

Achievements of History

Pioneer works to make products enhance quality of life.

MED-SCI >> SPECIAL ISSUE >>

Alinamin[®] and Dr. Motonori Fujiwara



The Takeda-Kyoto University partnership that created the best-selling vitamin supplement.



Prof. Emetitus Motonori Fujiwara of Kyoto University and the lineup of Alinamin[®]

SIXTY-FOUR YEARS before Takeda Pharmaceutical Co. Ltd. and the Center for iPS Cell Research and Application (CiRA) of Kyoto University started their extensive, 10-year joint program, collaboration between a Kyoto University School of Medicine scientist and Takeda researchers culminated in a nationally recognized vitamin supplement product: Alinamin[®]. This drug contains a vitamin B₁ derivative, fursultiamine, as its major active ingredient. The Alinamin[®] line-up includes over-the-counter tablets and nutritional drinks that have been best-sellers over a long period, as well as injectable solutions for use in clinical settings.

Humans rely on carbohydrates, lipids, and proteins as energy sources. Water-soluble vitamin B₁ is indispensable for metabolizing carbohydrates but absorbed in small amounts by the small intestine. Takeda Pharmaceutical marketed fursultiamine, a lipophilic vitamin B₁ derivative, which is more readily absorbed in large amounts in the small intestine and has a longer half-life than its active counterpart vitamin B₁. Fursultiamine is the main active component of Alinamin[®].

Since its market launch in 1954, Alinamin[®] has been one of Japan's best-selling commercial brands. Kyoto University researcher Dr. Motonori Fujiwara (1915-1994), then an assistant professor of medicine, played a critical role in the birth of this product. Dr. Fujiwara, born in Nagasaki, Japan, studied medicine at the Kyoto Imperial University College of Medicine and

served the Imperial Japanese Navy as a medical officer during World War II. Shortly after the end of the war, he started his research career in public health at the Kyoto



Medicine Building at the time

Imperial University College of Medicine. Throughout his life, he made important contributions to the development of public health and nutritional science in Japan. He had more than 220 books and journal articles published and theses and dissertations supervised, and was one of the frontrunners in vitaminology. His studies on vitamin B₁ (thiamine) were instrumental towards eradicating beriberi in the post-World War II period in Japan.

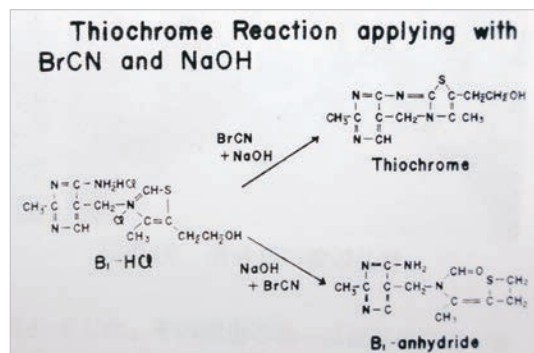
How did Dr. Fujiwara become involved in the development of Alinamin®? After serving in the military, Dr. Fujiwara was assigned a teaching post at Kyoto Imperial University in June 1945. During the wartime and post-war periods, overcoming beriberi caused by nutritional deficit was on the national agenda. The Vitamin B Research Committee was established as a government initiative, with Dr. Fujiwara a founding research member. His assignment was to determine the recommended minimum daily intake of vitamin B₁, later determined to be in the range of 0.2-0.3mg per 1000kcal. In the course of his research, Dr. Fujiwara developed a new vitamin B₁ quantification method.¹⁾

While preparing the final report of his results, he discovered by chance another important chemical reaction for vitamin B₁. One day, Dr. Fujiwara experimented with a variety of reagents available in his laboratory and left the test tubes by the window. Exposed to sun's UV rays, one of the tubes glowed in

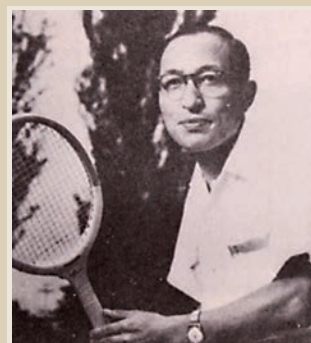


the waning late-afternoon daylight and caught his eyes. Dr. Fujiwara found that vitamin B₁ was converted to fluorescent thiochrome when mixed with BrCN under alkaline conditions (NaOH). This characteristic thiochrome (B₁-BrCN-NaOH) reaction proved to be very useful for vitamin B₁ quantification. Then, together with new laboratory members such as Dr. Hiroshi Watanabe (later appointed as professor at Mie University) and Dr. Kiyoo Matsui (later promoted to the Director General of Hyogo Prefectural Institute of Environmental Science), Dr. Fujiwara embarked on a project to identify vitamin B₁-decomposing substances present in bracken fern using this thiochrome reaction. Work by American scientist P. H. Weswid had previously shown that bracken fern contained substances capable of breaking down vitamin B₁, although their identities were totally unknown. Using the B₁-BrCN-NaOH reaction, Dr. Fujiwara and his colleagues discovered the heat-sensitive vitamin B₁-decomposing enzyme aneurinase (thiaminase) in bracken fern that was already known to be present in fish and shellfish. They also discovered the presence of heat-resistant vitamin B₁-degrading factors. Moreover, they found that substances that convert vitamin B₁ into compounds unresponsive to the thiochrome reaction are present in plant parts such as sweet potato vine, burdock root, butterbur stalk, and garlic bulbs, as well as materials of animal origin including saliva and bile juice.

Reflecting on this series of new findings, Dr. Fujiwara had a hunch that *garlic bulbs* must have



Motonori Fujiwara (1915-1994) was a medical researcher who pioneered vitamin research in post-war Japan. After graduating from Kyoto Imperial University College of Medicine in 1940, he obtained his medical license the same year. In 1945, he was appointed as a research assistant at Kyoto Imperial University College of Medicine. He was promoted to professor in 1959. He received an honorarium for developing Alinamin® from Takeda Pharmaceutical, and used the award to establish the Fujiwara Memorial Foundation in 1960. He received the Japan Academy Award in 1959. He was a renowned amateur tennis player and served as the student chair of Shiran-kai Tennis Club during its inception period. This was an on-campus organization for undergraduate and graduate medical students.





Dr. Fujiwara (second left) and Research Members

additional features of biological importance worthy of investigation. The reactive potential of garlic bulb was so powerful that only 0.1g were sufficient to convert 1 mg of vitamin B₁ (the recommended daily dose) into a derivative unresponsive to the thiochrome reaction. Based on this finding, he reasoned that if this reaction involved vitamin B₁ decomposition, as was the case with aneurinase, people eating garlic bulbs regularly should suffer vitamin B₁ deficiency, but this idea contradicted the time-tested reputation for garlic as a performance enhancer. His reasoning proved correct. *In vitro* and *in vivo* studies showed that although the addition of garlic extract to vitamin B₁ solution rendered it unresponsive to the thiochrome reaction, the mixture recovered powerful thiamine activity when administered to animals or mixed with reducing agents such as cysteine. Dr. Fujiwara termed the garlic-processed vitamin B₁ derivative unresponsive to the thiochrome reaction as “garlic B₁.” He found the same phenomena in long onion and other Allium species.

Thinking that he had completed the main part of the vitamin B₁ research project, Dr. Fujiwara proposed the laboratory members to sample the garlic B₁ juice to commemorate their progress. His idea was to measure the urinary levels of the unresponsive vitamin B₁ derivative in human volunteers orally given the vitamin B₁ solution treated with Allium plant extracts.

Whole laboratory filled with pungent smell of onion and scallion!

After the start of the joint vitamin B₁ project, piles of onion, scallion, and other pungent plants were brought into the Matsubara Group's laboratory rooms, releasing a powerful odor. The smell was a marker of newly started activities and added to the lively atmosphere of the laboratory. Of course, the people at the Department of Public Health, Kyoto University, were also not exempt from the battle against that unusual smell!

Each member took and swallowed the bitter-tasting vitamin B₁ cocktail of their preference, containing garlic, chive, or scallion, thinking that this “toasting” ceremony would mark the end of the project. To their amazement, however, the results completely betrayed their expectations. “We were so astonished,” the self-appointed “toastmaster” later described.

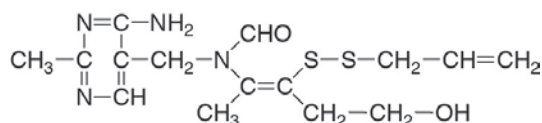
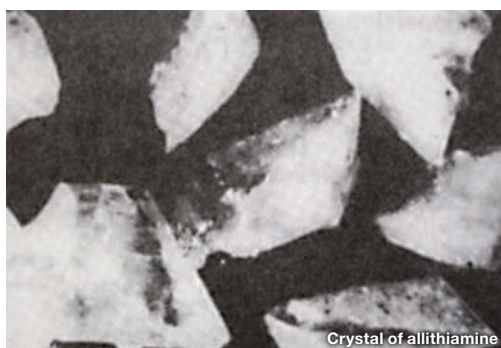
“I went to the fluorescence apparatus to measure the emission intensity. I tested again, same results. We were so astonished. The results showed that the levels of vitamin B₁ excreted into urine via unresponsive vitamin B₁ (= garlic B₁) were 10 times higher than typical plasma vitamin B₁ levels. I once encountered a similar case with S-B₁, an artificial vitamin B₁ analog synthesized by Dr. Taizo Matsukawa, former Director of Research Department, Takeda Pharmaceutical. S-B₁ was an exogenous product that had no thiamine activity. Animal studies have demonstrated that garlic B₁ is reduced to biologically active vitamin B₁ in vivo. The logical conclusion drawn from our unexpected results was that garlic B₁ was absorbed from the intestine highly efficiently.”²⁾

Dr. Fujiwara continues:

“On 15 September 1951, I went up to Tokyo to attend the Vitamin B Research Committee held at Japan Women's University for presenting our interesting results. It was a rainy day from early morning. In the Toden streetcar I took, I ran into Dr. Matsukawa from Takeda Pharmaceutical and started to share that day's presentation with him. This inspired him to make a formal offer for a joint research some time later.”³⁾

Coffee gets rid of garlic breath

The Japanese market release of 5mg Alinamin® Sugar Coated Tablets in 1954 met with great success. However, the garlic-like smell, attributable to the main active ingredient prosultiamine, was a big problem for both consumers and production line workers. Takeda Pharmaceutical started research to create less smelly compounds with similar efficacy. In an office conversation with his co-workers one day, one researcher questioned why the garlic breath from eating a steak disappears after drinking a cup of coffee. This question provided an important clue, and the non-smelling vitamin B₁ derivative, fursultiamine, was developed by analyzing coffee's flavor components.



allithiamine

Takeda Pharmaceutical had been producing bulk vitamin B₁ products by extraction since 1936 and by chemical synthesis since 1938. As explained above, Dr. Matsukawa at Takeda Pharmaceutical had discovered a new synthetic scheme for vitamin B₁ in 1949. He was one of Japan's top-ranking vitamin B₁ researchers, which Dr. Fujiwara acknowledged. Dr. Matsukawa's expertise in vitamin B₁ chemistry and the most advanced resources of his laboratory made him the best research partner for Dr. Fujiwara with medical and clinical perspectives. At the same time, Dr. Matsukawa had a great interest in garlic B₁'s potential as a new drug.

The first goal of the joint project was to isolate garlic B₁ in a crystal form. Initially, Dr. Matsukawa estimated that it would take one year before garlic B₁ could be crystallized. However, with the help from Dr. Jutaro Okada, assistant professor at Kyoto University Faculty of Pharmaceutical Sciences, Dr. Fujiwara was successful in two months (30 December 1951). Two weeks after the crystal was obtained, Shojiro Mangi at Takeda determined its chemical structure. These results were presented by the joint team at the meeting of the Vitamin Society held on 8 March 1952, where the new compound was called "allithiamine." The prefix "alli-" before thiamine (vitamin B₁) was derived from



2-(2-methyl-4-amino-5-pyrimidylethyl)-
formamido-5-hydroxy- Δ^2 -pentenyl-(3)-
allyl disulfide

"Allium" species to which garlic and many other plants with similar activities belong. After the discovery of allithiamine, a variety of derivatives were chemically synthesized at Takeda, including prosultiamine. Meanwhile, the Allithiamine Subcommittee was formulated within the Vitamin B Research Committee.⁴⁾

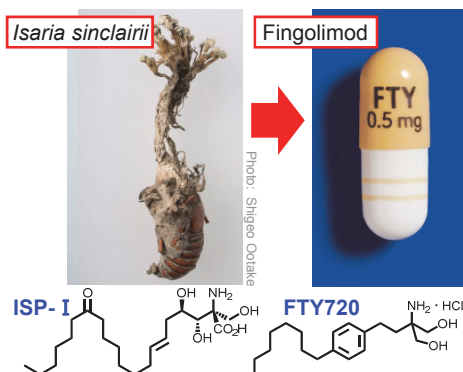
This subcommittee investigated the following aspects of allithiamine over the next two years: physical chemical properties, quantification method, animal toxicities and mechanism of action in humans, tissue distribution, pharmacokinetics, and clinical application. Taking note of the research results of the Allithiamine Subcommittee, Takeda Pharmaceutical launched 5 mg Alinamin® Sugar Coated Tablets in March 1954, which contained prosultiamine as the major active ingredient. Because prosultiamine had an unappealing garlic-like odor, fursultiamine was created to minimize the smell. In order to increase chemical stability, fursultiamine hydrochloride was subsequently developed, which is the main active component of Alinamin® F. Initially, Alinamin® was used in clinical settings for the treatment of beriberi and malnutrition or for vitamin B₁ supplementation. Over the years, it has attained the status of a best-selling non-prescription medication, owing to the post-war economic and industrial boom in Japan, commercial advertisements on television and other media, increased awareness of health and well-being among the general population, and discovery of new pharmacologic actions for fursultiamine. For over half a century, Alinamin® has served as a springboard for Takeda Pharmaceutical.

Acknowledgments The author thanks Prof. Shu Narumiya, Kyoto University Graduate School of Medicine, for his comments on the manuscript. The author also thanks Takeda Pharmaceutical Co., Ltd. for the presentation of valuable materials. Almost all of the figure and picture are from *Vitamin* (Japan), **73**(3), 177-197 (1999). The author express deep gratitude to the Vitamin Society of Japan and Public Utility Foundation for the Vitamin & Biofactor Society.

1) Dr. Fujiwara's new approach stirred up controversy from scientists who supported the Fujita method, considered the "golden standard" for quantitative vitamin B1 determination at that time. The debate ended in his favor. 2) Source: Dr. Motonori Fujiwara *Recollections from the discovery of allithiamine to the establishment of Fujiwara Memorial Foundation*. 1981. 3) Source: Motonori Fujiwara, 1981. 4) The members are Takashi Inoue and Masaya Araki of Kyoto Prefectural University of Medicine, Shinji Ito of Hokkaido University, Yoshito Sakurai and Norio Shimazono of the University of Tokyo, Toichiro Sawada of Kyushu University, Tomihide Shimizu and Eiji Hamamoto of Okayama University, Isamu Tachi and Motonori Fujiwara of Kyoto University, Ichiro Nakagawa of The Institute of Public Health, Harutada Niinomiya and Yoshito Nishizawa of Osaka University, Taizo Matsumoto of Takeda Pharmaceutical Company Limited.

Blockbuster Drug to Treat Multiple Sclerosis

FTY720, the world's first drug for multiple sclerosis developed at Kyoto University.



The invention of a new drug can sometimes save millions of lives, and research for the development of blockbuster drugs for diseases that have no effective treatment can bring hope to people suffering from various illness around the world. Dr. Tetsuro Fujita, professor emeritus of Kyoto University, played a key role in the development of Fingolimod Hydrochloride (Product Name: IMUSERA®, GILENIA®), the world's first medicine for multiple sclerosis, which has been long an intractable disease.

Dr. Fujita had been engaged in a long period of research on bioactive substances in plants when he was offered a professorship in the department of medicinal plant chemistry in Kyoto University's Faculty of Pharmaceutical Sciences. Upon taking up his new post, however, he decided to shift his focus to a research area directly related to medicine. This was around the time that organ transplant treatments were beginning to garner attention as a new medical technology, and Dr. Fujita embarked on research to explore substances that are able to suppress immune response. He focused on vegetative wasp, which is a parasitic fungus found on



moth larvae. Vegetative wasp is named *Dōng chōng xià cǎo* (冬虫夏草) in Chinese, which means “winter-worm, summer-grass,” because its shape resembles a worm in winter and a grass in summer. The fungus has long been valued as herbal remedy in traditional Chinese medicine and it is used as an ingredient in traditional medicinal dishes.

Dr. Fujita suspected that the vegetative wasp might contain an immune-suppressive compound-suspicions that were validated when he succeeded in extracting active substances with strong immune-suppressive qualities from *Isaria sinclairii*, a kind of vegetative wasp. He formed a collaborative research team in cooperation with Taito Co., Ltd. (now Mitsui Sugar Co., Ltd.), a company with advanced culturing techniques, and Yoshitomi Pharmaceutical Industries, Ltd. (the present Mitsubishi Tanabe Pharma), a company skilled in pharmacological evaluation and drug discovery. The three-way research collaboration resulted in the discovered of FTY720, which was derived from a natural immunosuppressive product (ISP-I) through chemical modification utilizing synthetic organic chemistry techniques. FTY720 was named after the initials of Fujita, Taito, and Yoshitomi, and was later renamed Fingolimod. After international clinical trials, Fingolimod was approved in the US in 2010 and in Japan in 2011 as the world's first drug for multiple sclerosis. Multiple sclerosis is a disease affecting the central nervous system and causing different nerve



Main Building of CiRA

The Center for iPS Cell Research and Application building is located in the southwest area of Yoshida Campus, near the famous Kamo River, which flows north to south through Kyoto City. The third, fourth, and fifth floors of the building are laboratory spaces for research experiments, each with a large open laboratory at their center. The second floor and first basement contain facilities for animal experiments and cell culture manufacture, which are collectively called the Facility for iPS Cell Therapy (FiT). The ceiling and floor of the open laboratories are a distinctive

blue color, providing a bright spacious atmosphere in keeping with CiRA's aim of creating a bright future. On the left, we see the new “Preemptive Medicine and Lifestyle Disease Research Center” under construction, funded by Himedic Inc, planned to be one of the largest facilities of its kind in the country.

Painter: **Kiyoko Yamaguchi, PhD** Alumnae of Kyoto University kiyoko-yamaguchi.com/



abnormalities. There was previously no effective treatment for the disease, so the discovery of Fingolimod was tremendous news for long-suffering patients. The drug has now become highly successful around the world.

The discovery of ISP-I, from which Fingolimod was derived, came about through a combination of serendipity and Dr. Fujita's foresight and rigorous research abilities. Dr. Fujita and his colleagues' passion to develop a new drug to help patients resulted in the development of Fingolimod (FTY720), which has greatly alleviated the suffering of many. Dr. Fujita's magnetic personality and ability to inspire others brought the collaborative research team together. Although he is now over eighty-five years old, Dr. Fujita is still active, and occasionally delivers lectures about the development of Fingolimod.

I took over the department of Medicinal Plant Chemistry Course (currently, the department of

Synthetic Medical Chemistry) as the third successor of Prof. Fujita. My specialty is synthetic organic chemistry, and my research includes studies of the chemical synthesis of bioactive natural products from plants or microorganisms, the molecular design of more useful compounds, and development of new reactions giving biological active compounds synthesis for high value-added. Following the spirit of Prof. Fujita, I hope that my research in Kyoto University's Graduate School of Pharmaceutical Sciences will help as many people as possible by leading to the production of innovative new drugs for the treatment of diseases.

Author : **Kiyosei Takasu, PhD**

Professor, Graduate School of
Pharmaceutical Sciences

WEB www.pharm.kyoto-u.ac.jp/gousei/



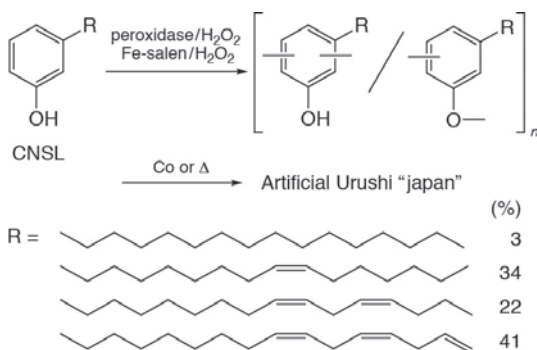
POL-CHEM

Japanese Lacquer Made of Cashew Nutshell Liquid

Green polymer chemistry produces artificial urushi lacquer.

Cashew nuts are a popular snack and food ingredient, especially in Indian cuisine. The oil extracted from cashew nut shells is a byproduct, meaning that cashew nutshell liquid (CNSL) is a cheap renewable raw material. Using CNSL, Prof. Emeritus Shiro Kobayashi developed a method to prepare artificial *urushi* lacquer through enzymatic polymerization. The physical properties of the artificial *urushi* lacquer, including its elasticity are good as genuine Japanese lacquer, and it can therefore be widely utilized for beautiful and robust coating materials. The advantages of the artificial *urushi* lacquer are as follows: i) instead of natural urushiol which has become hard to obtain in recent years, cheap renewable CNSL can be used, ii) the enzymes as well as the starting materials used in the preparation method are environmentally benign, and iii) urushiol causes an allergic skin irritation but CNSL causes little allergic reaction. In cooperation with Toyo Ink Co., Ltd., the technology patents were registered in Japan, the US, and Europe. At the moment, commercial products using the artificial *urushi* lacquer are not so common, but it has great advantages as a renewable material for sustainable societies.

Since retiring from Kyoto University, Prof.



Emeritus Kobayashi continues to undertake research and provide research guidance to students as a distinguished professor of the Kyoto Institute of Technology. He is currently involved in research on artificial *urushi* lacquer.

From the Editor Prof. Emeritus Shiro Kobayashi received the Japanese government's Medal with Purple Ribbon in 2007 and the Order of the Sacred Treasure, Gold Rays with Neck Ribbon in 2015.

Author : **Shunsaku Kimura, PhD**

Professor, Graduate School of Engineering

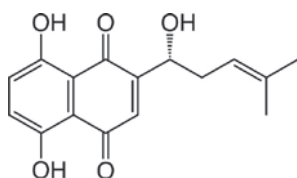
WEB pixy.polym.kyoto-u.ac.jp/english.html

Shikonin and Dr. Mamoru Tabata

Shikonin, a revolutionary plant metabolite developed in the 1980s.



Dr. Mamoru Tabata



Plants produce a large variety of specialized metabolites that have been used as medicines, fragrances, and pigments. The supply of such natural compounds can be limited when they are derived from endangered species. Shikonin is a red naphthoquinone pigment that can only be produced from a few boraginaceous plants, one of which is *Lithospermum erythrorhizon*. The late Prof. Mamoru Tabata established a shikonin-producing cell culture from this plant and applied it to the industrial production of this lipophilic pigment in collaboration with Mitsui Petrochemical Industries, Ltd. (now Mitsui Chemicals Inc.) in the early 1980s. The shikonin produced was used for the popular “BIO” brand of lipstick, manufactured by Kanebo Co. Ltd. In the 1990s, this achievement triggered a plant biotechnology research boom around the world.



Lithospermum erythrorhizon

PHOTO: Research Institute of Medicinal Plant Resources, Shinnihonseiyaku Co., Ltd.

Author : **Kazufumi Yazaki, PhD** Professor, Research Institute for Sustainable Humanosphere

WEB www.rish.kyoto-u.ac.jp/lpge/



FOOD-SCI

Distinctive Beers Bring the Taste of Ancient Egypt to Japan

A fusion of plant genetics research, Egyptian archeology, and Kyoto brewing technology.

White Nile, an original craft beer jointly developed by Kyoto University, Waseda University, and the long-established Kyoto brewing company Kizakura Co. Ltd., was launched in 2006 and has subsequently expanded into a range of beers that has proven popular, and achieved cumulative sales of 500,000 units and a total sales value of 200 million yen (as of May 2015). This is an unprecedented achievement for a university-developed beverage product.

In 2002, Egyptian archeologist Dr. Sakuji

Yoshimura, then a professor at Waseda University (currently professor emeritus of Waseda University and President of Higashi Nippon International University) elucidated the production process of ancient Egyptian beers in a collaborative research project with a beer company. He discovered that emmer wheat¹⁾ had been used to make beers in ancient Egypt. Although, today, emmer wheat is rarely grown anywhere in the world, and is therefore difficult to obtain, rare seed samples were being held by the Laboratory of Crop Evolution of



POINTS OF INTEREST

Research Promotion Institution for COI Site

The Research Promotion Institution for COI Site is a new hub for industry-academia cooperative research on Kyoto University's Yoshida Campus. The five-story building has one basement level, and a total floor area of 11,000 square meters. Its total construction cost was approx.

4 billion yen¹⁾. The facility contains the offices and laboratories of IT companies and manufacturers, including pharmaceutical companies, as well as Kyoto Prefecture and Kyoto City offices, an exhibition space and lounge. Visitors are welcome.



The opening ceremony was held on 25 May 2015.

1) The establishment of the facility was financially supported by the Ministry of Education, Culture, Sports, Science, and Technology of Japan (MEXT)

WEB www.coi.kyoto-u.ac.jp/en/access

Kyoto University's Graduate School of Agriculture.

The Laboratory of Crop Evolution was founded as a private laboratory²⁾ in 1942 by the late Prof. Hitoshi Kihara, an internationally recognized wheat expert and professor in Kyoto University's Faculty of Agriculture. The laboratory holds and maintains approximately 10,000 different wheat strains collected from Japan and abroad. The emmer wheat seeds were collected in Ethiopia by the Kyoto University Scientific Expedition to the Sahara and its Surrounding Area (KUSES) in 1967-1968. Thanks to the emmer wheat seeds, provided by Associate Prof. Taihachi Kawahara³⁾, The beer company's project succeeded in reproducing ancient Egyptian beer using the same raw materials and production process of that time.

Inspired by their success, Dr. Kazuo Oike, Kyoto University's president at the time, had the idea to put the research achievements to practical use. However, the authentically reproduced ancient Egyptian beer did not suit modern people's tastes, and so Kyoto and Waseda Universities jointly developed original craft beers in collaboration with the Kizakura brewing company. The concept behind the "Nile" series of beers is "good-tasting modern beer made of ancient wheat and utilizing advanced brewing technologies," which was suggested by Dr. Toru Fushiki, a professor in Kyoto University's Graduate School of Agriculture at the time (currently professor emeritus of Kyoto University and professor of Ryukoku University.)

In 2005, they succeeded in developing the first original beer made of durum wheat, which is a commercially available species related to emmer wheat. The beer was named "White Nile" after the primary tributary of the river Nile, and for the beer's characteristic white turbidity. Kyoto University's



Experimental Farm later established a method of cultivating emmer wheat, leading to the establishment of a mass production system by Tanaka Farm, a limited company in Tottori Prefecture. This facilitated the production of a new form of White Nile, made of emmer wheat, which was launched in 2007.

Currently, the product line comprises *Blue Nile*, a fresh-scented low-malt beer flavored with *yuzu* (a citrus fruit popular in Japan) and coriander, *Ruby Nile*, a high-alcohol beer with a mild but rich flavor, and *Cipher Nile*, a non-alcoholic beer with a fresh and rich taste. We urge you to enjoy the gift of Hathor, the ancient Egyptian goddess of beer, now being reborn as modern beer thanks to the collaboration between Kyoto University, Waseda University, and the Kizakura brewing company.

WEB www.kyoto-u.ac.jp/static/ja/news_data/h/h1/news7/2009/090420_1.htm

1) In his research, Assoc. Prof. Kawahara found that emmer wheat was established in south-eastern Turkey in approximately 8000 B.C.

2) Koichiro Tsunewaki, *Res. Act.* 4, No.3, 6-9 (2014)

3) Kawahara's research, *Res. Act.* 5, No.1, 23 (2015)

THIS ARTICLE'S
KEY WORDS

Kyoto University Scientific Expedition to Sahara and its Surroundings (KUSES)

The Kyoto University Scientific Expedition to the Sahara and its Surroundings (KUSES) was an expedition formed to collect extensive information about the northern Africa. The expedition spanned thirteen countries, covering the Sahara Desert, Lybian Desert, West Africa, and the Abyssinian Highlands, and lasted for half a year from November 1967 to April 1968. Led by Kosuke Yamashita, the expedition comprised seven groups dedicated to different areas of study: plants, agricultural culture, art and archeology, language, humanity, and medicine. The plant study group chose the Abyssinian Highlands as the main location for their studies. The area is an important location with regards to the origin and differentiation of cultivated plants, and the team collected approximately 3,800 specimens there. They also collected wild plants, and conducted investigations into agriculture, landholding systems, and ethnobotanical studies.

