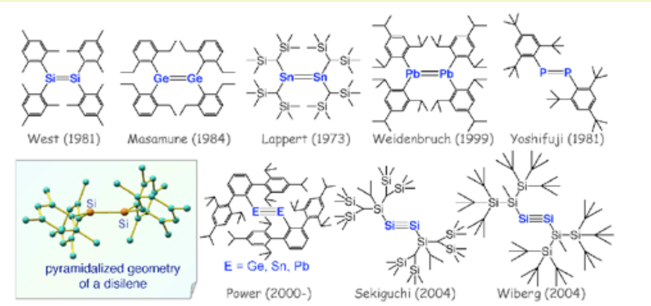


••• IChO2021 Problem Q5 •••

Unsaturated bonds between heavier main-group elements

In the late 1800s, the periodicity of the properties of elements was discovered; this concept suggests that elements that exhibit similar properties appear in a periodic order when arranged according to their atomic numbers. Ultimately, the stringent application of this principle resulted in the creation of the periodic table of elements by Mendeleev in 1869. In general, elements in the same group, *i.e.*, those located in the same column in the periodic table, are thus expected to exhibit similar properties. *What do you think about this statement? Is this true for all the elements in the same group?*

Silicon is the heavier homologue closest to carbon in the periodic table, and the analogies between carbon and silicon have been discussed controversially for a long time. For example, while the chemistry of unsaturated compounds of the main-group elements of the second row such as olefins ($R_2C=CR_2$) is plentiful, that of the heavier-element homologues of these multiple-bond compounds has remained underdeveloped in comparison, which is predominantly due to their extremely high reactivity and inherent instability under ambient conditions. Prior to the 1970s, all attempts to synthesize compounds with multiple bonds between heavier main-group elements were unsuccessful, and only cyclic oligomers or polymers with single covalent bonds between the main-group elements were obtained. Accordingly, the scientific consensus at the time was that such heavier main-group elements are probably not able to form π-bonds ('double-bond rule'). However, ambitious chemists were ultimately able to isolate and characterize several kinds of such compounds with unsaturated bonds between heavier main-group elements using bulky substituents for steric protection ('kinetic stabilization'). For example, the first distannene ($R_2Sn=SnR_2$, Lappert 1973), diphosphene (RP=PR, Yoshifuji 1981), disilene ($R_2Si=SiR_2$, West 1981), and disilynes (RSi≡SiR, Wiberg and Sekiguchi 2004) have been synthesized as stable compounds by using sterically demanding substituents, which disproved the double-bond rule. Since then, the unique features of unsaturated compounds of heavier main-group elements have been investigated in detail, attracting much attention to the area of main-group-element chemistry. For example, it has been reported that disilenes ($R_2Si=SiR_2$) and disilynes (RSi≡SiR) exhibit pyramidalized and bent geometries, respectively, which stands in sharp contrast to the planar geometry of ethylene and the linear structure of acetylene. These different structural features should in turn cause different reactivity and properties, and thus, the chemistry of unsaturated silicon compounds can be expected to be characterized by unprecedented functions and chemistry that is different from that of carbon. Thus, it should be noted here that the structure and chemistry of the second-row elements is considerably different in from those of the heavier main-group elements, as exemplified by the case of H_2O (bp: 100 °C; ∡HOH ≈ 104.5°) vs. H_2S (bp: –60 °C; ∡HSH ≈ 92°).



Chemistry! It's Japan!

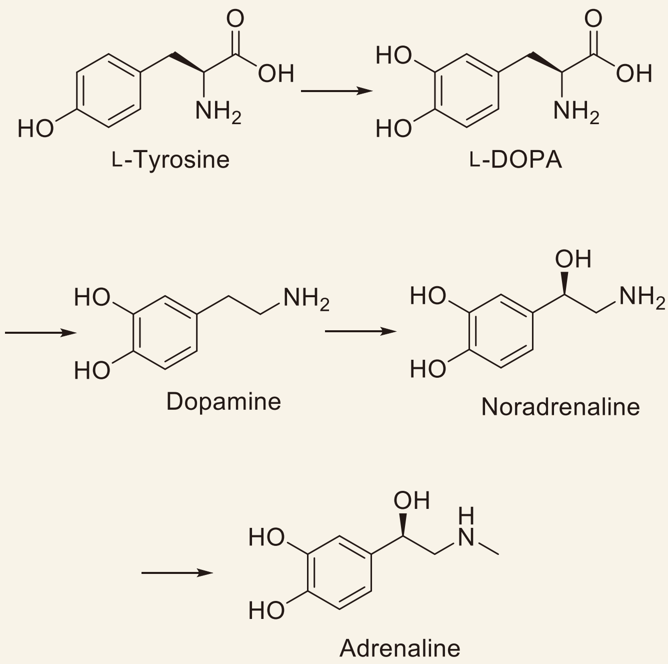
Discovery of Adrenaline

Jokichi Takamine / Keizo Uenaka

When one feels anxious, excited, or nervous, such as during important exams, public presentations, cheering on sports teams, muscle training, or when in love, our blood pressure rises and our heart rate increases. A hormone called adrenaline is secreted by the adrenal medulla when the sympathetic nervous system becomes dominant. Adrenaline was the first hormone to be isolated by scientists, in the year 1900. Jokichi Takamine and Keizo Uenaka (1876–1960) played key roles in this discovery. They succeeded in obtaining 7 grams of adrenaline crystals from 9 kilograms of bovine and sheep adrenal tissue by repeated acid and base extraction. Only after the first successful isolation did the hormone become commercialized as adrenaline preparation. Since then, it has become an indispensable agent for raising blood pressure in surgery, ophthalmology, and internal medicine. The number of lives adrenaline has saved to date is testament to the importance of this achievement for humanity.

Dr. Jokichi Takamine (1854–1922)

In vivo, adrenaline is biosynthesized via L-tyrosine, L-dopa, dopamine, and noradrenaline.



Kansai Scenes 6

Daibutsuden

The world's largest wooden structure

Construction of the Great Buddha of Nara started in the year 745, after Emperor Shomu decided to build a huge statue of Buddha to placate social disturbances in the wake of multiple coups and rebellions. The Buddha statue was completed in 752. The current Buddha is approximately 14.7 meters tall, and the circumferences of the platform, the head, and the palm are 70 meters, 2.6 meters, and 2.6 meters respectively. The head was restored in the Edo (Tokugawa) period (1603 to 1868), and most of the body was restored during the Kamakura period (1185 to 1333), but parts of the original statue still remain. The amount of copper used for building the Buddha varies slightly, depending on the historical record, but it is estimated to be 500 tons. Mercury used as a solvent in the plating process and arsenic contained in copper are said to have caused poisoning of nearby residents, and a medical center was established to treat these patients. The Hall where the Great Buddha (*Daibutsuden*) is enshrined today is 57.5 meters wide in the east-west direction, 50.5 meters deep, and 49.1 meters high to the ridge of the roof. It is the largest wooden frame building in the world, and was designated by the Japanese government as a National Treasure in 1952.

Today's schedule Jul. 30

Student

- Video: Practical Examination explanation

Mentor

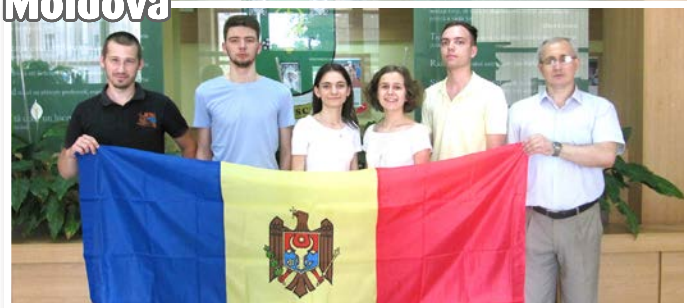
- **Receive grading** (from Organizer, Request arbitration)
  J 09:00 C 02:00 E 20:00 (Jul. 29)
- **Deadline of request, Jury meeting**
  J 21:00 C 14:00 E 08:00

Have a nice day!

J: JST = UTC + 9 C: CET = UTC + 2 (summer time) E: EST = UTC - 4 (summer time)

Early Bird Communication

Moldova



Cyprus

Answer for Q5

2 Davy

Humphrey Davy discovered as many as six elements from nature in his lifetime by electrolyzing a huge number of substances using Volta batteries.

Element #5 Japanese mineral resources Palladium

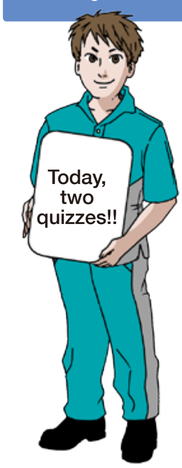
Basic Information

Origin of the name: Named after the asteroid Pallas
Discovered by: W. H. Wollaston (the UK) [1803]
Global production: 210 tons
Major producers: Russia, South Africa, Canada

Palladium catalysts are vital to the efficient formation of carbon–carbon bonds. The compounds produced by cross-coupling reactions with these catalysts are indispensable to industry, from pharmaceuticals and agricultural chemicals to liquid crystals and organic light-emitting diodes. About 60% of palladium production is used in catalysts (three-way catalysts) for the removal of incomplete combustion products and unburned gasoline in automobile exhaust.

© Crystal Museum

ELEMENT QUIZ Q6



① The 2001 Nobel Prize in Chemistry was awarded "for the development of catalytic asymmetric reactions". Which catalytic metal was NOT used in the chemical reactions for which the prize was awarded?

1 Osmium 2 Palladium
3 Ruthenium 4 Rhodium

② Which of the following halogen elements is contained in vancomycin, a chemical widely known as an antibiotic?

1 Fluorine 2 Chlorine
3 Bromine 4 Iodine

Chemistry! It's Cool!

53rd IChO 2021 JAPAN

IChO2021 Catalyzer No. 6

Official Website
https://www.icho2021.org/
icho2021

Jul. 30
1905
Published!
Special relativity by Albert Einstein

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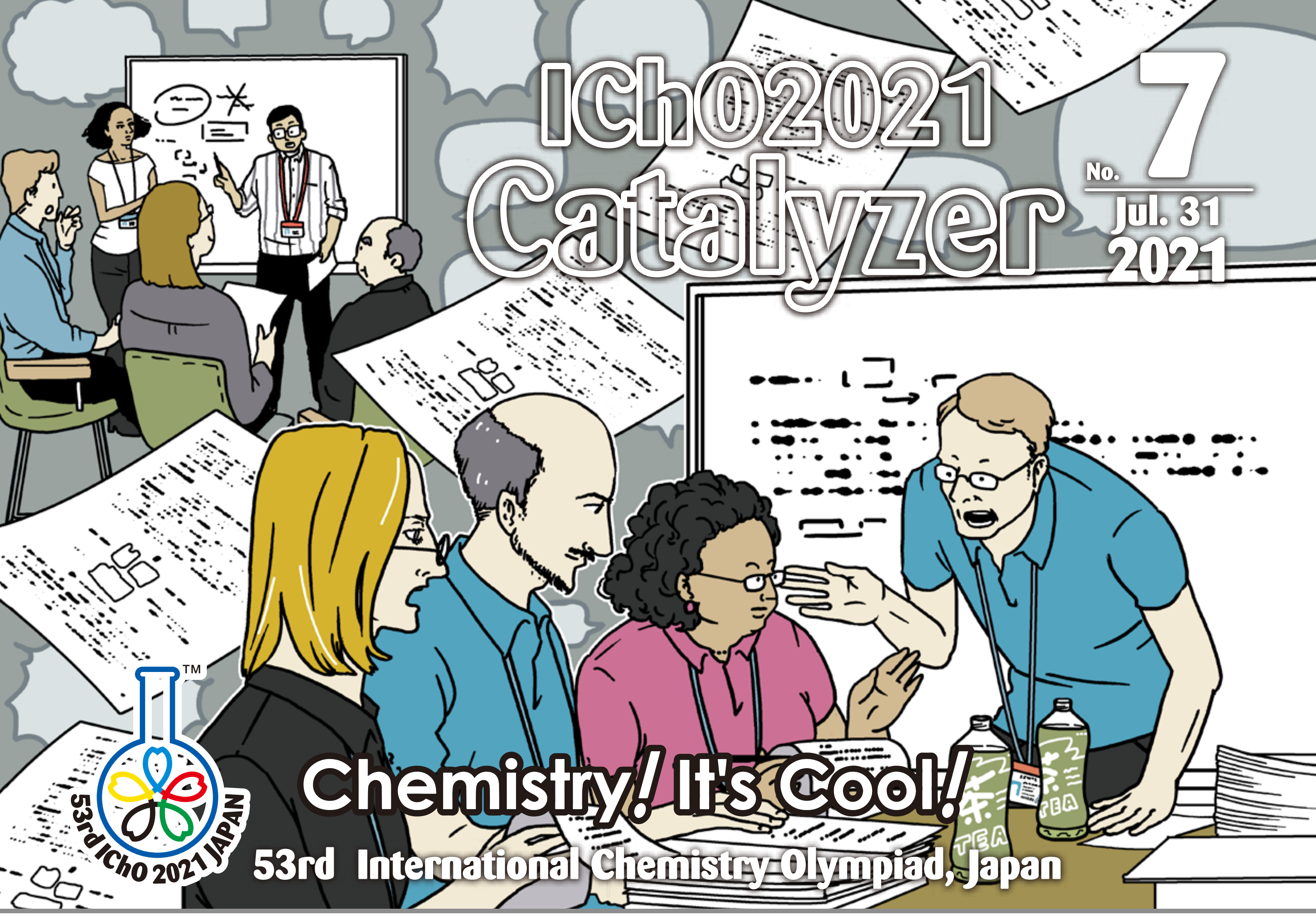
English Editor: Maiko Katayama
Illustration: Science Manga Studio

ICho2021 Catalyzer

No. 7 Jul. 31 2021



Cover illustration : Grading & Arbitration

Nobel Prize Research from Japan 07

Green Fluorescent Protein

Osamu Shimomura

Osamu Shimomura became interested in how the bioluminescent jellyfish *Aequorea victoria* glows in the dark, and went to Friday Harbor in the U.S. state of Washington with his family every summer to solve the mystery. They collected as many as 850,000 jellyfish and investigated the nature of the substance that made them glow. He isolated the substance in question, a kind of protein called green fluorescent protein (GFP). This protein undergoes a structural transformation to become a chromophore and emits fluorescence; specifically, via cyclization and oxidation of three amino acid residues, Ser65-Tyr66-Gly67. In the jellyfish body, the calcium-responsive protein aequorin absorbs light, and then emits blue fluorescence; in turn, GFP absorbs this blue light and glows green. However, GFP can also glow on its own, so Martin Chalfie and Roger Y. Tsien used genetic engineering to develop a method of attaching GFP to other proteins and making them glow. This tool enabled the analysis of various biological phenomena in cells to reveal the subcellular localization of proteins (GFP tags), and advanced research in a wide range of fields including cell and molecular biology, developmental biology, and medicine. The 2008 Nobel Prize in Chemistry was awarded to Osamu Shimomura, Martin Chalfie, and Roger Y. Tsien for "the discovery and development of the green fluorescent protein, GFP." Today, artificial fluorescent proteins that glow in a variety of colors are being produced.

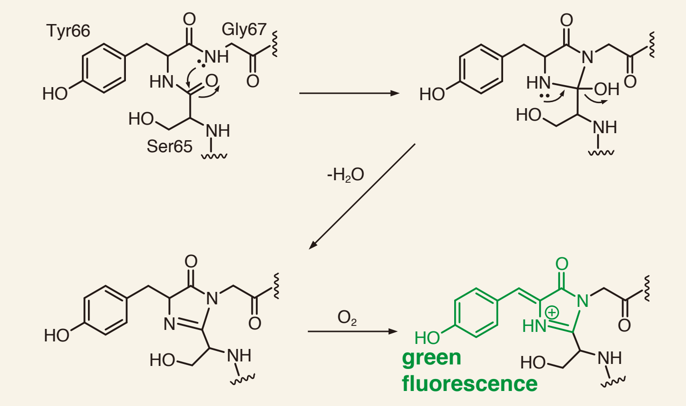


Photo by Nagasaki University

Dr. Osamu Shimomura
(1928–2018)

••• IChO2021 Problem Q6 •••

Coordination polymers: found in minerals - promising storage materials for small molecules

An enormous variety of minerals exist in nature. Most of these are inorganic compounds, while some are known as organic minerals. For example, there are currently 23 known organic minerals that contain carboxylic acids such as formic acid, oxalic acid, or acetic acid. In oxalate minerals, the two carboxylate groups ($-COO^-$) of oxalic acid are linked to various metal ions by coordination bonds to form network crystal structures (Fig. 1). Although not an organic mineral, Prussian blue, which was accidentally discovered in Germany in the early 17th century and has ever since been valued as a blue dye, adopts a crystal structure in which iron cations and cyanide anions (CN^-) are linked by coordination bonds (Fig. 2). Prussian blue was also used in Katsushika Hokusai's famous woodblock print "*Under the Wave off Kanagawa*" (ca. 1831; Fig. 2). Such crystalline network structures, which arise from coordination bonds between metal ions and bridging ligands, are called 'coordination polymers'.

In the middle of the 19th century, in parallel to the development of X-ray crystallography, chemists began to synthesize new coordination polymers using organic ligands that do not necessarily exist in nature. The crystal structure of an organic ligand-bridged coordination polymer that consists of adiponitrile and copper ions was firstly reported by Yoshihiko Saito et al. in 1959 (Fig. 3; left). We can only wonder how amazed these scientists must have been at the time by the complexity of the "reticular" networks of these crystal structures. After that, various other crystal structures were reported and chemists started to think about useful applications for these characteristic crystal structures.

In 1997, Susumu Kitagawa of Kyoto University discovered that the nanometer-sized small pores formed inside coordination polymers that consist of cobalt ions and bipyridine could be used as a gas-storage material (Fig. 3; right). Such "porous coordination polymers" can store large amounts of gas inside the crystals and are now being put to practical use. The applications of these materials can be expected to continue to expand in the future and probable applications include storing H_2 to power fuel cells, capturing CO_2 to ameliorate global warming, and storing H_2O to water the desert.

Fig. 1. (left) Photo of a macroscopic crystal of calcium oxalate and (right) its microscopic crystal structure determined by single-crystal X-ray diffraction analysis.

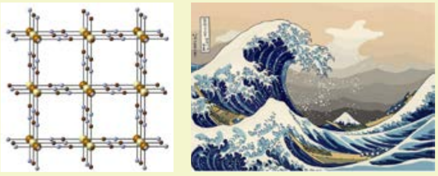


Fig. 2. (left) Microscopic crystal structure of Prussian blue. (right) Katsushika Hokusai's "*Under the Wave off Kanagawa*".

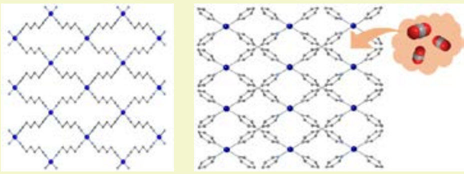


Fig. 3. (left) Crystal structure of a coordination polymer that consists of copper ions and adiponitrile ligands. (right) A representative porous coordination polymer that is able to store gas molecules inside its small pores.

VR TOUR SPring-8

The world's largest synchrotron radiation facility

Kumano Kodo

Kansai Scenes 7

Kumano Kodo (literally means the old ways of Kumano) is a general term for the network of pilgrimage routes that lead to the three main Kumano Shrines: *Kumano Hayatama Taisha*, *Kumano Hongu Taisha*, and *Kumano Nachi Taisha*. Located in the southwestern part of the Kii Peninsula and starting eastwards from the city of Tanabe, the network spans Mie, Nara, Wakayama, and Osaka Prefectures. It was registered as a UNESCO World Cultural Heritage Site in 2004. Kumano is regarded by the Japanese people as a sacred place for mountain worship, a practice that originates from the worship of nature in which the gods dwell in rivers, waterfalls, and huge rocks. The *Kumano Kodo* is also mentioned in the ancient history book *Nihon Shoki*, written during the Nara period (710 to 794). People walking the routes today can see the same scenery as the pilgrims who visited Kumano to gain enlightenment in the old days, including such joys of nature as the large cypress trees that are more than 800 years old, and the smooth cobblestones on the paths.

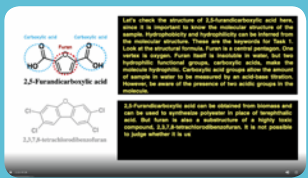
Other Local Dialects in the Kansai Region

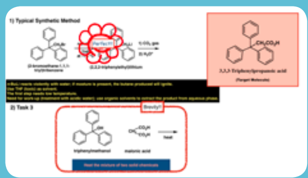
In Catalyzer No. 0, we presented a list of useful Japanese phrases, and in Catalyzer No. 1, a comparison of everyday phrases in Standard Japanese and *Kansai-ben*, a dialect spoken in the Kansai region. There are several sub-regional dialects too, each with distinctive expressions, spoken in various parts of Kansai. When a Kansai person speaks, we can often tell which part in the region they come from. The English phrase "Very Good!", for example, is Totemo Iine! in standard Japanese, *Meccha Eeyan!* in Osaka; *Erai Yoroshiyan!* in Kyoto; *Erai Eegai!* in Hyogo; *Erai Eenaa!* in Shiga; *Gottsu Eena!* in Nara; and *Yanikoo Eewaisho!* in Wakayama. Look at some of the other differences in the table below.

English	Standard Japanese	Osaka	Hyogo	Kyoto	Shiga	Nara	Wakayama
I agree.	Sou-dane.	Seya-na.	Seya-na.	Soya-na.	Hoya-na.	Seya-na.	Soya-ne.
No, you can't!	Dame-dayo!	Akan-de!	Akkai-ya!	Akan-shi!	Akasen!	Akan-de!	Akanaa!
Lots	Takusan	Gyousan	Jousan	Tanto	Yokke	Youke	Yousan
No problem.	Kamaimasen.	Kamahen.	Becchonai.	Dannai.	Dannai.	Kamahin.	Kitsukainai.
I can't.	Dekinai.	Dekehen.	Dekihin.	Yousimahen.	Dekihin.	Dekiyan.	Yousen.
Bottom	Saikai	Dobe	Getta	Bebetako	Gebeccha	Bebeta	Betta
Do not come	Konai	Kēhen	Kōhen	Kīhin	Kiyahen	Kyahen	Kēhen

* These words are just some examples.

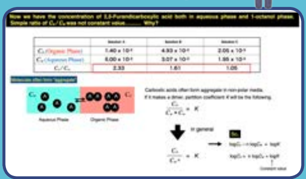
Practical Examination





Let's go to Labo!

Let's leave the Labo!



A message from the student narrators of the practical examination video

We are fortunate to be given this opportunity to help the International Chemistry Olympics in this way. We are students who like both English and chemistry. We believed challenging ourselves to try new things would give us new perspectives, and we thought taking this opportunity would give us new discoveries and experiences. Being able to participate in this event with friends was another incentive as well.

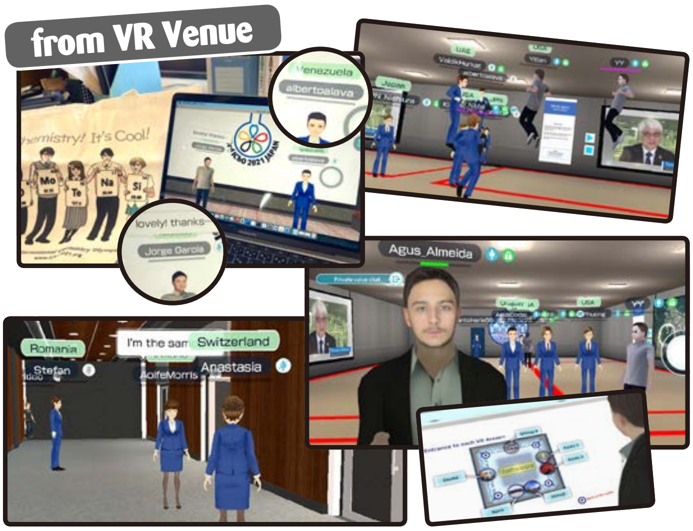
Although it wasn't an easy task to pronounce the long names of chemical substances or highly technical chemistry terms properly, we enjoyed dealing with it.

Most of us hope to work in a science field such as medicine, biology, or space aeronautics. Some of us would like to deal with environmental problems in the future as well. We are sure we need to use English to work in this field with the global scene. We will make good use of this experience that has given us a chance to get to know what practical English is like. Thank you.

Kyoto Prefectural Sagano Senior High School

PHOTO SELECTION

from VR Venue



during IChO2021

Turkey

Bangladesh

Japan

Short short from Editors

The book to take you to the world of Chemistry

Do you remember what made you fell in love with Chemistry? In Japan, there are illustrated books that introduce chemistry to children and fascinates chemists at the same time. Kako is also a scientist himself and has written many Chemistry stories for children. One of them is "Nakayoshi Ijiwaru Genso no Gakkou." It means "School of ELEMENTS with good friends and mean friends." This book introduces the process of creating the periodic table by comparing the properties of elements to the personalities of human classmates.

Little Daruma series

Today's schedule Jul. 31

Student

- **Activity** Video: History and Culture of Nara

Mentor

- **Arbitration** (America (west) ››› Asia ››› Europe ››› America (east))
  J 09:00 C 09:00 E 20:00 (Jul. 30)
- **Activity** Video: History and Culture of Nara

J: JST = UTC + 9 C: CET = UTC + 2 (summer time) E: EST = UTC - 4 (summer time)

Early Bird Communication

China

Uruguay

We could not take a group photo since the COVID-19 situation in Uruguay would not allow it. Even when the situation is getting better and the students will perform the test at the same classroom, asking them to travel to the main city, Montevideo, just to take a photo, could not be the best choice.

Sri Lanka

Sri Lankan team meeting with mentors

Element #6 Japanese mineral resources Indium

Basic Information

Origin of the name: Latin word *indicum* (indigo)
Discovered by: H. T. Richter and F. Reich (Germany) [1863]
Global production: 900 tons
Major producers: China, South Korea, Japan

Indium is an essential material for liquid crystal displays (LCDs), which are widely used for flat-screen TVs and notebook computers. Indium tin oxide (ITO) is used for electrodes in LCD panels because it is both transparent and conductive. Most of the world's indium is now produced in China, but in the past, the Toyoha Mine in Sapporo on the Japanese island of Hokkaido was the world's largest producing mine of indium. However, the mine was closed in 2006 because of its low profitability and the depletion of the resource.

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ELEMENT QUIZ Q7

A shape memory alloys is made by mixing two metals in a 1:1 ratio. Which of the following is the correct combination of two metals?

1 (Zn, Cu) 2 (Al, Cu)
3 (Ni, Ti) 4 (Ni, Fe)

Answer for Q6

① 2 Palladium
Osmium was used in the oxidation by Dr. Sharpless, and ruthenium and rhodium were used in the hydrogenation by Dr. Noyori and Dr. Knowles. Palladium was not used in either of these reactions.

② 2 Chlorine
Vancomycin is an antibiotic that belongs to the family of glycopeptides, which contain chlorine.

Chemistry! It's Cool!

53rd IChO 2021 JAPAN™

IChO2021 Catalyzer No. 7

Official Website
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Jul. 31
1800
Birthday
Friedrich Wöhler, Father of Organic Chemistry

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Edited by the Team Catalyzer IChO2021
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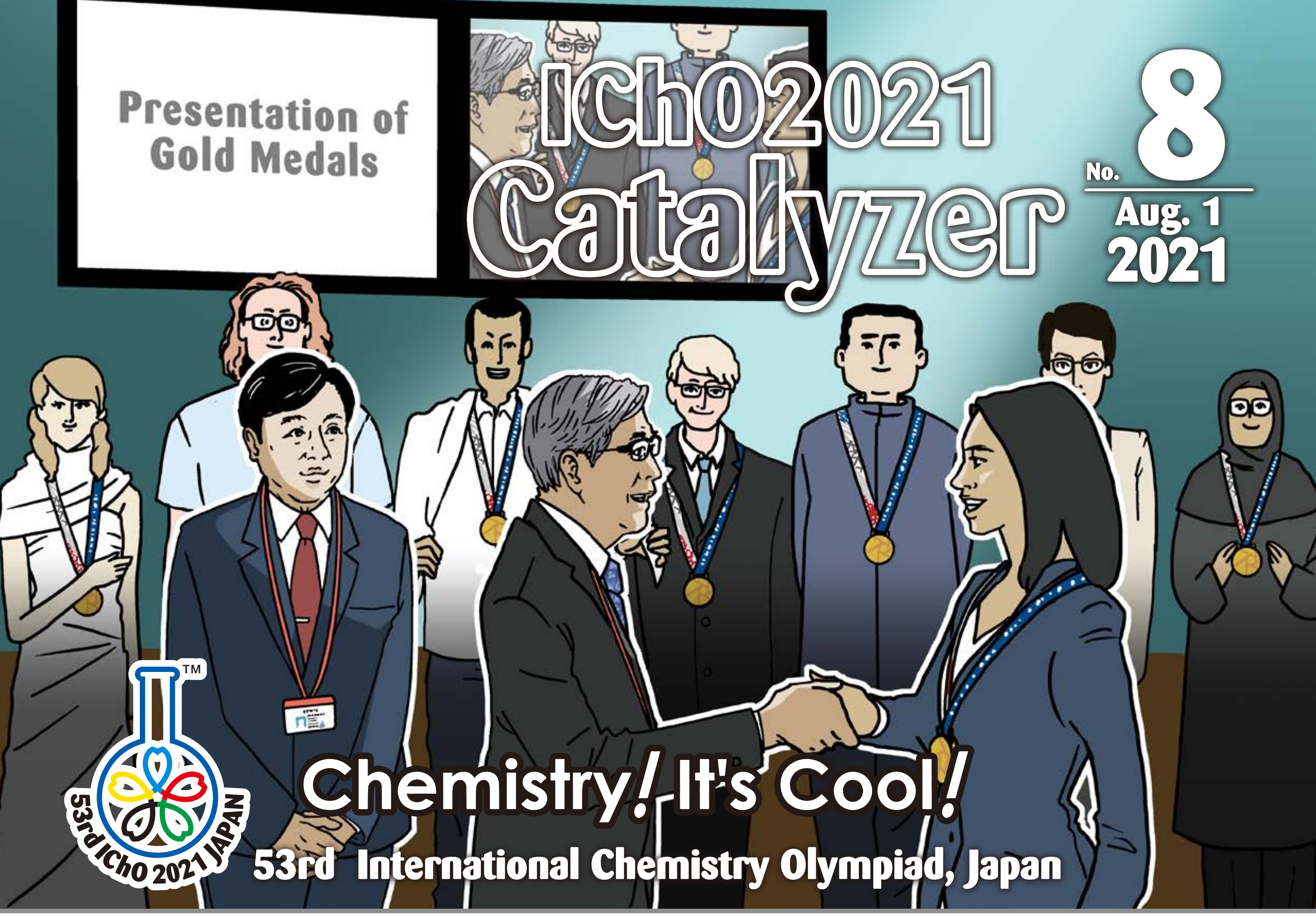
Illustration: Science Manga Studio



IChO2021 Catalyzer

No. 8

Aug. 1 2021

Chemistry! It's Cool!

53rd International Chemistry Olympiad, Japan

Cover illustration : Award Ceremony

Medal Design Concept: "The Chemical Vortex Leading to the Future"

Designer: Sakiko Matsumoto

From the center to the edge, the entire medal forms the shape of a vortex, giving the impression of a whirling motion. This movement represents the global impact and upcoming success of young students, originating at IChO2021 Japan. Through the designs found on both sides of the medal, IChO2021 supports the bright future of the contestants.

The obverse side features three kinds of popular auspicious patterns to express aspects of Japanese culture.

The reverse side contains the logo, which is represented in a simple and emphatic way through an image that spreads across the world.

Seigaiha (青海波) translates to blue ocean waves. The endlessly calm waves are a prayer for long-lasting happiness and a peaceful life.

Shippō Tsunagi (七宝つなぎ) is a pattern of connecting circles, expressing a wish for happiness, harmony, and connection. This connection is as valuable as the Seven Treasures of Buddhism: gold, silver, lapis lazuli, agate, seashell, amber, and coral.

Asanoha (麻の葉) is a pattern representing hemp leaves. Because hemp is resilient, grows vigorously, and requires little care, it is often used as a pattern in the *kimono* of young children in the hope that they grow up big and strong. It is also meant to ward off evil.

The ribbon represents the image of a whirlpool flowing from the medal in indigo, black, and vermillion, which is the color of Japan. The design also expresses the impact that the students will have in the world.

Nobel Prize Research from Japan 08

Discovery and Development of Conductive Polymers …. Hideki Shirakawa

Plastics (polymers) are used in all aspects of our daily living and enrich our lives with their low cost, light weight, and flexible formability. Initially, plastics were thought not to conduct electricity and were used as insulators. However, various conductive polymers have now been developed and boast a wide range of applications, including touch panels for smartphones and electrodes for lithium-ion batteries. The development of conductive polymers that led to innovation in the world of plastics was triggered by a serendipitous (unexpected) discovery by Hideki Shirakawa. When a student in his laboratory accidentally used one thousand times the required amount of catalyst to synthesize polyacetylene, he obtained a shiny, film-like material that was completely different from the conventional black powdery polyacetylene. Although polyacetylene has many π-electrons, they cannot move freely, and the film-like polyacetylene did not show sufficient conductivity in its original state. However, through trial and error, they came up with a method to dope carriers that act as electron acceptors, and when they added a small amount of bromine or iodine, the conductivity surged 10 million times. This discovery led to a dramatic development in research on conductive polymers. For this series of achievements in laying the foundation for the development of conductive polymers, which became indispensable to modern society, Hideki Shirakawa was awarded the Nobel Prize in Chemistry in 2000, together with Alan Jay Heeger and Alan Graham MacDiarmid.

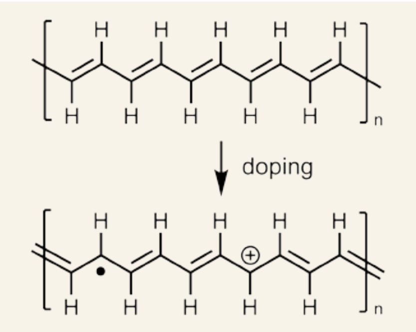


Photo by Kazuhiko Sugano

Dr. Hideki Shirakawa (1936–)

Japan is a "fermentation powerhouse"

Japan, with its warm and moist climate, is a "fermentation powerhouse" where microorganisms are very efficacious. Fermented foods such as soy sauce, *natto* (fermented soybeans), and *katsuobushi* (dried bonito flakes), which are made by growing mold on fish to remove moisture, are world-famous.

Soy sauce

Natto

Katsuobushi

Kansai is also home to many fermented foods rooted in the local climate. In Wakayama, facing the Pacific Ocean, "*Nare-zushi*", salted fish wrapped in plant leaves with rice and then lacto-fermented, is served on celebratory occasions. "*Funa-zushi*", a kind of *Nare-zushi*, is made along the shoreline of Lake Biwa. *Funa-zushi* is made by marinating spawning crucian carp in salt and fermenting it with rice for one to three years. The lactic fermentation gives it a novel cheese-like flavor and sourness, and the acidity increases its shelf life. There are two types of pickles in Japan: those made of lacto-fermented vegetables, and those made by soaking veges in *koji* (rice malt) or sake lees to add to their flavors. For example, "*Suguki-zuke*" is a lacto-fermented turnip and "*Nara-zuke*" is a type of cucumber or squash pickle that has been pickled in sake lees for years.

Nare-zushi

Funa-zushi

Suguki-zuke

Nara-zuke

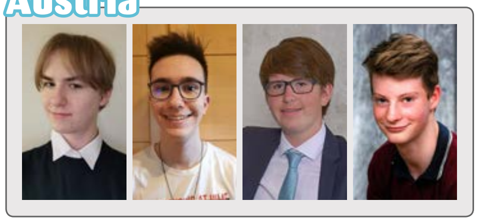
Koji and yeast are crucial for making sake and basic seasonings such as soy sauce, miso, mirin, and vinegar. Jokichi Takamine who succeeded in crystallizing adrenaline (Catalyzer No. 6), devised a method to extract a type of diastase (digestive agent), named Takadiastase later, during the process of growing *koji*. *Koji* is deeply connected to the history of biochemical research in Japan. Against this background, *Aspergillus oryzae*, the main body of *koji* that supports Japanese food culture, was designated as Japan's national fungus in 2006 by the Brewing Society of Japan.

IChO2021 Participating Teams

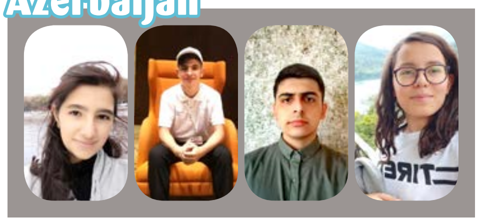
Armenia

Australia

Austria

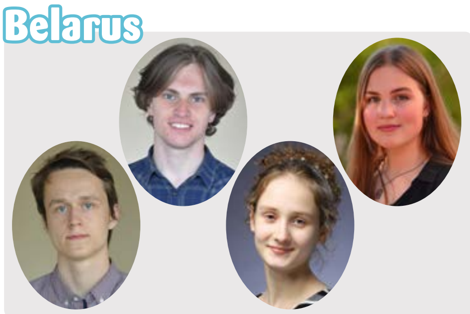


Azerbaijan

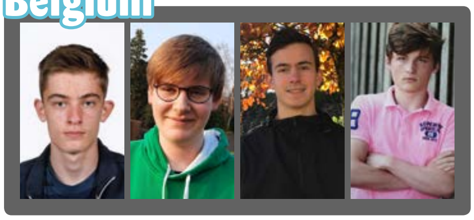


Bangladesh

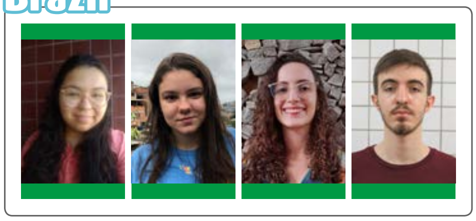
Belarus



Belgium

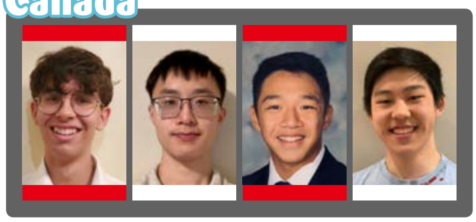


Brazil



Bulgaria

Canada

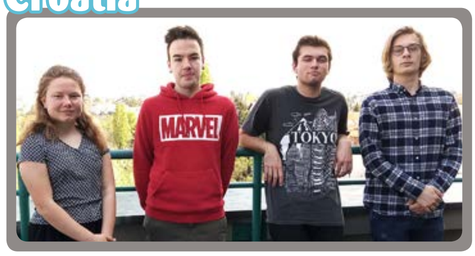


China

Chinese Taipei

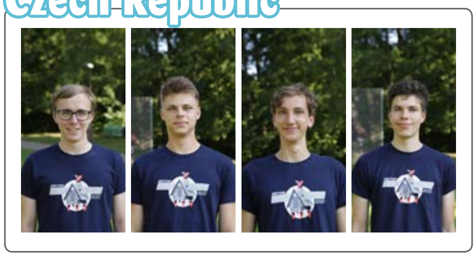
Costa Rica

Croatia

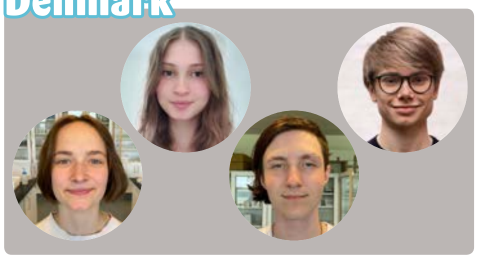


Cyprus

Czech Republic



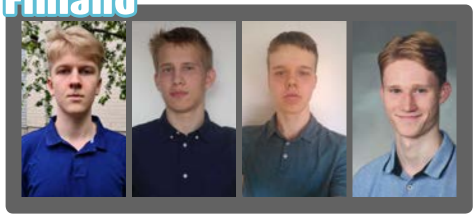
Denmark



El Salvador

Estonia

Finland

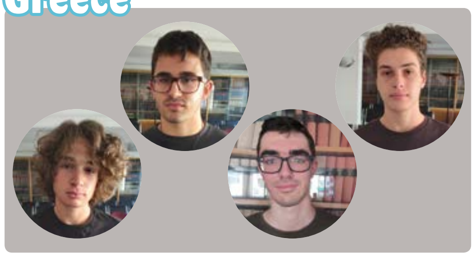


France

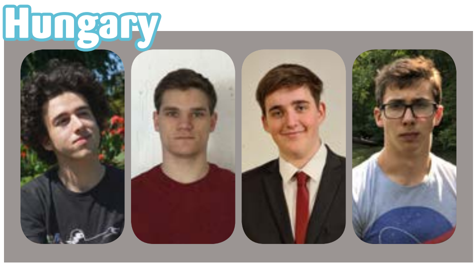
Georgia

Germany

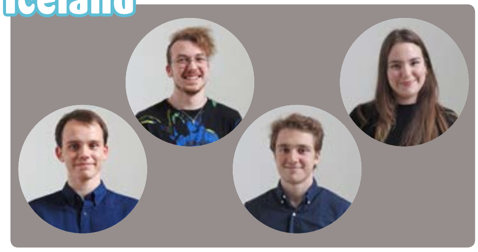
Greece



Hungary



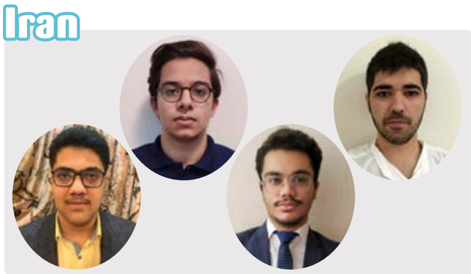
Iceland



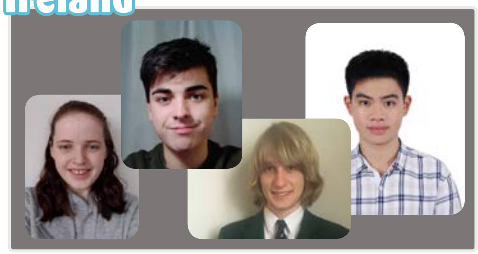
India

Indonesia

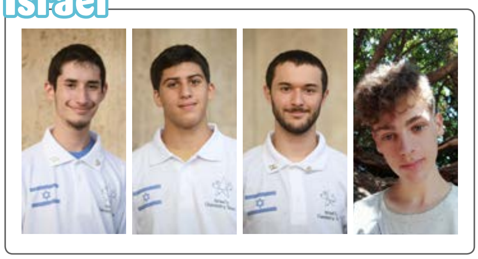
Iran



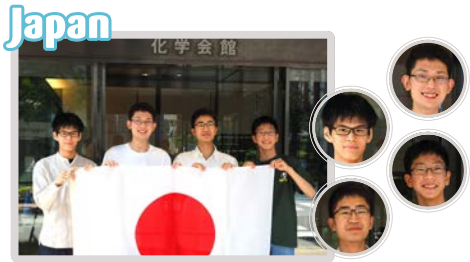
Ireland



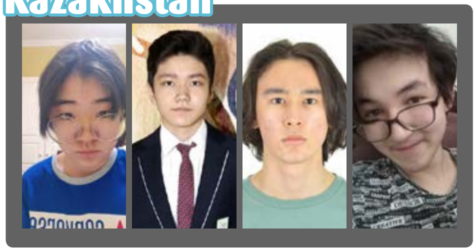
Israel



Japan

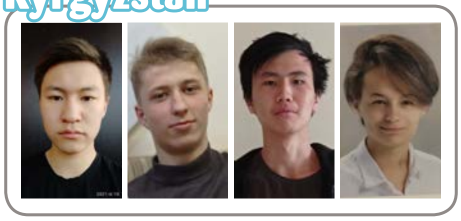


Kazakhstan



Korea

Kyrgyzstan



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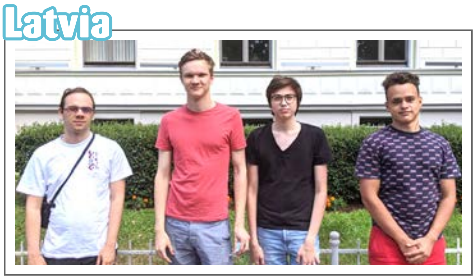

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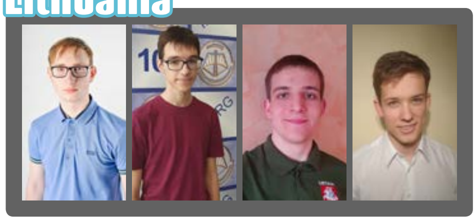

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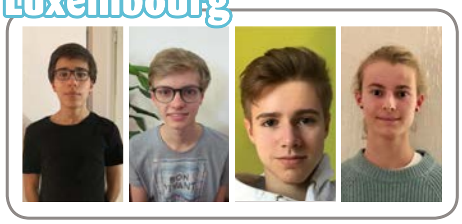

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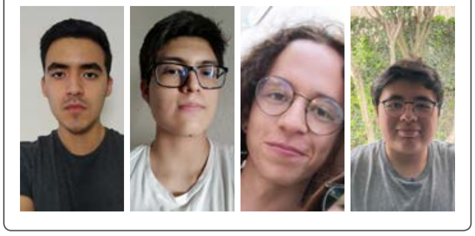

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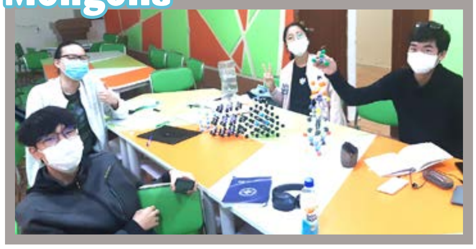
Mongolia



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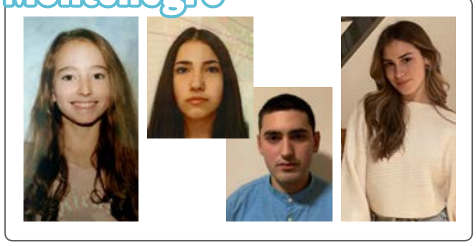

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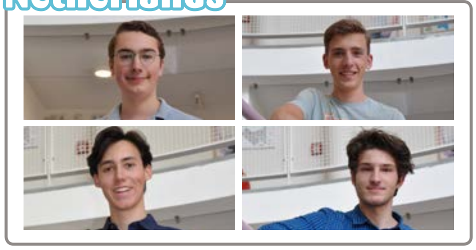

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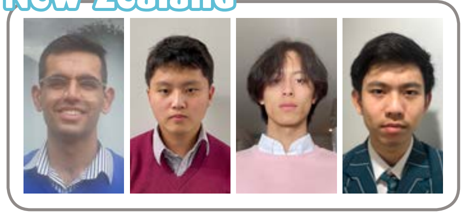

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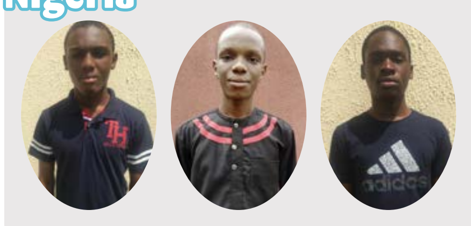

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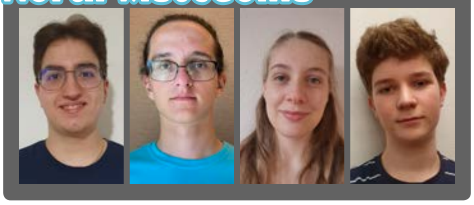

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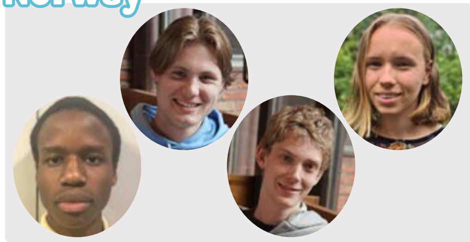
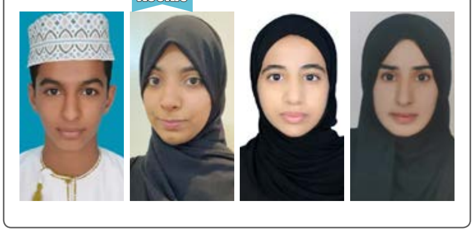


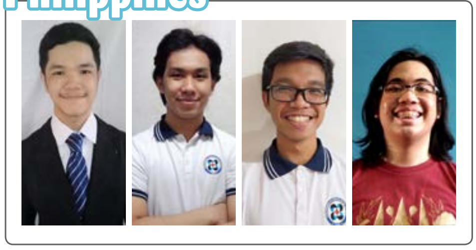
Oman

Rookie



Pakistan

Philippines



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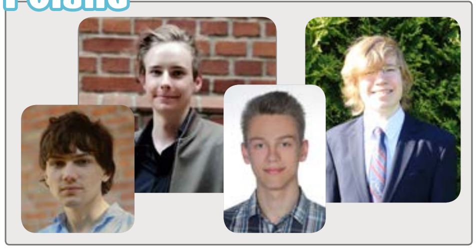

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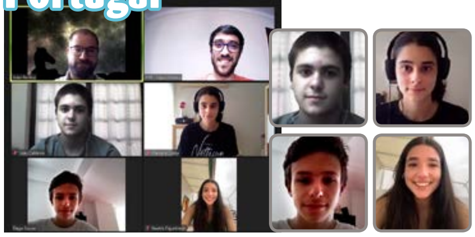

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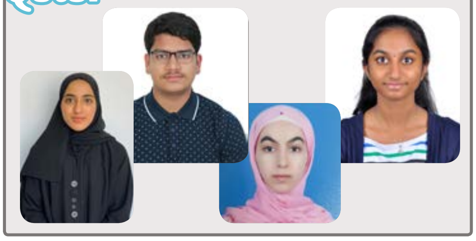

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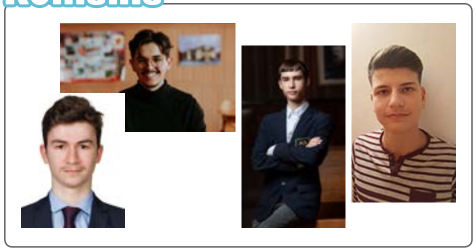
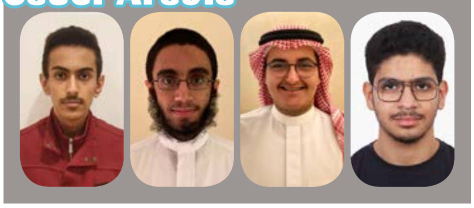


Russian Federation

Saudi Arabia



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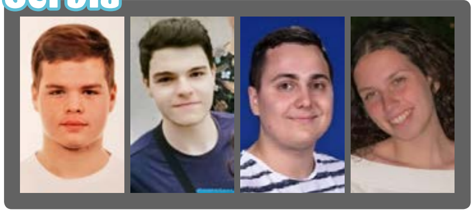

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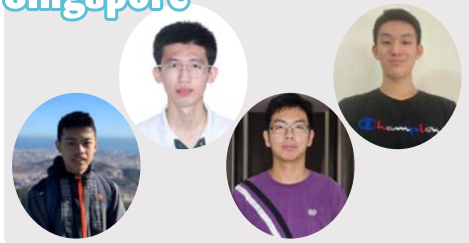

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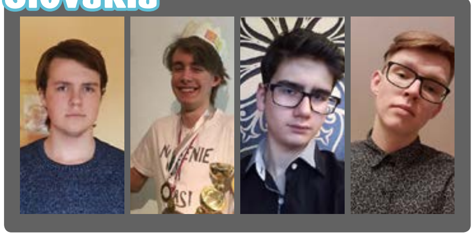

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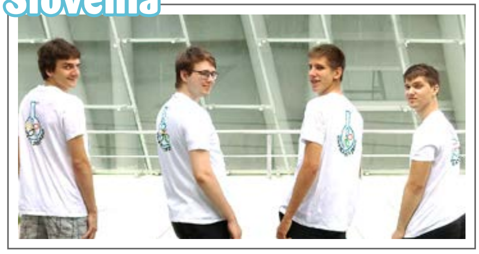

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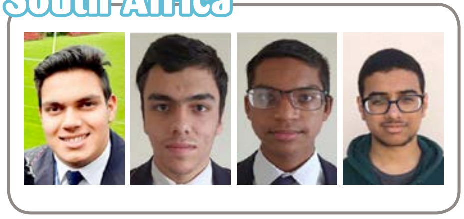

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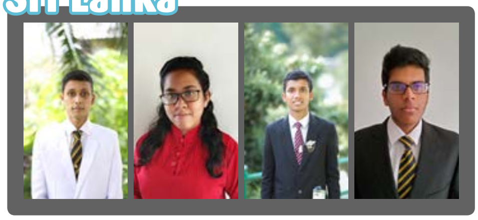

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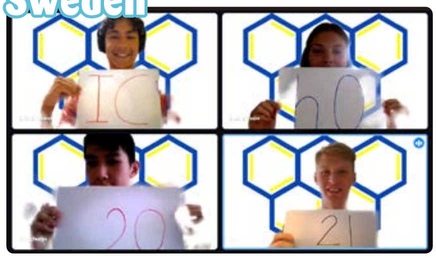

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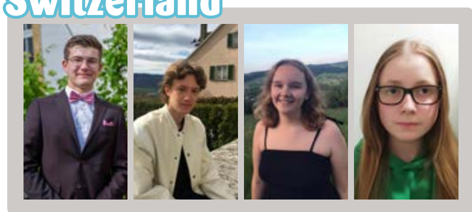

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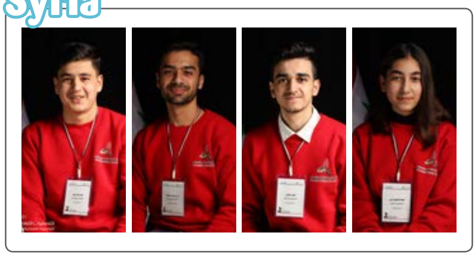
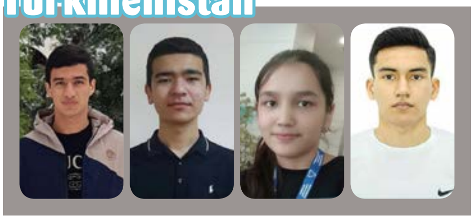


Tajikistan


Thailand


Trinidad and Tobago


Turkey


Turkmenistan


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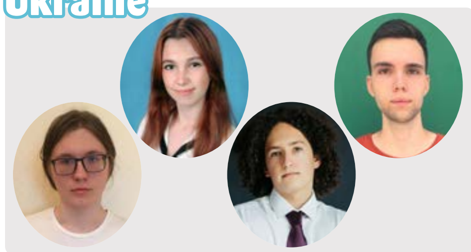
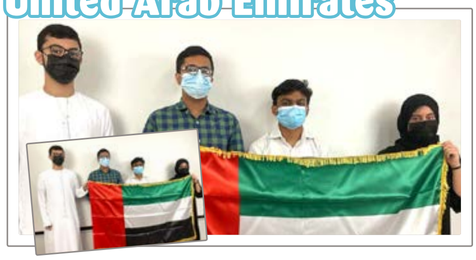
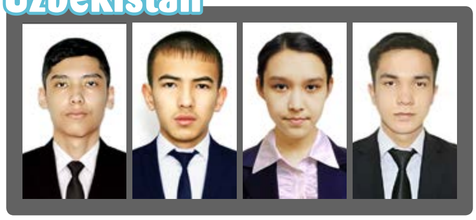


United Arab Emirates


United Kingdom


United States of America


Uruguay


Uzbekistan


Venezuela


Vietnam


Remote IChO2021 Japan

Looking Back Remote IChO2021

Nobuhiro Kihara

Vice-chair of Executive Committee,
Vice-chair of Science Committee
for the 53rd IChO2021, Japan

The 53rd International Chemistry Olympiad (IChO) 2021 Japan was originally planned to follow the 2020 Olympic and Paralympic Games in Tokyo, Japan. The interest to chemistry from the people was expected to be enhanced when a scientific Olympiad would be held after the excitement of a sporting Olympiad.

When we heard the first reports of COVID-19 early in 2020, it appeared to be a minor concern. Despite the virus being thought of as causing a new kind of cold, we knew that the common cold is inactive in summer, when the IChO was to be held. However, shortly after the pandemic spread across the globe, it became evident that COVID-19 was active in summer, too. The 2020 Olympics and Paralympics were postponed, and the 52nd IChO2020 in Turkey was held remotely, because the University venue could not be used for an in-person event in the period of IChO.

The IChO is composed of three key elements:

(1) Examination

Chemistry is an experiment-based science, with every theory coming out of the laboratory. Therefore, both theoretical and practical examinations play important roles in the IChO.

(2) Communication

Talented students from all over the world come together to take part in the IChO. Conversation, cooperation, and communication with each other provide a great opportunity for promising youngsters to enjoy international experiences and to make friends with other participants via their common interest, chemistry.

(3) Culture

The venue chosen for IChO2021 Japan was the ancient capital of Japan, where the first government of Japan was established 2681 years ago (according to Japanese legend). Several places were to be visited, including not only very old temples but also state-of-the-art scientific institutes.

In the middle of January 2021, the Organizing Committee of IChO2021 Japan met with the Steering Committee (SC) of the IChO. We discussed two proposals; for an in-person IChO and a remote IChO. Unfortunately, it was already clear that all the elements of the IChO described above could not be included in an in-person IChO during the COVID-19 pandemic, due to difficulties in immigration control and of the need for social distancing.

The first priority of IChO is, of course, the safety of all participants. After our meeting with the SC, we finally decided to hold IChO2021 Japan as a remote event. At the end of February, when we had a second meeting with SC, the holding of a remote IChO was approved.

Even in a remote format, all elements essential to the IChO had to be maintained as much as possible:

(1) Examination

The competition involves theoretical problems, and was strictly monitored to avoid cheating. However, in order to reinforce the importance of laboratory work, an activity was developed in which the practical tasks prepared for IChO2021 Japan were demonstrated. We are delighted if those who are inspired by the demonstration can prepare and submit original videos in which they attempt the practical tasks and discussions. Reports on the tasks will also be highly welcome.

(2) Communication

We prepared avatars for all participants. Everyone participated in events and activities via their avatars. We also prepared virtual venues in which avatars can enjoy close conversation, cooperation, and communication with others. Some events also took place in such virtual venues.

(3) Culture

IChO participants were offered the opportunity for virtual visits to several locations. As well as those locations that had been planned for the in-person IChO, we have added several that are very interesting to experience but not suitable for in-person visits due to hazards, sensitivity, space limitations, or language difficulties. However, the participants' avatars can readily visit such restricted locations. The menu of cultural tours for our remote IChO holds more interest than would otherwise be possible.

This remote IChO has given us the chance to make the latest technology to provide great opportunities and special experiences to all participants.

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Vice Chairs
Kyohei Takahashi
Yoshiki Chujo
Tadao Kondo
Teiji Koge
Hiroshi Nishihara

Finance Committee
Chair Tadao Kondo
Chair Teiji Koge

Executive Committee
Chair Yoshiki Chujo
Vice Chair Nobuhiro Kihara

Science Committee
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Takashi Uemura

Secretariat
Masaya Sasaki
Hiroshi Seta
Junko Kotoku

Today's schedule Aug. 1

Student
- **Activity Video: Himeji Castle, Osaka, and Kyoto**

Mentor
- **Receive final results** J 09:00 C 02:00 E 20:00 (Jul. 31)
- **Activity Video: Himeji Castle, Osaka, and Kyoto**

J: JST = UTC + 9 C: CET = UTC + 2 (summer time) E: EST = UTC - 4 (summer time)

ELEMENT QUIZ Q8

① The term "atom" is said to have been derived from a Greek word "atomos", which literally means "something that cannot be divided". What is the origin of the term "electron"?

1 amber
2 something that shines
3 musical instrument
4 something like water

② Which country is the largest producer of selenium in the world?

1 USA 2 Japan 3 Mexico 4 China

Answer for Q7

3 (Ni, Ti)

Zinc-copper alloy is brass, aluminum-copper alloy is duralumin, and nickel-iron alloy is called permalloy. A nickel-titanium alloy that consists of same ratio of the two metals is called a shape-memory alloy because it has the property of returning to its original shape when heated above a certain temperature, even after deformation.

Element #7 Japanese mineral resources Silicon

Basic Information

Origin of the name: Latin word *silex* (hard stone, flint)
Discovered by: J. J. Berzelius (Sweden) [1823]
Global production: 8 million tons
Major producers: China, Russia, Brazil

Silicon does not exist in its pure metal form in nature; however, massive amounts of silicon can be found in soil, stones, and minerals in oxide forms, typically SiO_2, a major constituent of sand. Yamanashi Prefecture in Japan is famous for its natural quartz crystal. Silicon metal is a very important material for industry today, used widely in semiconductors, microchips, and photovoltaic panels.

© The Courtyard of our Minerals

Daisenryo Kofun — Kansai Scenes 8

The *Daisenryo Kofun*, located in the city of Sakai in Osaka Prefecture, was built in the early to mid-5th century and is considered to be Japan's largest *kofun* (Emperor's tomb). It is one of the more than 200 burial mounds that make up the Mozu Tumulus Group, which were built between the late 4th and early 6th centuries. The three-tiered, keyhole-shaped tomb is 486 meters in length and 654 meters at its widest, and is surrounded by a three-tiered moat. Although the actual identity of the Emperor buried there is unknown, the *Daisenryo Kofun* was recorded as the tomb of Emperor Nintoku in a collection of laws compiled by the Imperial Household Agency in the early 10th century. The *Daisenryo Kofun* is one of the three largest tombs in the world, together with the pyramid of King Khufu in Egypt and the tomb of Qin Shi Huang in China. It was designated as a UNESCO World Heritage Site in 2019.

Chemistry! It's Cool!

IChO2021 Catalyzer No. 8

Official Website
https://www.icho2021.org/
icho2021

Aug. 1
1774
Discovered!
Oxygen
by Joseph Priestley

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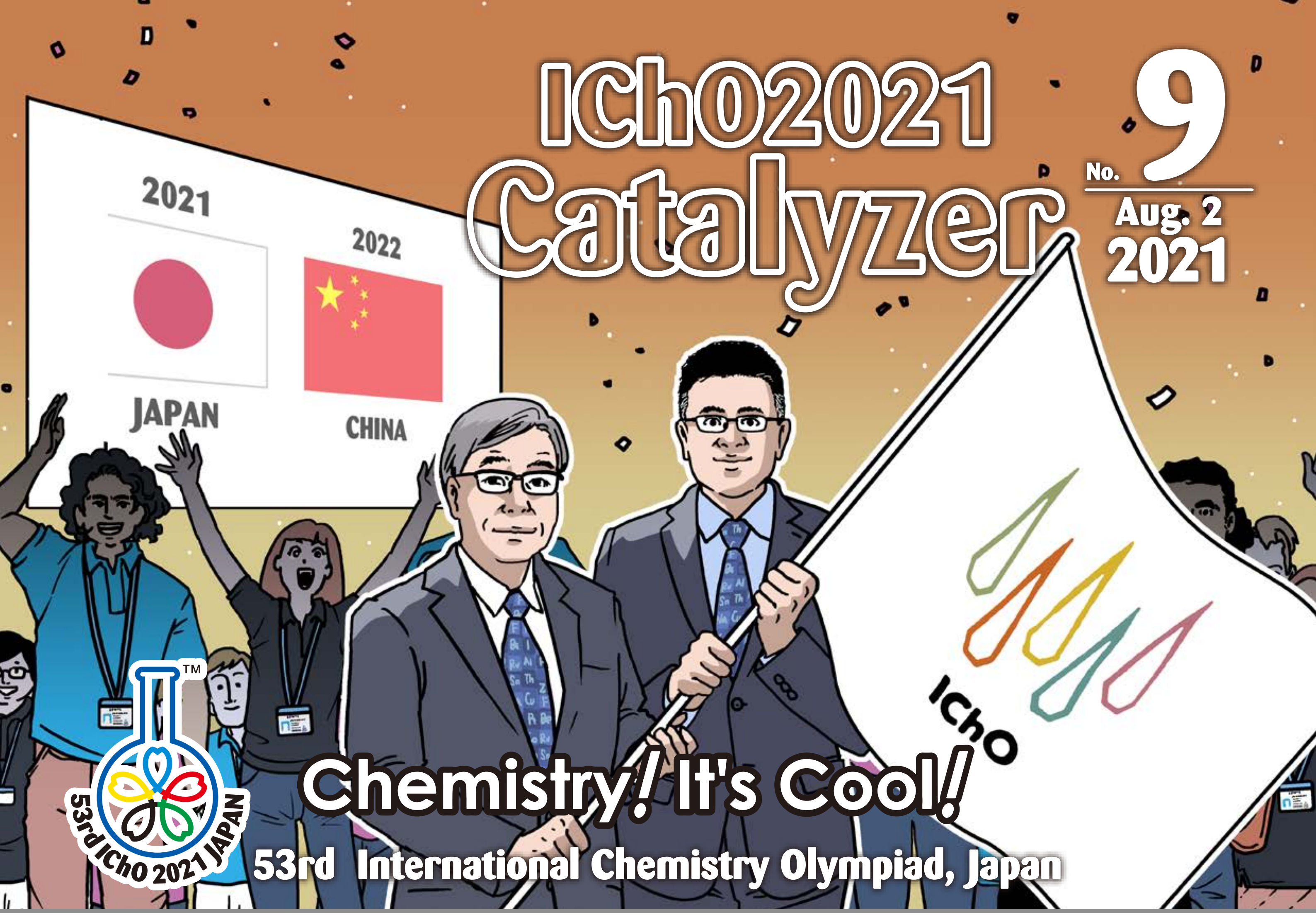
Edited by the Team Catalyzer IChO2021
English Editor: Maiko Katayama
Illustration: Science Manga Studio



Cover illustration : IChO flag Ceremony

Welcome Message from China ･･･ IChO2022

We are looking forward to welcoming you from all over the world to participate in the 54th Chemistry Olympiad in 2022, at Nankai University, in Tianjin city. Tianjin, a meaning of the 'emperor's docks,' resides in Northern China, the key junction of transportation and communication for China and its connection with the world.

As the Vice-Chancellor of Nankai University, it is my greatest pleasure to introduce Nankai University as the 54th IChO host. Founded in 1919, Nankai University has played a vital role in Chinese education over the last 100 years. Today, Nankai has grown to three modern university campuses, plus a full range of educational institutions. Nankai University is a leading multidisciplinary and research-oriented state university, consisting of 26 colleges, covering areas from natural science to humanities, at all levels. As a member of the Global University Leaders Forum, Nankai University strives continuously to deepen its internationalization and globalization process, both in education and research. Not only does Nankai offer opportunities for students to study abroad, but it also provides a growing number of well-supported international studentships and scholar bursary programs each year. These broaden our academic horizons and contribute to building a worldwide academic community and a shared future for humankind.

As a chemist, I have found that Chemistry can start from simple concepts and extend to understand the complexities of the world. Here at Nankai, one is always encouraged to develop social responsibility, practical capabilities, and a creative spirit. This spirit is coincidently shared with the IChO, so we are genuinely looking forward to welcoming the young Olympians to Nankai University, bringing sparks of inspiration and ideas, scientific talent, and starting friendships. Right now, we are working as hard as possible to ensure you will have a safe, and a special IChO in China. We sincerely hope that the pandemic will be over and the world will go back to normal quickly.

Finally, we are looking forward to welcoming you to Tianjin, in 2022!

Prof. Jun Chen
The Chair of the Organizing Committee of IChO2022
The Vice-Chancellor of Nakai University

ICHO2021 Japan Closing Remarks by Vice President of IChO2021

Thank you for kind introduction. My name is Kyohei Takahashi, and I'm originally from a Japanese chemical company, and also ex-Chairman of Japan Chemical Industry Association, an association of all Japanese chemical companies. In Japan, academic society and industry association jointly continue to contribute to overall chemical society, and it is my honor to work as a representative from the chemical industry in this International Chemistry Olympiad Japan Committee.

The 53rd International Chemistry Olympiad in Japan, or IChO2021 Japan, will be closed today after the fruitful session of 9 days. Although due to the ongoing COVID-19 pandemic, we had to have the meetings by WEB system, we had participants from 85 countries and regions. This is the largest number IChO has ever had.

This was made possible by the devoted efforts of the Steering Committee and Chairman Dr. Gábor Magyarfalvi, all national contacts of each country and region, and those who conducted selection of student representatives. I would like to express our sincere thanks to all of you. In addition, thanks to the grate efforts of all mentors, science observers, and invigilators, examinations in all countries and regions were fairly conducted. I really appreciate your efforts and cooperation.

In the host country Japan, sponsorship was provided for us by many governmental agencies including Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry, Japan Science and Technology Agency, and more than 180 chemical companies and associated companies. Here I would like to report that this IChO has been operated under the partnership of All-Japan. Let me express my heartfelt thanks to all organizations and persons who supported us.

Now all of more than 300 students from all over the world taking part in IChO2021 Japan, thank you for your on-line participation despite this difficult situation! Did you demonstrate your ability and results of your daily efforts to the full? I believe all of you did! Properly speaking, you should come to Japan, become good friends with other students, and directly feel Japanese science, technology, society, and culture. However, we could not invite you to Japan due to the pandemic. Nevertheless, we provided you with many extraordinary programs and events only an on-line would be capable of. We provided you with virtual-tour of SPring-8, which is the world's largest radiation facility, and on-line visit to Buddhist temples, Himeji Castle, Kyoto, and Osaka. I am sure you enjoyed these virtual tours! We also hope you enjoyed communication with many new friends from all over the world in the virtual space.

For all of you who gloried as gold, silver, and bronze medal winners, congratulations! Your past effort comes into full bloom now! Also, let me congratulate all other students participated, because taking part in the IChO as representatives from your country or region is an honor you should be proud of. Your experience of this time will let you gain great self-confidence and support in your future.

Chemistry has infinite potential. The chemical industry is the only industry which has a name of science in its name, while other industries, such as the automobile industry and the steel industry, are called with names of products. This is because the chemical industry is based on chemical technology. Our industry manufactures various products, and chemistry is utilized in every possible scene of our life. Therefore, we can say that the chemical industry is the blood for all other industries.

Today we are facing global-scale problems such as global environmental issues, natural resource problems, and energy problems. These problems may jolt the future of human beings. As you know, the UN Sustainable Development Summit held in September 2015 adopted a set of international development goals called "Sustainable Development Goals" known as SDGs and most of such 17 goals requires innovations by chemistry. We believe and hope young people like you, who have rich knowledge and capability about chemistry, will lead the achievement of such goals. My dear students, this time you represented your home countries. But in the future, you must lead chemistry in the world, you must work together with other participants in this IChO, and you must make great contribution to the solution of difficult global problems. My young friends, please have high aims, and attempt new challenges!

At the end of my closing address, I wish you great success in your bright future. Thank you very much and good luck!

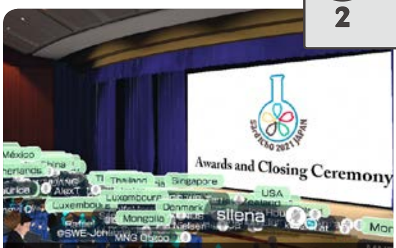
Kyohei Takahashi

Vice President, IChO2021 Japan Committee
Vice Chair, Organizing Committee
for the 53rd IChO2021, Japan

Awards and Closing Ceremony

Program

- Opening Movie
- Introduction of Sponsors
- Explanation of Examination by Prof. Hiroshi Nishihara
  Chair of the Science Committee
- Awards Ceremony
- Message from Prof. Gábor Magyarfalvi
  Chair of the Steering Committee
- Closing Remarks by Kyohei Takahashi
  Vice President of IChO2021 Japan Committee
  Vice Chair of IChO2021 Organizing Committee
- Introduction of Organizing Committee Members
- IChO Flag Handover Ceremony
- Welcome Message from Prof. Jun Chen
  Chair of the Organizing Committee of IChO2022
  Vice-Chancellor of Nankai University
- Closing Movie



Closing Ceremony # Awards
Aug. 2, 2021

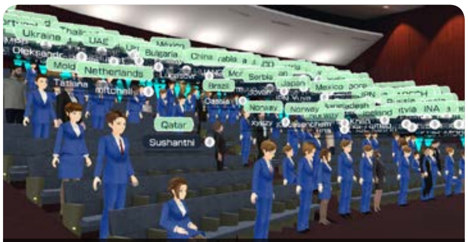
Top 3 of Gold Medalists # 1st, Shu Yang # 2nd, Zhangyi Huang # 3rd, Xinyu Cai
Congratulations! # 3 avatars with reflecting winner's faces

Gold
Congratulations!

Silver
Congratulations!

Bronze
Congratulations!

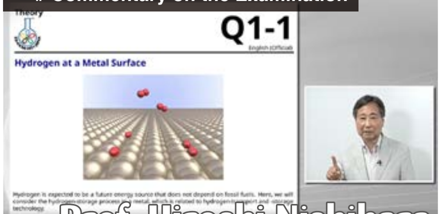
Honorable Mention
Congratulations!



Avatars attended
Remote # Virtual venue

Participants communicated using avatars.
The space is virtual, but your new friendship is real!

Commentary on the Examination



Prof. Hiroshi Nishihara
Chair of the Science Committee

Message

Prof. Gábor Magyarfalvi
Chair of the Steering Committee

Closing Remarks

Kyohei Takahashi
Vice President of IChO2021 Japan Committee

Welcome IChO2022

Prof. Jun Chen
Chair of Organizing the Committee of IChO2022
Vice-Chancellor of Nankai University

Congratulations!!

▎IChO2021 Japan

Jul. 25 (Sun.) – Aug. 2 (Mon.) 2021

Remote Examination

Jul. 28 (Wed.)

▎Participants (85 Teams)

521 Total Participants
- 312 Students
- 157 Mentors
- 52 Observers and Guests

183 Invigilators

▎Awards

Gold Medal : 33
Silver Medal : 67
Bronze Medal : 94
Honorable Mention : 24

Best of IChO2021

1. **Shu Yang** China
2. **Zhangyi Huang** China
3. **Xinyu Cai** China

Gold

Shu Yang	China
Zhangyi Huang	China
Xinyu Cai	China
Bangsen Zhao	China
Sobirjon Amanov	Uzbekistan
Mircea Raul Bodrogean	Romania
Aleksandr E. Trofimov	Russian Federation
Anh Duy Nguyen	Vietnam
Bo-An Chen	Chinese Taipei
Georgii M. Zhomin	Russian Federation
Chun-Cheng Ting	Chinese Taipei
Phuong Duc Nam Pham	Vietnam
Qiyang Zhou	United States of America
Berkan Tarak	Turkey
Chen Yizhou	Singapore
Alexander Ramsay Thow	United Kingdom
Rui-Xi Wang	Chinese Taipei
Cheng Jun Nicholas Goh	Singapore
Nir Cohen	Israel
Timofey A. Charkin	Russian Federation
Tudor Lile	Romania
Adarsh Reddy Madur	India
Mahbod Alian Fini	Iran
Deniz Guner	Turkey
Andrei S. Tyrin	Russian Federation
Dhananjay Raman	India
Yitian Zhu	United States of America
Filip Hůlek	Czech Republic
Harry John List	United Kingdom
Anh Le Thao Nguyen	Vietnam
Mahyar Afshinmehr	Iran
Myeongjin Shin	Korea
Alexandru Catalin Dianu	Romania

Silver

Duong Hoang Nguyen	Vietnam
Stefan Dimitriu	Romania
Sebnem Gul	Turkey
Uladzislau Hlatankou	Belarus
Alphonsus Yu Xiang Neo	Singapore
Michal Piotr Lipiec	Poland
Oscar Dong	Australia
Seung Jae Kang	Korea
Nikhil Seshadri	United States of America
Faatih Regind Qashash Roman	Indonesia
Bernard Tze Wei Kwee	Singapore
Hsuan-Ting Lin	Chinese Taipei
Mahit Rajesh Gadhiwala	India
Seyed Mohammad Hossein Barakati	Iran
Oisín Colm Ó Feinneadha	Ireland
Oleksandr Zaporozhets	Ukraine
Goktug Gulsoy	Turkey
Shahzod Nazirov	Tajikistan
Hee Seong Yoon	Korea
Jirapat Rujirayuk	Thailand
Jovan Marković	Serbia
Linus Albert Schwarz	Germany
Muhammad Barotov	Tajikistan
Vinicius da Silveira Lanza Avelar	Brazil
Lucio Saracco	Hungary
Ioannis Karageorgiou	Greece
Nichawadee Kanjanakosit	Thailand
Davut Muhammetgulyyev	Turkmenistan
Takahiro Takemoto	Japan
Kohei Nishiura	Japan
Bruno Andrzej Skoczen	Poland
Khaidar Kairbek	Kazakhstan
Mohammad Solaiman AlHadlaq	Saudi Arabia
Marek Pavlica	Czech Republic
Ehsan Naderi Donig	Iran
Patrik Žnidaršič	Slovenia
Seoyeon Kim	Korea
Gerel Bayarmagnai	Mongolia
Temujin Orkhon	Mongolia
Kien Phuong	United States of America
Tong Wu	Ireland
Zachary John McGuire	United Kingdom
Rishit Singla	India
Andy Cai	Canada
Lita Tantipraphat	Thailand
Džonatans Miks Melgalvis	Latvia
Yuya Koike	Japan
Mohammad Rashed AlHudaithi	Saudi Arabia
Abdulaziz Abdulrahman AlJuaid	Saudi Arabia
Matúš Tomčo	Slovakia
Itamar Steinitz	Israel
Gozel Dovranova	Turkmenistan
Ron Angelo A. Gelacio	Philippines
Simon Bukovšek	Slovenia
Michael Schembera	Austria
Sanzhar Bissenali	Kazakhstan
Tim Bastian Enders	Germany
Pavel Atanasov Nikolov	Bulgaria
Berdigylych Rejepbayev	Turkmenistan
Dávid Benkő	Hungary
Yusup Dovletmyradov	Turkmenistan
Madiyar Kassymaly	Kazakhstan
Povilas Dapsys	Lithuania
Nathan Wayne F. Ariston	Philippines
Daniils Kargins	Latvia
Jakub Krzysztof Kwiatkowski	Poland
Ihor Kholomieiev	Ukraine

Bronze

Kevin Lius Bong	Indonesia
Tadas Danilevicius	Lithuania
Khanim Yagublu	Azerbaijan
Sathira Jantarakulchai	Thailand
Irmuun Altankhuyag	Mongolia
Kamil Mambetov	Kyrgyzstan
Neta Eiger	Israel
István Babcsányi	Hungary
Samuil Vladimirov Petkov	Bulgaria
Durdona Muxtarxujayeva	Uzbekistan
Lazar Savić	Serbia
Hanif Muhammad Zhafran	Indonesia
Darko Stojchev	North Macedonia
Vladislavs Tiščenko	Latvia
Maciej Swiatek	Austria
Keith Wong	Australia
Johann Sora Blakytny	Germany
Andrei Banica	Canada
Firdavs Sobirov	Uzbekistan
Ketevan Peranidze	Georgia
Abdur-Raheem Idowu	Norway
Ruben Tapia	France
Austin Lin	Australia
Patrik Fábrik	Slovakia
Aigerim Turuspekova	Kazakhstan
Nathanael Reza Putra Widjaja	Indonesia
Edvards Jānis Treijs	Latvia
Georgi Neliyanov Nedyalkov	Bulgaria
Salman Huseynov	Azerbaijan
Cassia Caroline Aguiar da Ponte	Brazil
Angelina Rogatch	Belarus
Benedek Sajósi	Hungary
Alina Tumashyk	Belarus
Nariman Shirinli	Azerbaijan

Saeed Sultan Baghdadi	Saudi Arabia
Ahmad Thaer Ater	Syria
Maha Ali	Syria
Jorge García-Ponce	Mexico
Michael Li	Canada
Lukas Rost	Austria
Teodor Svilenov Maslyankov	Bulgaria
Nadun Naveendra Rajapaksha	Sri Lanka
Yurii Okis	Ukraine
Dimitrije Gligorovski	Serbia
Achira Hansindu Kelambi Arachchige	Sri Lanka
Marina Malta Nogueira	Brazil
Fran Miletic	Croatia
Haruhi Isse	Japan
Jernej Birk	Slovenia
Yangyi Qi	Sweden
Aleksandr Beditski	Estonia
Vincent Ng	Australia
Anas Abbas	Syria
Adam Szymon Sukiennik	Poland
Tomáš Heger	Czech Republic
Ikromiddin Boymahammadov	Uzbekistan
Fynn Lasse Noah Kessels	Germany
Jakub Sochor	Czech Republic
Emilio Alonso Venegas-Hernandez	Mexico
Michael Estes	Denmark
Liis Siigur	Estonia
Jochem van den Broek	Netherlands
Nino Abesadze	Georgia
Hayk Aghekyan	Armenia
Aames Juriel B. Morales	Philippines
Théodore Halley	France
Valerian Mocreac	Moldova
Alexandre Bloquel	France

Laimis Jurkenas	Lithuania
Mahsati Piriyeva	Azerbaijan
Daan Roger Stan Vanhaecke	Belgium
Simonas Melaika	Lithuania
Sandro Pfammatter	Switzerland
Ioane Kapanadze	Georgia
Fredi Manuel Barraza Hernandez	El Salvador
Tatiana Sviriniuc	Moldova
Mason Minghan Liu	New Zealand
Ján Plachý	Slovakia
Oscar Eric Moran Despard	Ireland
Leonid Asatryan	Armenia
Terry Wang	Canada

Hana Gabriela Albuquerque Sousa	Brazil
Tal Sason	Israel
Tigran Harutyunyan	Armenia
Andrei Kornijenko	Estonia
Nevena Stojković	Serbia
Adelina Andrei	Moldova
Samuel Kolesár	Slovakia
Sebastian Jacob Krikke	Netherlands
Paul Johann Dorfer	Austria
Lin Bigom-Eriksen	Denmark
Manujaya Praveen Wijesinghe	Sri Lanka
Kiryl Maroz	Belarus
Maxim Cojocari-Goncear	Moldova

Honorable Mention

Bumchin Dolgormaa	Mongolia
Abhinav Chawla	New Zealand
Aku Hertell	Finland
Daria Klymenko	Ukraine
João Pedro Bonito Caldeira	Portugal
Théo Mignen	France
Ali Marouf	Syria
Olga Jerkovic Peric	Croatia
Sam Wuji Zhuang	New Zealand
Samuel Klaver	Finland
Vid Kavčič	Slovenia
Jessica Rebekka Kurmann	Switzerland

Safwan Sakib	Bangladesh
Gerardo Emiliano Gutierrez-Alvarez	Mexico
Rafael Dux	Luxembourg
Aoife Mary Morris	Ireland
Henri Kärpijoki	Finland
Dinithi Shalika Madhubhashini	Sri Lanka
Daniel Jiyoun Jang	New Zealand
Athanasios Feidakis	Greece
Jean-Marc Furlano	Luxembourg
Vaidik Rajesh Hurkat	United Arab Emirates
Mahin Kamal Sawdager	Bangladesh
Khalid Hasan Tuhin	Bangladesh

out of 309 students

Element # 8

Japanese mineral resources

Antimony

Basic Information

Origin of the name: Greek word *anti-monos* (not alone)
Discovered by: known since early history
Global reserves: 1.9 million tons
Major reserve countries: China, Russia, Bolivia
Global production: 153,000 tons
Major producers: China, Russia, Tajikistan

Pyroxene is a mineral composed mainly of antimony sulfide (Sb_2S_3). In Japan, the Ichinokawa mine in Ehime Prefecture on the island of Shikoku used to produce large and beautiful pyroxene specimens. A simple substance of antimony can be obtained by reducing pyroxene with iron, or oxidizing it by combustion first then reducing with carbon. Antimony is still used as an electrode material and as a wear-resistant material for secondary batteries, as well as for flame retardants, type metals, and semiconductors.

© The Courtyard of our Minerals

Answer for Q8

① **1** amber

When J. J. Thomson (1856–1940) discovered that cathode ray was actually a stream of particles, G. J. Stoney (1826–1911) named it "electron" after the Greek word *aelectron*, which means amber. It was given the name because the particles were produced by rubbing an amber rod.

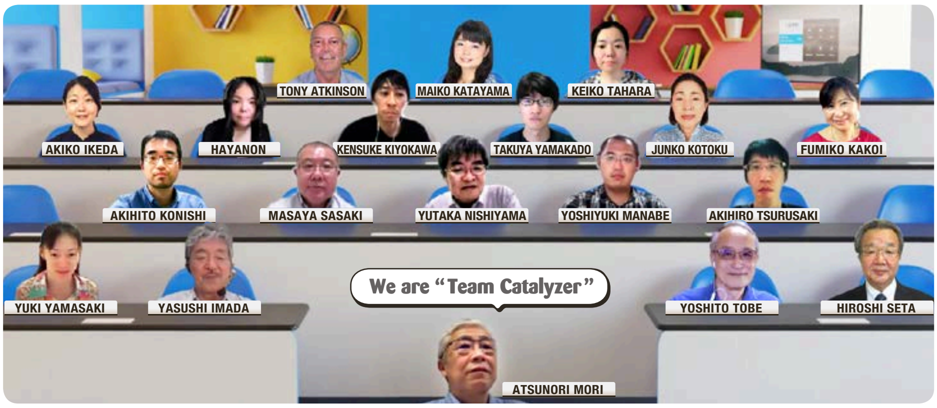
② **2** Japan

Japan produces 28% of the world's selenium (770 tons; 2019 data). Selenium has a range of industrial uses; it is found in applications from electronic devices to pigments, beauty products, and other daily items.

This popular word has the meaning of "thank you". Many people in the Kansai area say "Ohkini" at the end of conversation to smooth relations with the person. Ohkini was originally an adverb that indicated large quantities. Therefore, "Ohkini Arigato" is the equivalent of "Thank you very much." Over the years, this was abbreviated to just "Ohkini."

We deeply regret that editing of Catalyzer has mostly been done by remote. We have had little chance to meet and discuss face-to-face upon editing. The photo below is the immersive view in the Zoom meeting of the Team Catalyzer. We hope that human overcomes COVID-19 pandemic soon and the next Chemistry Olympiad the 54th IChO2022 will be held as the really REAL mode.

The Team Catalyzer IChO2021



Chemistry! It's Cool!

53rd IChO 2021 JAPAN ™

IChO2021 Catalyzer No. 9

Official Website
https://www.icho2021.org/

icho2021

Aug. 2
1932
Discovered!
Positron
by Carl David Anderson

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