From Kyushu University to the world.
Introducing research activities that will bring us to the realization of a carbon-neutral society.

Hello! I²CNER vol.8

International Institute for Carbon-Neutral Energy Research

Energy

Solution

Engineering

Impacting Society By solving Problems

Earth

Science

Experimentation

wpi World Premier International Research Center Initiative

I²CNER

KYUSHU UNIVERSITY

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Megan Emigh

My research focuses on the effects of hydrogen on the microstructure of metals subject to high strains, as well as rolling contact fatigue. When I return to University of Illinois at Urbana-Champaign (UIUC), I will measure the hardness of my samples, use a focused ion beam to create small specimens, and observe the microstructure in a transmission electron microscope.

Taking the First Step

As a Ph.D. Student at the University of Illinois at Urbana-Champaign, Megan has taken the first step in the journey toward becoming a world-renowned researcher. Among other things, her two-month trip to Kyushu University (KU) was an excellent opportunity to experience what it will be like to be a researcher full-time. Below is the schedule of a typical day for Megan during her time at KU.

Schedule

9:00	• Arrive at Ito Campus, Kyushu University • Check emails and research papers
10:00	• Prepare specimens for study
11:00	• Lunch at a school cafeteria "Big Dora"
12:00	<Experiment> • Observe a change in metal microstructure affected by hydrogen ※Realization of the hydrogen energy society requires the elucidation of hydrogen's damaging effect on metals.
13:00	
14:00	
15:00	
16:00	
17:00	
18:00	• Write notes on my day →Travel back home
19:00	• Dinner • Go out with friends to downtown
20:00	
21:00	• Study for qualifying exams, send emails • Learn Japanese

The Japan Experience

My favorite thing to do in Japan is explore and learn about the fascinating culture. It is really hard to pick just one favorite memory: I've gone to a baseball game, learned how to make a tea bowl, went to the mariner's parade, visited a cat café, and browsed through many, many museums. On the weekend I've also been to Kyoto, Yanagawa, and Kumamoto. My favorite memory is of my visit to Karatsu. I saw many places in the town but when I went to the Takatori House, a tour guide offered to show Kelly and me around. We learned many things about Japanese architecture and artwork, including the meanings behind paintings, the design of a garden with borrowed scenery (*shakkei*), and the special properties of Japanese paper. It was an amazing experience. I am going to miss the rich culture, hospitality, and the amazing fresh seafood in Japan. I am incredibly grateful for the experience and I hope I will have the opportunity to come back very soon.

"Fun Facts"

In my spare time, I enjoy playing the piano, singing, and swing dancing.
I hope to complete my Ph.D. at UIUC and then work in academia and travel around the world.

Research Division Introductions

What is a carbon-neutral society?

This is a society where CO_2 emissions generated by energy use are reduced to a minimum, and where a balance is achieved between emissions and the amount absorbed and stored in the nature world.

Energy Analysis

Energy Analysis of the relevance of I²CNER research from Science, Technology, and Time Scale viewpoints.

Hydrogen Production

Researches a hydrogen production method with zero CO_2 emissions that uses solar power.

Hydrogen Materials Compatibility

Investigates the mechanisms by which hydrogen is deleterious to the strength of metals, and conducts research into materials that can handle hydrogen safely.

Hydrogen

Production Storage Distribution Use

Hydrogen Storage Materials

Conducts research on materials that can store hydrogen compactly and safely.

Catalytic Materials Transformations

Studies green chemical reactions that realize materials transformation without producing waste as a by-product.

Fuel Cells

Conducts research on next-generation fuel cells that can efficiently realize direct electricity generation from hydrogen etc., and proposes new concepts to that effect.

Thermal Science and Engineering

Conducts research on the thermophysics of hydrogen and CO_2 in various conditions, including high pressure behavior and heat conductive properties, and studies how heat is transmitted.

Carbon Dioxide

Collection Capture Reduction

CO_2 Capture and Utilization

Studies inexpensive methods of efficiently separating and utilization CO_2.

CO_2 Storage

Studies stable methods of storing (sequestering) separated and concentrated CO_2 deep underground or under the sea.

Introducing the nine research divisions of I²CNER, who are engaged in cutting edge research to create a green and clean carbon-neutral society free of CO_2 emissions.

Science Cafe

HELLO!! I²CNER

“Are fuel cells as great as they sound?”

Major automakers have announced plans to launch fuel cell-powered vehicles in 2015. Japan is also taking a major first step toward a fuel cell-oriented society. Dr. Masamichi Nishihara, who researches materials used in fuel cells, and students at Fukuoka Seiryou High School recently held a discussion asking, “Are fuel cells as great as they sound?”

Discussion

Assistant Professor, Fuel Cells Research Division
International Institute for Carbon-Neutral Energy Research, Kyushu University

Masamichi Nishihara

VS

Fukuoka Seiryou High School
Daichi Uchida, second-year student
Takuya Soukei, first-year student
Mitsuki Makiyama, first-year student
Kazuma Horishita, first-year student
Hitoshi Sugaya, first-year student
Tomohiro Yoshikawa, first-year student

The current state of fuel cell research

Nishihara: We’re here at the International Institute for Carbon-Neutral Energy Research at Kyushu University, or as we call it, “I²CNER”. Do you know what kind of research we carry out here?

Uchida: Based on the name, I guess you’ re involved in research into carbon…

Nishihara: Uchida-san is pretty sharp, as you’ d expect from someone who’ s a member of his school’s Science Club. First, let me explain a little bit about I²CNER. We conduct fundamental research with the goal of reducing CO_2 emissions and building energy systems that rely on non-fossil fuels.

Soukei: Which means that you’ re working to address the problem of global warming.

Nishihara: Exactly. Today, I’d like for us to think about fuel cells, which are a sort of trump card in solving the problem of global warming, from a variety of perspectives. As it happens, this model automobile is powered by a fuel cell.

Makiyama: It’s a lot smaller than I had imagined. When I looked up fuel cells on the Internet, what I found was bigger.

Nishihara: The fuel cells you found were probably designed for use in automobiles. This model of a fuel cell-powered automobile costs about ¥20,000, but do you know how much the small fuel cell it uses costs?

Horishita: About ¥2,000?

Nishihara: ¥20,000. Most of the cost of the model consists of the cost of the fuel cell.

All: That’s expensive!

Nishihara: Indeed. One problem with fuel cells is their high cost.

Uchida: Are there other problems, too?

Nishihara:There are a number of other issues that must be solved in order to popularize fuel cells. I’ ll explain them as we go. Do you know how fuel cells are being used right now?

Sugaya: Fuel cells are used by Ene-Farm cogeneration systems, right?

Yoshikawa: Hold on a second--I thought Ene-Farm was a kind of hot water heater.

Nishihara: Ene-Farm systems capture hydrogen

Masamichi Nishihara

Assistant Professor, Fuel Cells Research Division
International Institute for Carbon-Neutral Energy Research, Kyushu University

from natural gas and use it in a fuel cell to generate electricity. Since that hydrogen capture process generates heat, the system also puts the heat to good use.

Uchida: So basically the system's cooling water is turned into hot water and used in the home.

Nishihara: You've done your homework. Fuel cells are also used to power forklifts that are used in warehouses. Why do you think that might be?

Soukei: Because they're emission-free?

Nishihara: Were exhaust gases to accumulate in the confined space of a warehouse, it would cause working conditions there to deteriorate. In this way, one benefit of fuel cells is that they don't emit CO_2 when generating energy.

Why are fuel cells attracting attention now?

Nishihara: Are you aware that the city of Itoshima in Fukuoka Prefecture has built a Hydrogen Town with 150 households?

Uchida: I think I've heard about this Hydrogen Town before.

Nishihara: Fukuoka Prefecture and several energy companies are working together to verify the energy-saving benefits of using Ene-Farm as they work to create the home of the future, one that is energy self-sufficient. By the time you all are ready to buy houses, environmentally friendly homes like those in Hydrogen Town will probably be an option.

Makiyama: So the fuel cell era is that close at hand. Speaking of which, I read in the newspaper that fuel cell-powered automobiles will be launched in 2015.

Nishihara: To that end, work will begin in earnest next year to build a network of hydrogen filling stations. Why do you think fuel cells are attracting all this attention?

Horishita: Because we're running out of oil?

Uchida: Maybe because we've figured out technologically how to commercialize fuel cells?

Nishihara: You're right on both counts. First, there's no doubt that fuel cell technology has matured. As far as the problem of oil depletion goes, experts believe we have nothing to worry about for the time being. However, because the geopolitical context surrounding oil is unstable, there's a significant likelihood that the price of oil will increase.

Sugaya: And there's the worry that global warming will accelerate if we continue to use oil at the present pace.

Nishihara: If we can use hydrogen instead of oil, that will help solve the problem of global warming. Moreover, hydrogen is a clean energy that we can use in an almost unlimited manner.

The mechanism by which fuel cells work

Nishihara: Do you all understand the mechanism by which fuel cells work?

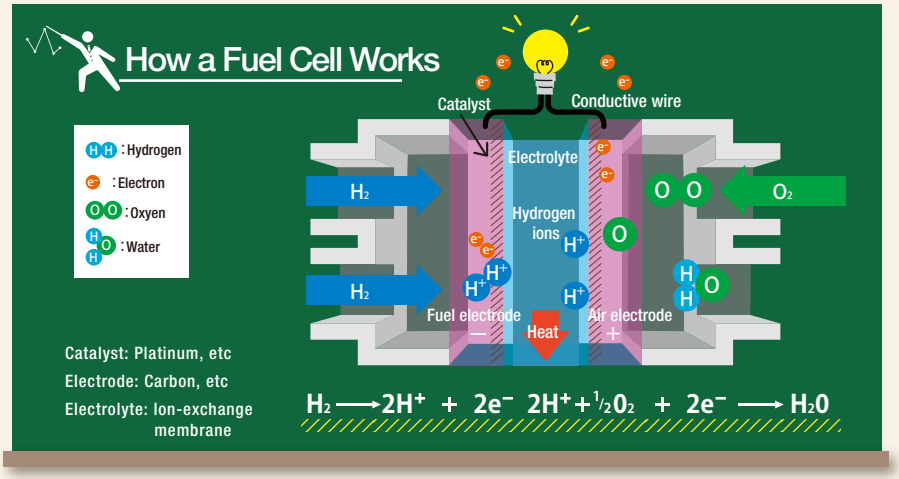
Sugaya: I heard that the reaction is the opposite of what happens when water is electrolyzed…

Yoshikawa: Speaking of electrolysis, isn't that the experiment where you pass a current through water containing an electrolyte and it generates hydrogen and oxygen?

Nishihara: That's right. So when you do the opposite--when you use platinum as a catalyst and cause a reaction between hydrogen and oxygen--you get water and electricity. The mechanism is extremely simple.

Science Cafe

HELLO!I²CNER



Soukei: If the mechanism is that simple, why weren't we able to commercialize it sooner?

Nishihara: That's a very good question. Why do you think that might be? This model fuel cell-powered automobile was running until a little while ago, but now it's stopped.

Makiyama: Is it because the battery's been used up?

Uchida: No, that can't be right. One advantage of fuel cells is that they can be used over and over.

Nishihara: Certainly that's true, but the parts sustain damage over time. The platinum that is used as the catalyst degrades, and the carbon that is used as the electrode peels off.

Horishita: Nobody would buy an actual fuel cell-powered automobile if it were to break in a short period of time. It sounds like developers need to use a lot of platinum and make the carbon more robust.

Nishihara: Those are precisely the problems we face in commercializing fuel cells. Platinum is very expensive--it costs about ¥5,000 per gram (as of August 2013). For example, if we assume that it takes about 100 grams of platinum to manufacture a fuel cell-powered automobile, the platinum alone would cost ¥500,000.

Uchida: That would be an extremely expensive car.

Sugaya: About how much will the fuel cell-powered cars that are supposed to be launched the year after next cost?

Nishihara: Such vehicles would have cost ¥100 million or more about 10 years ago, but observers speculate that they will be made available at a price of ¥5 million or less once companies begin mass-producing them. The key to widespread use of fuel cell-powered automobiles will be how much further those prices can be lowered after their introduction.

Issues with fuel cells

Yoshikawa: By the way, how is the hydrogen that is needed by fuel cells made?

Nishihara:As I touched on briefly when talking about Ene-Farm systems, hydrogen is captured from natural gas and oil right now. However, that process requires electricity. If we rely on thermal power generation for that electricity, ultimately we will not have reduced CO_2 emissions. Can you think of any other good methods?

Soukei: Can solar power be used?

Uchida: Wind power, tidal power, and geothermal power are also options.

Nishihara: Yes, that's right. What are those kinds of energy called, collectively?

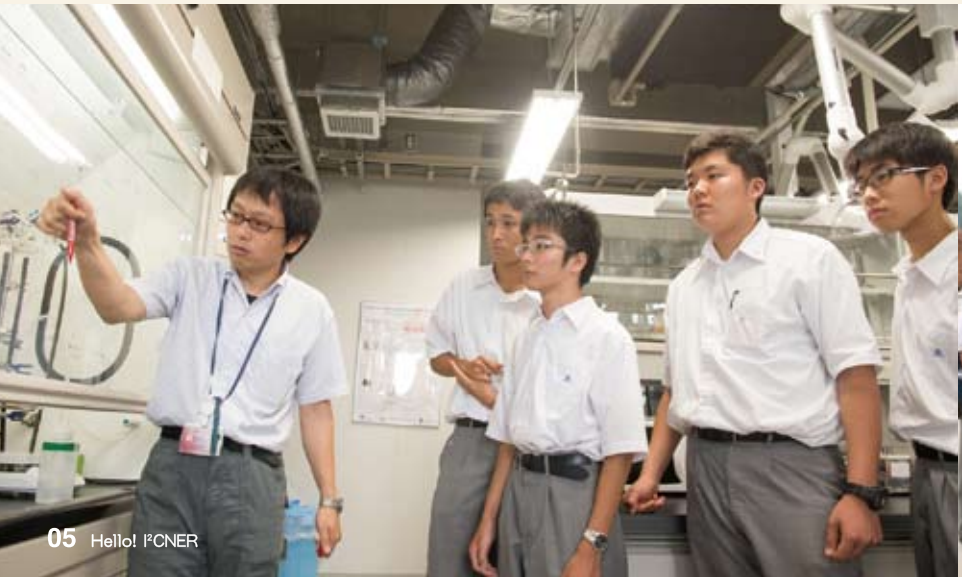
Sugiya: Renewable energy.

Nishihara: Exactly. If we combine the various energy sources that nature provides and use them to generate electricity and create hydrogen, then we will have created an ideal energy system that emits no CO_2. However, in reality, our task is not so easily accomplished. Why do you think that is?

Makiyama: Isn't it due to problems of efficiency and location?

Nishihara: And one more issue: cost. Since renewable energy systems have not yet been put in place, renewable energy costs more than oil and natural gas.

Yoshikawa: I recall learning that hydrogen gas is difficult to handle.



Kyushu University Hydrogen Station

Nishihara: Hydrogen is a gas that is 1/10 as heavy as air. Furthermore, what is the significance of the fact that it is at the very top of the periodic table?

Soukei: That's because it's very small.

Nishihara: Yes, because it' s the smallest element, it can pass through various substances. Consequently, we must think of mechanisms for keeping hydrogen from leaking.

Horishita: If hydrogen leaks so readily, won' t the hydrogen stations that fill fuel cell-powered automobiles be extremely dangerous places?

Nishihara: Even if the hydrogen tank in a fuel cell-powered automobile were to rupture in a collision, the tank's contents would dissipate up into the air in an instant because hydrogen is so light. Therefore, I don' t see the risk of hydrogen catching fire as a realistic problem for this type of vehicle.

Future issues

Nishihara: As we work to popularize use of fuel cell-powered automobiles, automakers are faced with the need to lower the cost of fuel cells, convert hydrogen into energy efficiently, and increase the reliability of systems so that they can be used over the long term with confidence and peace of mind. At I²CNER, we are pursuing research into topics such as the development of methods for efficiently creating hydrogen and materials capable of increasing the generating efficiency of fuel cells while controlling associated costs.

Sugaya: It seems that costs are always a consideration.

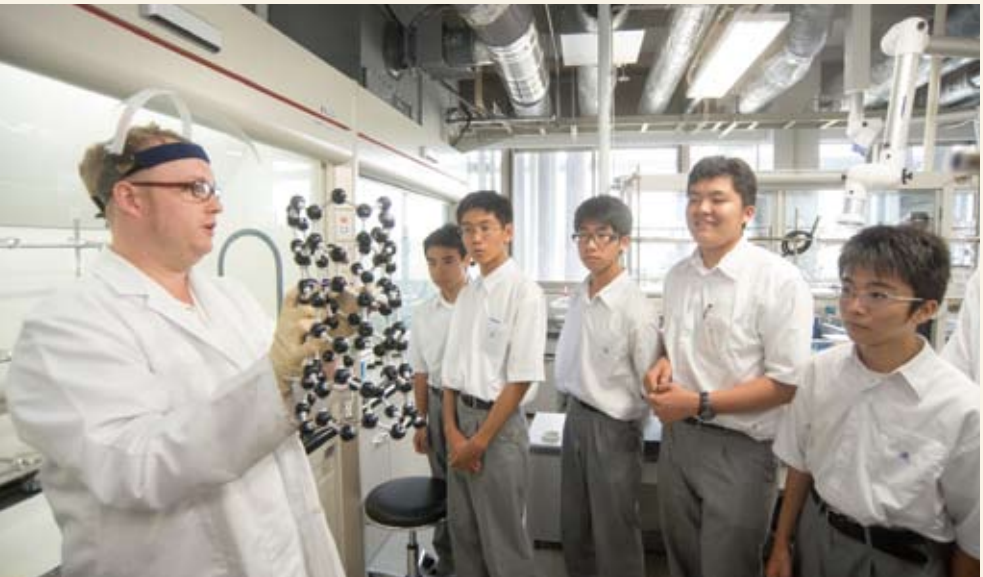
Nishihara: Indeed. If the only issue were boosting efficiency, it would just be a matter of using large quantities of platinum. However, that approach would be too expensive. Creating robust materials isn't particularly hard either, as long as money is no factor.

Yoshikawa: It must be difficult to search for the best possible combination of characteristics while maintaining a good balance between cost and quality.

Nishihara: It is. It would probably be difficult for companies, which must deliver efficiency, to conduct this kind of fundamental research. That' s why research institutions such as ours must do our best in this area. Another factor that you must bear in mind is the need to create revolutionary ideas. Original ideas are born from thinking that doesn' t simply seek to extend the way we've done things in the past.

Soukei: Research that seeks to create the future is exciting.

Nishihara: At I²CNER, researchers from around the world have gathered to pursue research day in and day out with the objective of realizing a hydrogen energy-powered society under the leadership of our American director. If you' re interested in energy issues, I would certainly encourage you to become researchers and work with I²CNER in this important area.



Impression of the discussion

I gained an understanding of the surprising potential of hydrogen.

Daichi Uchida

Now I understand how amazing fuel cells are.

Takuya Soukei

I will definitely drive a fuel cell-powered automobile in the future.

Mitsuki Makiyama

Kazuma Horishita

What happens to CO_2 when you add something?

Hitoshi Sugaya

I'm going to make an airplane that runs on a fuel cell and fly it.

Tomohiro Yoshikawa

I'm going to think of a new idea every day. My dream is to become a university professor.

Fukuoka Seiryou High School

This discussion was made possible by the cooperation of the students of Fukuoka Seiryou High School. Thanks to the school's leafy, mountainous location, students apply themselves to their studies while experiencing the four seasons. The school's extensive selection of international exchange programs includes exchanges with a sister school in South Korea and a language education program in Australia.
Members of the Science Club, which was established during the current academic year, participate in an ambitious series of activities, including exploration of the fields in which they are interested, joint research, interesting experiments, and science fairs.

Breaking News!!

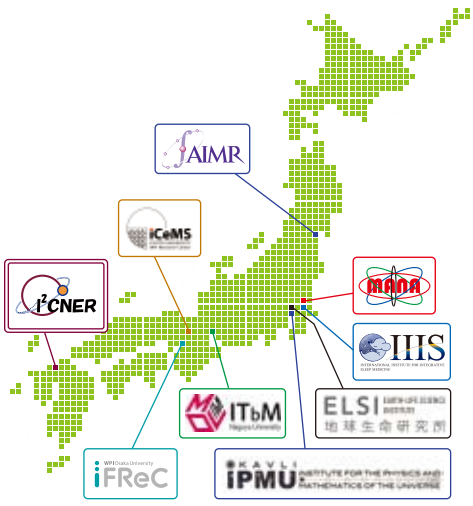
A special lecture at the 2013 school festival of Seinan Gakuin Senior High School

On July 12th and 13th, the school festival of Seinan Gakuin Senior High School, “Seinan Festival 2013,” was held.
On day one of the event, Dr. Fujikawa, Lead Principal Investigator of CO_2 Capture and Utilization Research Division, gave a special lecture with the theme “My job as a researcher who can be one of the foremost discoverers in the world!”, which was attended by more than 1300 students. He explained his research, the world’s thinnest nano-membrane, and how it is useful for the reduction of CO_2 emissions. He also told the students how his experiences led him to become a researcher. At the end of the lecture, he participated in a question and answer session with the students.

What is WPI?

wpi World Premier International Research Center Initiative

The World Premier International Research Center Initiative (WPI) is a project that was launched by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2007. The WPI seeks to form an ideal research environment within visible research centers that maintain high research standards, where leading researchers will be attracted from all over the world.



I²CNER Kyushu University
International Institute for Carbon-Neutral Energy Research (I²CNER)

Toward the realization of a low-carbon society, I²CNER aims to resolve the challenges of the use of hydrogen energy and CO_2 capture and sequestration by fusing together sciences from atomic level to global scale.

AIMR Tohoku University
Advanced Institute for Materials Research (AIMR)

Integrating physics, chemistry, materials science, bioengineering, electronics and mechanical engineering, AIMR is striving to create innovative functional materials. A mathematical unit joined the team in 2011 to help establish a unified theory of materials science, aiming at the realization of a global materials research hub.

iFReC Osaka University
Immunology Frontier Research Center (IFReC)

An innovative research center, which pursues the goal of comprehensive understanding of immune reactions through the fusion of immunology, various imaging technologies, and Bioinformatics.

MANA National Institute for Materials Science International Center for Materials Nanoarchitectonics (MANA)

A major focus of our activities is the development of innovative materials on the basis of a new paradigm “nanoarchitectonics,” ground-breaking innovation in nanotechnology.

iCeMS Kyoto University
Institute for Integrated Cell-Material Sciences (iCeMS)

Established to integrate the cell and material sciences, the iCeMS combines the potential power of stem cells (e.g., ES/iPS cells) and of mesoscopic sciences to benefit medicine, pharmaceutical studies, the environment, and industry.

IPMU Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU),
Todai Institutes for Advanced Study, The University of Tokyo

With accumulated research on mathematics, physics and astronomy, this research core works to bring light to the mysteries of the universe, such as its origin, and to provide an analysis of evolution.

ELSI Tokyo Institute of Technology
EARTH-LIFE SCIENCE INSTITUTE(ELSI)

ELSI focuses the origins of Earth and life. Both studies are inseparable because life should have originated in unique environment on the early Earth. To accomplish our challenge, we establish a world-leading interdisciplinary research hub by gathering excellent researchers in Earth and planetary sciences, life science, and related fields.

IIIS University of Tsukuba
International Institute for Integrative Sleep Medicine(IIIS)

IIIS seeks to elucidate the fundamental mechanism of sleep/wakefulness, to develop strategies to regulate sleep, and to contribute to the enhancement of world health by combatting sleep disorders and associated diseases.

ITbM Nagoya University
Institute of Transformative Bio-Molecules (ITbM)

The goal of ITbM is to develop innovative functional molecules that make a marked change in the form and nature of biological science and technology (transformative bio-molecules). ITbM will connect molecules, create value, and change the world, one molecule at a time.

Refer to:
MEXT Website http://www.mext.go.jp/english/research_promotion/1303822.htm
JSPS Website http://www.jsps.go.jp/english/e-toplevel/index.html

Editors’ Postscript

- I²CNER holds a variety of events.
  For details, please see: ➡ http://i2cner.kyushu-u.ac.jp/ja/results/seminar.php
  (I²CNER Event Information)
  Search by I2CNER
- It has been three years since the first publication of “Hello! I²CNER.” In celebration of this exciting milestone, we have re-designed the publication and added new contents which we hope will be refreshing for our dedicated readers. Moving forward, we would like to understand and consider the readers’ perspective on energy problems. With that in mind, we welcome you to share your opinions and comments with us.

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