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THE CHEMISTRY OF PAMUKKALE (COTTON CASTLE)

Pamukkale, meaning cotton castle in Turkish, is a natural site in Denizli in southwestern Turkey. The area has been declared a World Heritage Site by UNESCO, and the ancient Greco-Roman city of Hierapolis was built on top of the white "castle". It is known as Pamukkale or ancient Hierapolis (Holy City). This area has been built gradually by the thermal springs since the time of classical antiquity.

The Turkish name refers to the surface of the shimmering, snow-white limestone, shaped over millennia by calcium-rich springs. Dropping slowly down the vast mountainside, mineral-rich waters foam and collect in terraces, spilling over cascades of stalactites into milky pools below. There is a legend that says the formation is solidified cotton (the area's principal crop) that was left out to dry.

The water dissolves pure calcium carbonate ($CaCO_3$), becomes saturated with it, and carries it to the earth's surface, where it bursts forth and runs down the steep hillside. Cooling in the open air, the $CaCO_3$ precipitates from water, adheres to the soil, and forms white calcium carbonate "cascades" frozen in stone called travertines.

Pamukkale travertine terraces at sunset. Denizli, Turkey

Natural travertine pools and terraces at Pamukkale. Cotton castle in southwestern Turkey

A travertine is a slip formed by a multifaceted chemical reaction and subsequent precipitation of various causes and environments. The geological events that led to the thermal source of Pamukkale affected a large area. In this region, there are 17 hot water areas with temperatures ranging from 35 to 100 °C. Pamukkale's thermal source has been used since antiquity. Some travertines are yellow as they contain iron oxide, for example, Karahayıt travertines in other areas.

The thermal water comes from the source in a covered channel of 320 m length per travertine, and from there it pours into the travertine floors where 60-70 m of partial sedimentation takes place, and it travels 240-300 m on average.

The mineral-rich Pamukkale hot spring waters are high in calcium, magnesium sulfate, and bicarbonate. They also contain carbon dioxide (CO_2) and radioactive content of 56 becquerels/L. The water temperature is 36-38 °C with a pH of 6. The total mineral contents are 2430 mg/L. The waters are used for drinking and bathing.

Travertines of Pamukkale spa resort. Turkey

When the water starts to lose its warmth, CO_2 is released into the air. As a result, $CaCO_3$ is precipitated. Thus, the water forms the magnificent travertines. The chemical precipitation reaction from the beginning to the end is:

$$Ca(HCO_3)_2 \text{ (aqueous)} \longrightarrow CaCO_3 \text{ (solid)}\downarrow + H_2O \text{ (liquid)} + CO_2 \text{ (gas)}\uparrow$$

The precipitate is in gel state in the first step. The reaction is occurs chemically. It hardens and becomes travertine over time. However, the walking and playing of visitors on the floors cause the soft $CaCO_3$ to be crushed and to disintegrate.

The waters are recommended for the treatment of rheumatic, dermatological, and gynecological diseases; neurological and physical exhaustion; digestive maladies; and nutritional disorders.

Since the amount of thermal water is not sufficient, the water should be supplied to the terraces alternately. The site is a truly remarkable natural phenomenon and it would be a pity if human interference damaged it permanently for future generations.

Emin Erdem

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Hüseyin YURTTAŞ, Esra HALICI,
Burak Muhammet GÖKLER,
Muhammed Emin DOĞAN

SUMELA MONASTERY

Sümela Monastery, located at a height of 300 meters in the Maçka district of Trabzon Province, is also known as the Virgin Mary Monastery. The name Sümela comes from the word "melas", meaning black. The monastery was first established by two monks named Sophranios and Barnabas, who came from Athens to Maçka during the reign of Byzantine Emperor Theodosius I (375-395). It took its current form in the 13th century.

In 1461, the region came under Ottoman rule. The Ottomans protected the rights of the monastery and granted it privileges.

Cultural Heritages

In the 18th century, some walls were decorated with frescoes and many parts were renovated. Some buildings were added in the 19th century. That was followed by one of its brightest and richest periods and it gained the magnificent appearance that exists today. During the Russian occupation between 1916 and 1918, the monastery was seized. In 1923, it was completely abandoned.

Sümela Monastery includes a library, a sacred spring, student rooms, a guesthouse, a kitchen, a chapel, and a rock church. There are guardrooms next to the entrance. From there, you can go down to the inner courtyard.

The outer and inner walls of the rock church and the adjacent chapel in the monastery are decorated with scenes from the Bible.

Sümela Monastery stands at the foot of a steep cliff facing Altındere valley in the district of Maçka in Trabzon Province. The Orthodox monastery, which was named Panaghia tou Melas in Byzantine Greek, was founded in the 4th century by two monks called Barnabas and Sophronius.

Painting on Sümela Monastery in Trabzon, Turkey. The Black Sea region has become a popular tourist destination in recent years. There are many small and large plateaus in the region. In recent years, plateau tourism began in this region. The district attracts attention due to its different architecture as well as its incredible nature. The architectural details of the wooden houses are also interesting.

Close-up view of Sümela Monastery


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2019 THE YEAR OF PROF. DR. FUAT SEZGIN

Prof. Dr. Fuat Sezgin (24 October 1924-30 June 2018) was one of the world's leading names in the field of Islamic science and technology research. In Turkey, 2019 was dedicated to this distinguished scientist and his works were introduced through various activities.

By permission of Corporate Communications Directorate, Ataturk University, Turkey

Prof. Dr. Fuat Sezgin, who had wanted to study mathematics at university and become an engineer, changed his mind and decided instead to study the history of science after attending a seminar by Prof. Dr. Helmut Ritter, working at the Institute of Oriental Studies at Istanbul University. Prof. Dr. Sezgin completed his doctoral thesis, entitled "The Sources of Al-Bukhari", in 1956 under the supervision of Prof. Dr. Ritter and went to Germany in 1960. In 1965, he wrote his second doctoral thesis, on "Jabir ibn Hayyan", at the University of Frankfurt and received the title of professor a year later. Prof. Dr. Sezgin, in his work "History of Arabic-Islamic Science", which is a comprehensive study of Arabic written works, covered subjects including Quranic sciences, hadith sciences, history, fiqh, theology, sufism, poetry, medicine, pharmacology, zoology, veterinary medicine, alchemy, chemistry, botany, agriculture, mathematics, astronomy, astrology, meteorology and related fields, grammar, mathematical geography, cartography in Islam (cartography), and history of Islamic philosophy.

Prof. Dr. Sezgin, who founded the Arab-Islamic History Institute at Goethe University in Frankfurt in 1982, opened the Museum of Islamic Science History a year later. In the museum, more than 800 examples of models of the inventions of scientists raised among Islamic culture based on written sources are exhibited. There are 45,000 volumes of books and 10,000 microfilms in the History of Sciences Library established within the museum. Prof. Dr. Sezgin founded the Istanbul Museum of the History of Science and Technology in Islam in 2008.

The museum has 570 tools, copies of devices, model collections, and maps related to the fields of astronomy, timepiece technology, maritime navigation, war technology, medicine, minerals, physics and technology, optics, chemistry, mathematics and geometry, architecture and city planning, and geography. With this feature, the museum is the first example in Turkey in this field and the second in the world after Frankfurt. The inventions and discoveries by Muslim scientists in the museum comprehensively reveal the changes in different fields of the history of science. The museum also has a catalogue entitled "Science and Technology in Islam", written by Prof. Dr. Sezgin. To date, this work, which has been written as a museum catalogue, has been published in four languages: Turkish, English, German, and French.

Prof. Dr. Sezgin was deemed worthy of many awards internationally for his work in the field of the history of Islamic science. Among the awards he received were many important ones such as the Frankfurt am Main Goethe Plaque, German First Class Federal Service Medal, German Distinguished Service Medal, Iran Islamic Science Book Award, Hessen Culture Award, and Turkish Presidential Culture and Arts Award.

Bilim ve Teknik (Science and Technology magazine), January 2019

Şahin İdin

THE SCIENCE HISTORIOGRAPHY OF FUAT SEZGIN

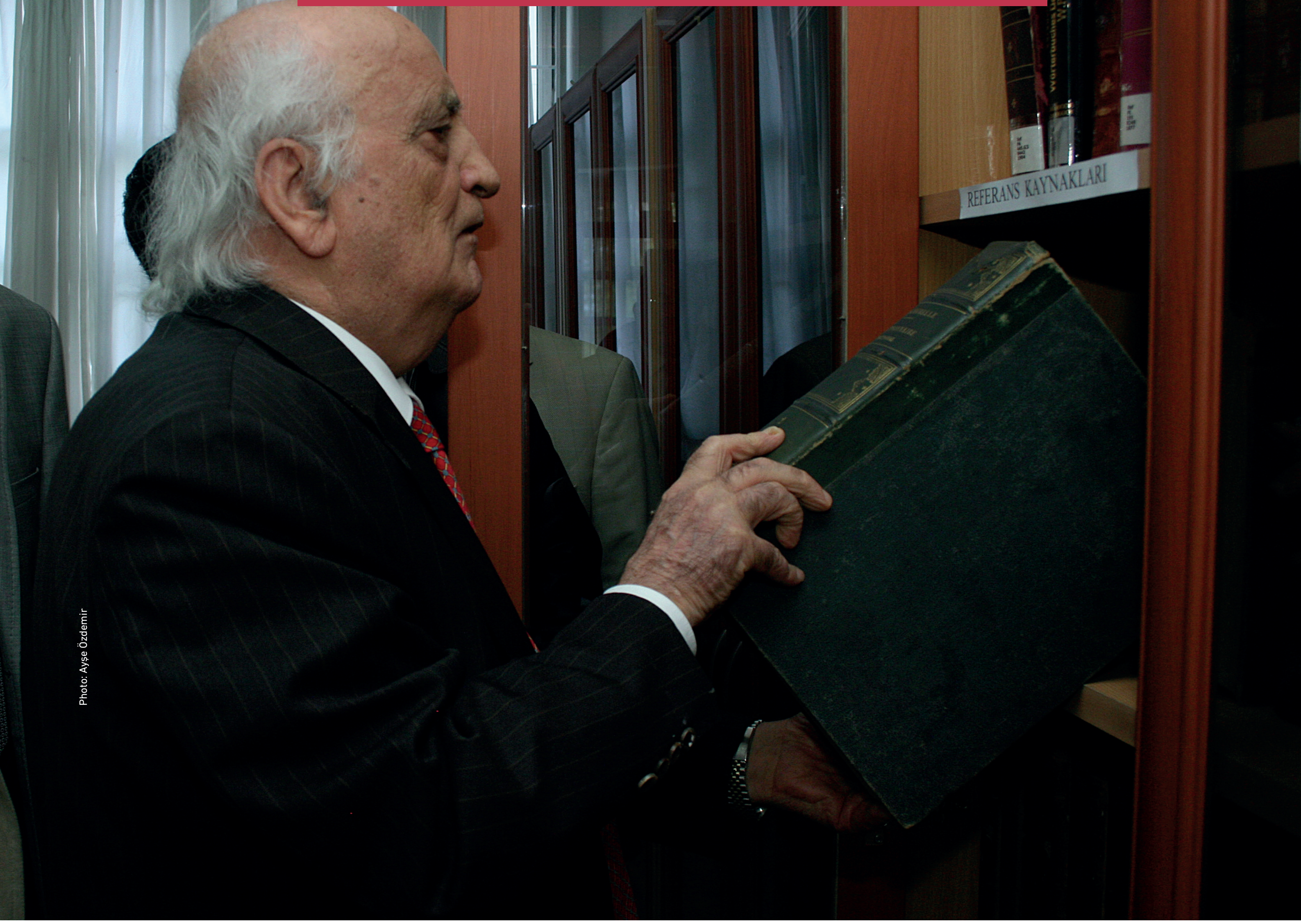

Photo: Ayşe Özdemir

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Ritter was undoubtedly influential in the formation of the scientific thinking of Fuat Sezgin and shaping his identity as a historian of science as a discipline, since they met very early and worked together for a long time. However, it is noteworthy that in almost all of his writings he spoke of another thinker he carefully mentioned. This person whom he calls a close friend and qualifies as a genius is Matthias Schramm. Sezgin states that Schramm developed an understanding of science history based on the principle of “Science history is the common heritage of humanity” and that he has the same view. Without discussing whether this point of view is appropriate for justifying the intellectual heritage of humanity, we must state that the famous science historian George Sarton (1884-1956) laid the foundations for the birth of this proposed idea.

According to Sarton, the progress of humanity is based on the development of positive knowledge and the development of one branch of science is directly related to the development of another. This means unity of knowledge; on the other hand, the development of science depends not on one person but on the common effort of people, which means the unity of humanity; these two units form two aspects of a great truth. In order to fully grasp these qualities of science, a true science historian needs to know at least one Western language, have knowledge of paleography and political history, and have a basic education in natural science. In this respect, Sarton calls the history of science "new humanism" in order to draw attention to how important the studies of science history are. Therefore, Schramm's claim is a generalized version of Sarton's idea.

However, Sezgin mentions that a thinker other than Schramm was more influential in forming his own understanding of science history. That thinker was Joseph-Toussaint Reinaud (1795-1867). According to Reinaud, people do not invent and discover; they just develop. In this context, sciences do not undergo leaps either; they progress gradually and continuously. Thus the task of science historians is to find continuity by finding the missing piece.

This perspective constitutes Sezgin's way of evaluating the history of science. Accordingly, the progress observed in sciences takes place in a linear way. Thus, it is seen that Sezgin did not compliment the well-accepted philosopher of science, Kuhn, who advocates that progress in science is through leaps or revolutions.

When evaluated in the light of these explanations, it is understood that Sezgin adopted an understanding that sees civilization as a whole and sees the young Western civilization as the continuation of Islamic civilization under different geographical and economic conditions. Another point to be mentioned in this context regarding Sezgin's understanding of science history is his adherence to the principle of continuity of scientific studies. In this context, Sezgin stated that Muslims were constantly engaged in obtaining Greek, Indian, Byzantine, and Iranian knowledge until the 9th century, and the phases of assimilating this acquisition phase and producing new information followed. While making these determinations, it was carefully emphasized that every society receiving past information could not contribute to the information or even failed to understand it, but Muslims carried out successful studies until the 16th century.

Stating that there are a few basic rules of scientific development in a society, Sezgin summarized the topic under three headings:

- Determined and intense acquisition and learning of the legacy of past civilizations;
- Support of this process systematically by the state
- The process is not disturbed by religion.

According to him, in order to achieve success after acquisition in this way, it is imperative that the knowledge, experience, and tools received are not only used but also developed in a way that aims to contribute as a part of the new cultural environment.

Sezgin listed the main factors that enabled scientific development in the Islamic world between the 8th and 16th centuries:

- Readiness to take from the past;
- Encouragement of this initiative by religion;
- Support from the state;
- Respect for the other;
- An effective learning system;
- Conducting science and philosophy with a worldly understanding, not a theological one;
- Effective socialization of information;
- Advanced language;
- Advanced philology knowledge to connect with other languages;
- A serious terminology study;
- Development of tools (such as paper and ink) that will ensure the circulation and permanence of information.

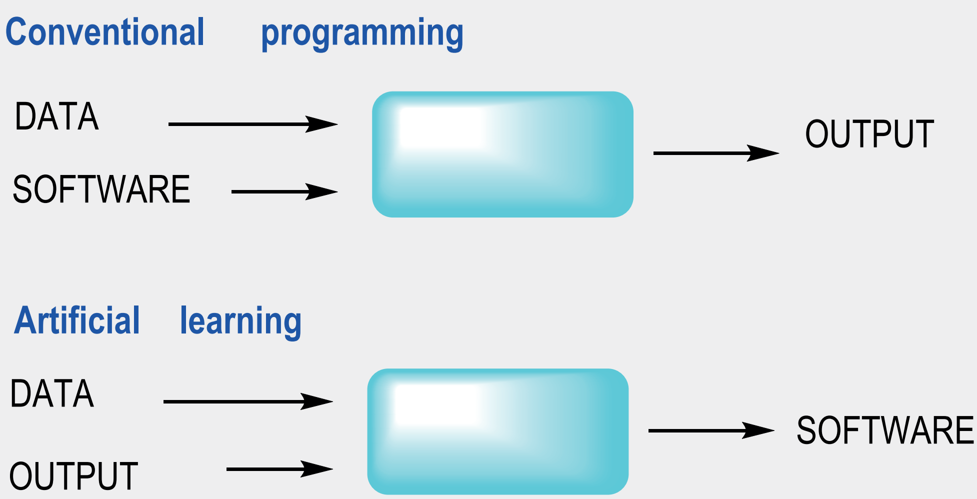
Stating that all of these factors dominated the Islamic world between the 8th and 16th centuries and that the decline occurred since the moment they were moved away from, Sezgin's thoughts support the views of scientists and intellectuals such as Al-Kindi, Al-Farabi, İbn Rushd, and Al-Biruni, who lived between the 8th and 14th centuries.

Bilim ve Teknik (Science and Technology magazine), June 2019

Hüseyin Gazi Topdemir

A LIGHT ON DARK REACTIONS

You may have heard that Edison tried thousands of different materials, including human hair, until he found a long-lasting filament for light bulbs. For scientists trying to synthesize new crystals, the situation is not more comforting. Approaches based on trial and error take both time and effort; almost all of the unsuccessful attempts remain confined to the laboratory and dusty notebooks.



The laboratory notebooks of scientists trying to synthesize new crystals contain many trials that have yielded little or failed completely. Many changes are made until the chemicals necessary for obtaining the desired product are determined and the physical conditions of the reactions are optimized, and the experiments are repeated many times. Sometimes experiments are successful and sometimes they come to nothing, and laboratory notebooks are filled up and put aside.

Scientific articles mostly report successes, like the biographies of successful people. The unsuccessful results compared to the findings shared in articles are like the hidden part of an iceberg. This information often remains in the minds of scientists as to what works and what does not. It cannot be transferred from one research group to another.

The Dark Reactions Project, which was on the cover of the May 2016 issue of the journal Nature, provided a glimpse of the data that remained in the dark and did not enter the articles. The founders of the project, Haverford College researchers, aimed to accelerate the synthesis of new inorganic–organic hybrid crystals by evaluating the data of experiments with poor or no results.

They used artificial learning algorithms, which are often used in the solution of such complex problems.

The rules for organizing and evaluating data in traditional software are coded in detail. The software is deterministic and the purpose of software development is automation. If the data change over time, the programmer updates these rules to keep the program alive. Software based on artificial learning algorithms examines the data and finds the rules between inputs and outputs.

Pedro Domingos, a researcher at the University of Washington, likens artificial learning algorithms to seeds, data to fertilizer, and programs to plants. The task of the programmer is just like that of a gardener to select algorithms suitable for the purpose and develop the program by applying it to the data sets. As the amount of data encountered by the software increases and diversifies, its predictive power also increases. Just as a chemist working in a laboratory for many years gains experience, the more information about the experiment, the higher the success rate of the software.

In the Dark Reactions project, software has been developed to learn which chemical reactions give crystals in which cases and in which cases they do not. Approximately 4000 successful and unsuccessful reactions were used for this. The rate of estimating whether the developed software will form crystals is quite high: the model correctly predicted the result of the reactions 79% of the time when the chemicals and reaction conditions used in the synthesized crystals were given as input. The researchers also tried the model on vanadium selenite crystals, which had not been previously synthesized. These crystals are compounds formed by vanadium, selenium, and oxygen atoms with small organic molecules, such as amines. In the testing of 500 crystals, the predictive power of a chemist with 10 years of experience in crystal synthesis was 78%, while the artificial learning models were 89% successful. This success shows the role that artificial learning techniques can play in finding new compounds and materials.

Artificial learning techniques provide important advantages especially for scientists dealing with complex data, but they also have disadvantages. The most important of these is that the software does not explicitly reveal the relationships between variables and targeted features and so it is difficult to understand what the machine has learned in a sense. In this case, although the software has a high predictive power, it does not help scientists develop different hypotheses. The Haverford researchers used a decision tree as a solution to this. The decision tree developed is a model of artificial learning that people can understand. With questions such as whether there is oxygen in the crystal in question and whether the acidity level is less than 3 or larger, experiment results can be estimated and different hypotheses can be developed by going along different paths on the decision tree.

The Dark Reactions project is a new source of hope for experiments that were produced in crystal synthesis studies but remained in the dark. If you have failed reactions and want to contribute to the project, you can register at https://darkreactions.haverford.edu/ and add your reactions to the database. Thus, you will shed light on studies that remain in the dark.

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Bilim ve Teknik (Science and Technology magazine), February 2017

Şule Atahan Evrenk

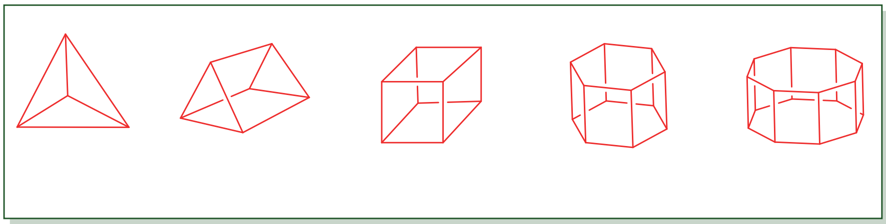
TODAY'S PROBLEM AND YESTERDAY'S ANSWER

Problem 8.

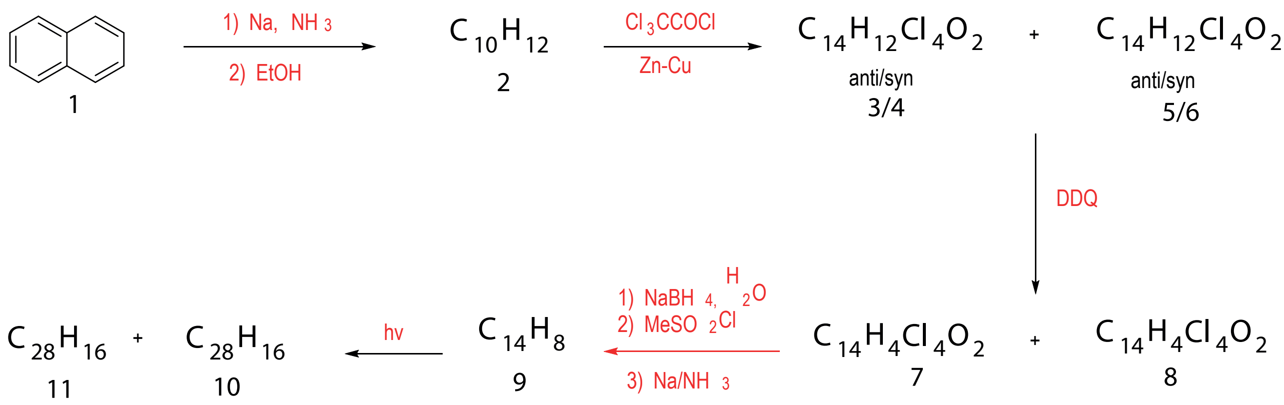
A dream of a Chemistry Olympiad student

The synthesis of lattice-shaped molecules such as **A-E** with uniform geometry has attracted the attention of researchers working in organic chemistry for many years.

Arif Daştan

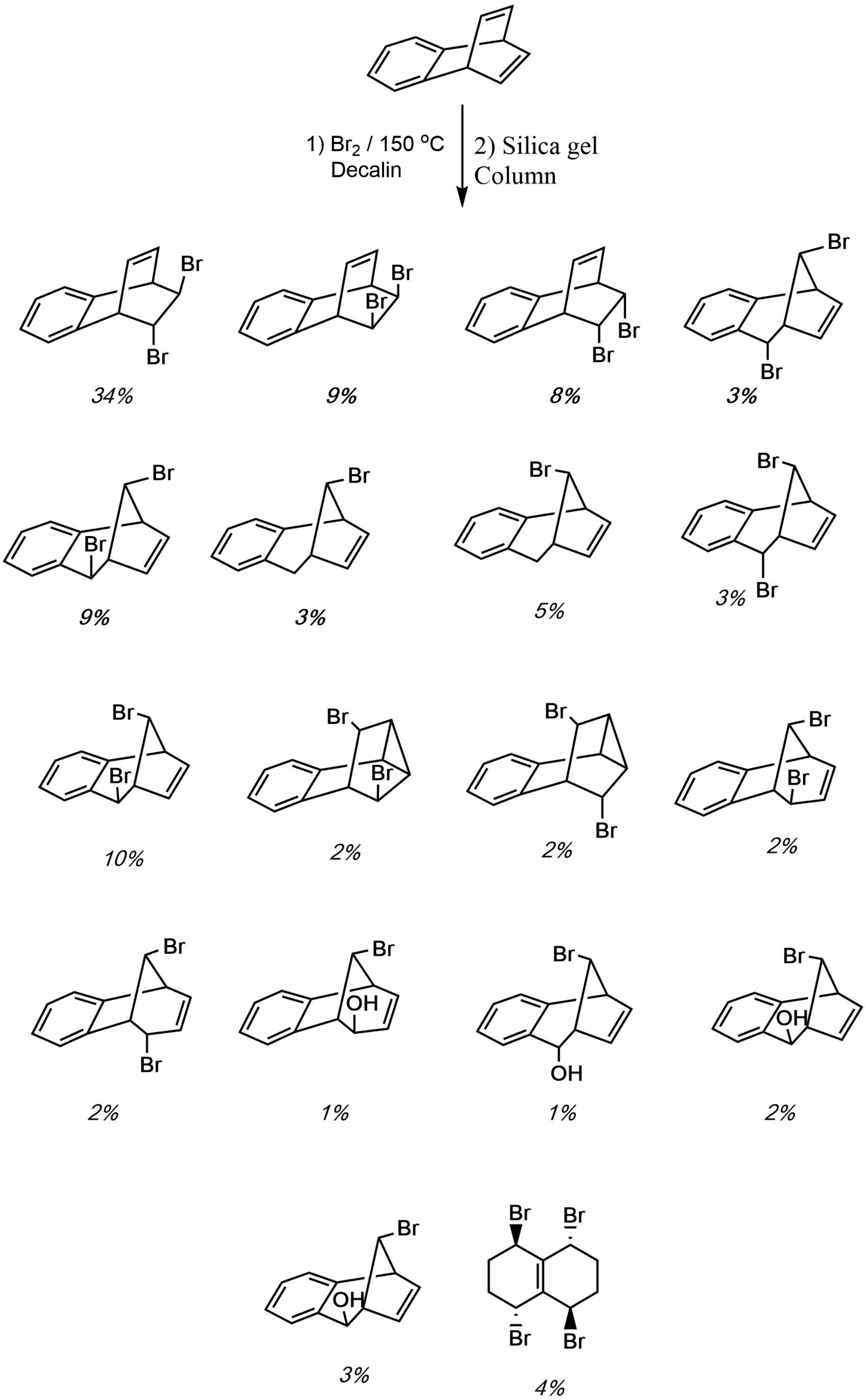


A Chemistry Olympiad student, İbiş, dreams of the synthesis of such a molecule in a lattice structure. For this purpose, İbiş is designing the following synthesis plan. He selects naphthalene (**1**) as its starting molecule. He plans the synthesis of **2** hydrocarbons of formula $C_{10}H_{12}$ by treating naphthalene (**1**) with sodium metal at low temperature (-78 °C) in liquid ammonia and then adding ethyl alcohol to the reaction medium. İbiş predicts that four isomers will be formed in structures **3-6** with the formula $C_{14}H_{12}Cl_4O_2$ by reacting the hydrocarbon **2** with Zn-Cu and trichloroacetyl chloride reagents. The reaction of the isomer mixture (**3-6**) with DDQ is intended to form two isomers (**7/8**) with the formula $C_{14}H_4Cl_4O_2$. The reaction of these two isomers (**7** and **8**), $NaBH_4/H_2O$, methanesulfonyl chloride, and sodium metal in liquid ammonia is expected to result in the formation of a molecule **9** with the formula $C_{14}H_8$. From the photochemical reaction of hydrocarbon **9**, İbiş's dream is to form hydrocarbon number **10** in the lattice structure, as well as isomeric hydrocarbon **11** with anti-configuration.



Find the structures of molecule **10** in the dream of the Chemistry Olympiad student İbiş and the isomer **11** that would be formed from this reaction plan.

Solution Problem 7.



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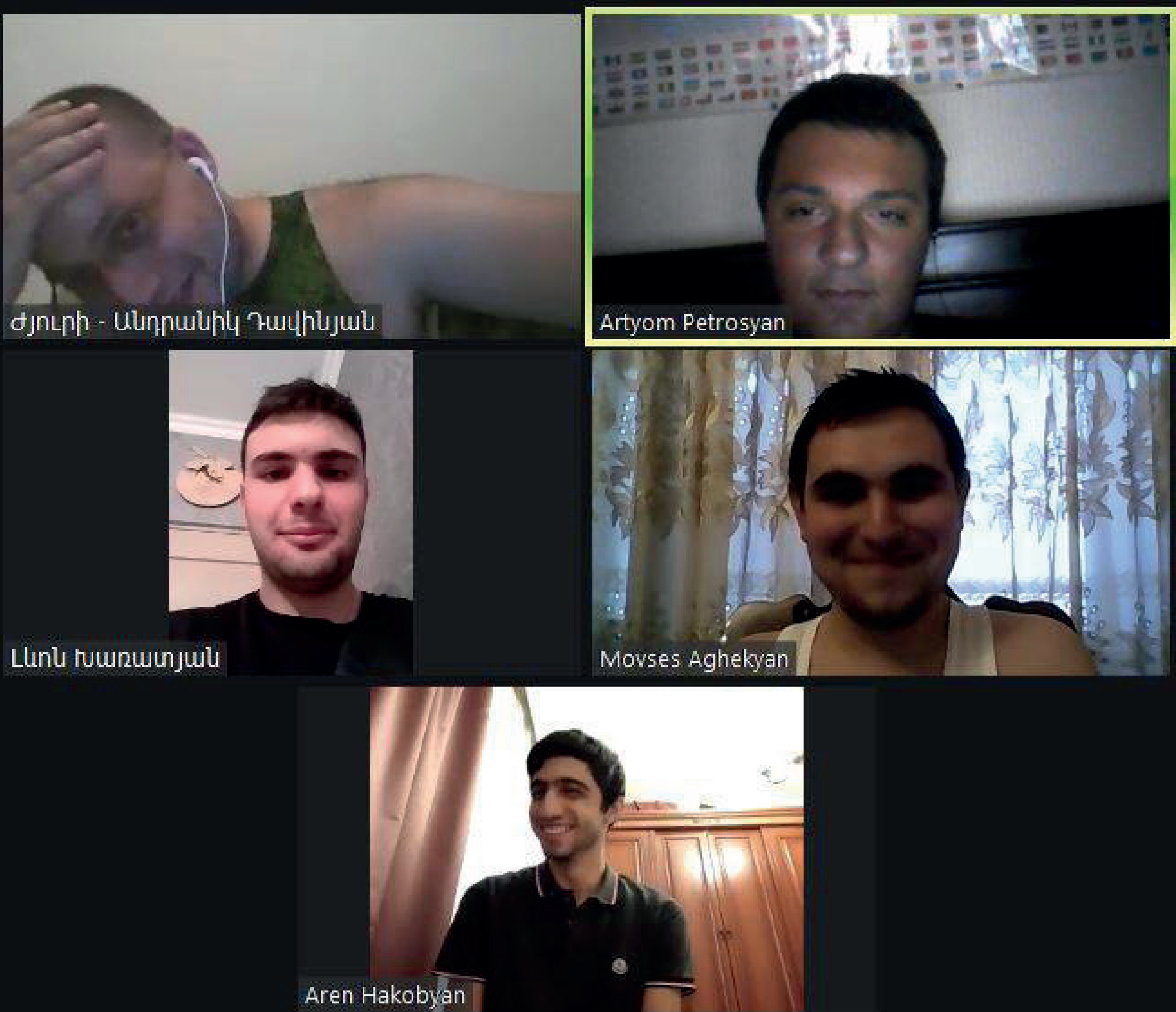
NEWS FROM NATIONAL TEAMS OF COUNTRIES

ARMENIA

We are just discussing preparatory problems.



CHINESE TAIPEI

Room F322 is the room for the Chinese Taipei team.

NETHERLANDS

Picture of the theoretical exam of the Dutch team.

PAKISTAN

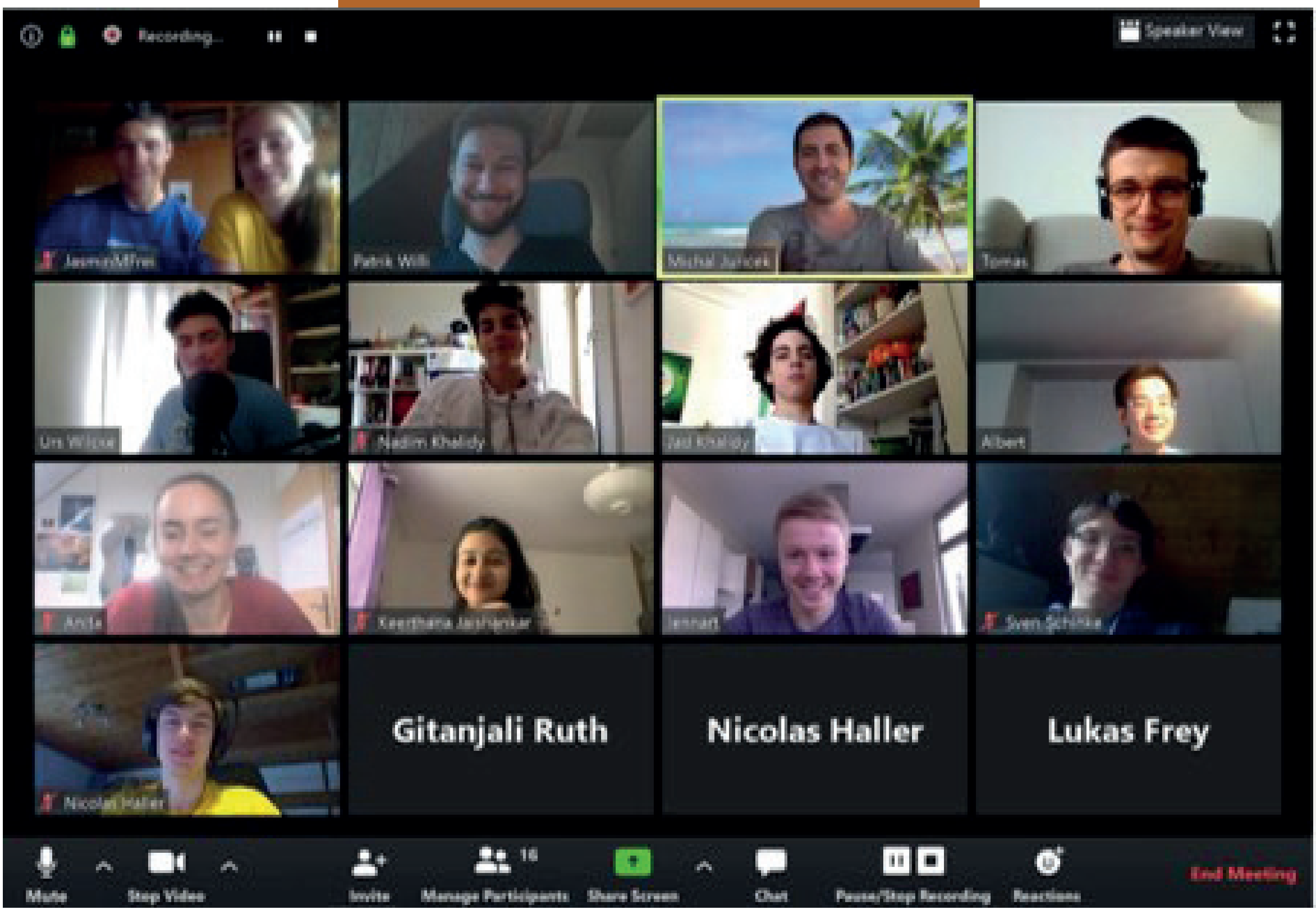
Group Photo with 50 top student out of 5000 thousand.

SINGAPORE

The only possible mode for training the team - Zoom!

SWITZERLAND

Swiss preparatory weekend at the end of March hosted by the University of Zurich.



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