OIST News No.12 Okinawa Institute of Science and Technology

OIST News

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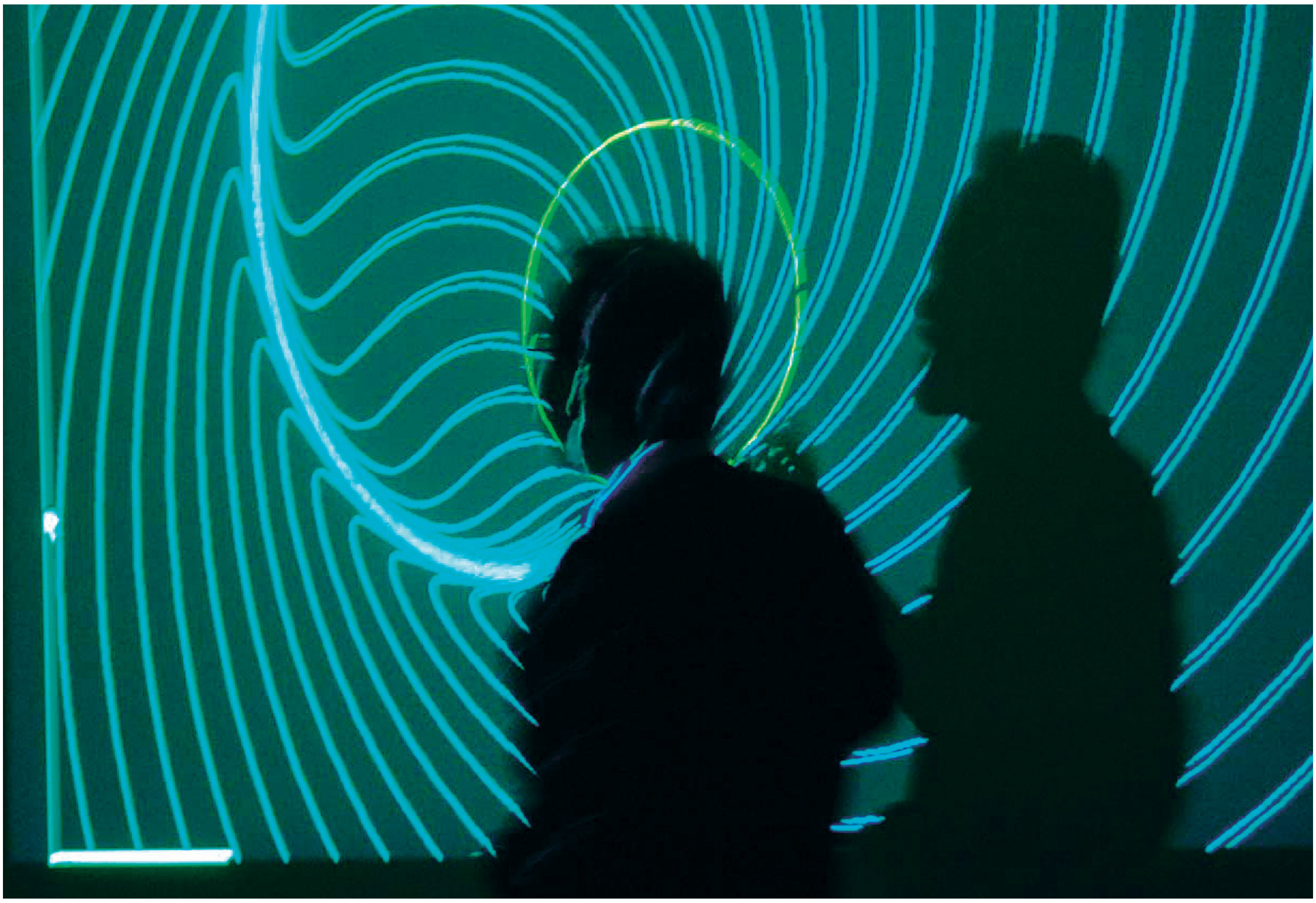
The Okinawa Institute of Science and Technology Promotion Corporation is an independent administrative institution launched in September 2005 to conduct outstanding research and to prepare for the establishment of a graduate university of science and technology in Okinawa. OIST News is a print publication intended to highlight current activities at OIST.



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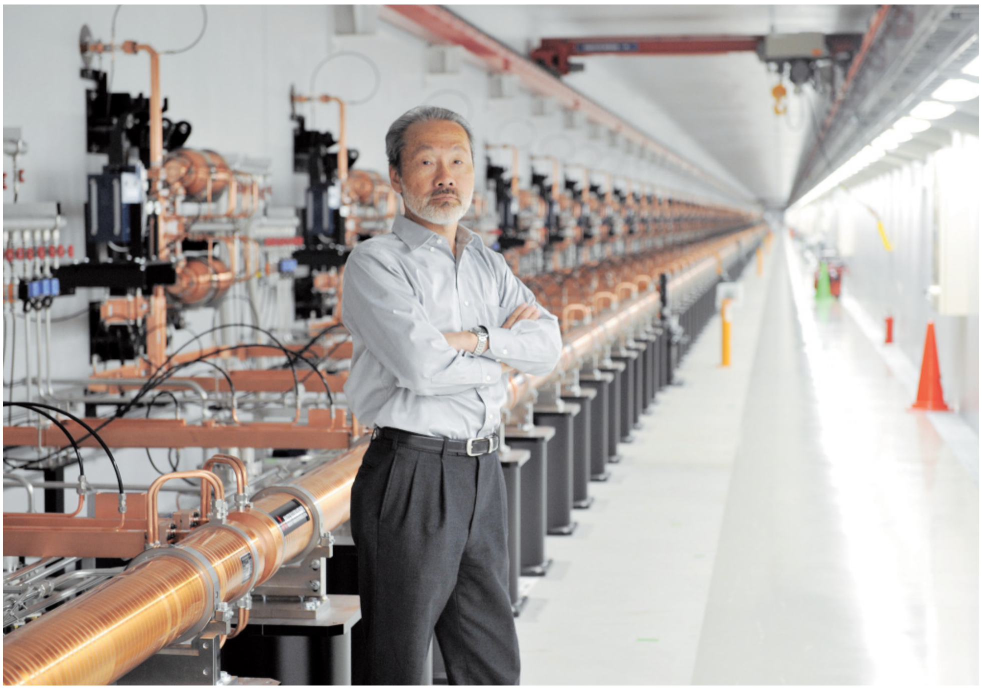
Award-winning Physicist welcomed at OIST

Interviewed and written by Juliette Mutheu

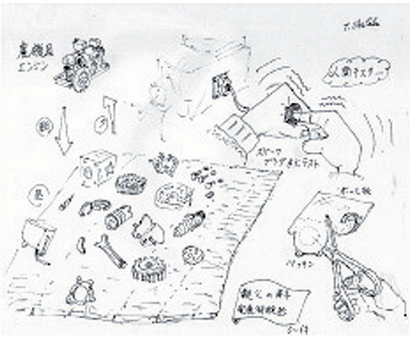


Dr. Tsumoru Shintake stands next to his award winning C-band Main Accelerator at the SACLA facility. He now leads the **Quantum Wave Microscopy Unit at OIST.**

Cover page: Radiation-2D,
Dr. Tsumoru Shintake talks radiation. He demonstrates how moving an electron in a circular manner creates synchrotron radiation which is electromagnetic radiation emitted when electrons are forced to move radially.

Physicist at age 5

At the age of five, young Tsumoru Shintake was already wearing an engineer's helmet as he worked on the farm tractor engine with his dad. "I remember my father and I spending an entire day dismantling the engine to fix the broken mechanical seal, the gasket, which prevents leakage from one cylinder to another. Once the engine was reassembled, however, we were unable to restart the tractor. My father asked me to stick my finger in a spark plug socket and when I suddenly got zapped, he realized that he had forgotten the gasoline," recaps Dr. Shintake. It may sound farfetched but believe it or not, this was the physics career start for award-winning Dr. Shintake. Since last summer OIST has launched an active recruitment of physicists with Dr. Shintake being OIST's newest physicist.



Sketch of Dr. Shintake's physics beginning.

Farming, Italy & World-famous Inventions

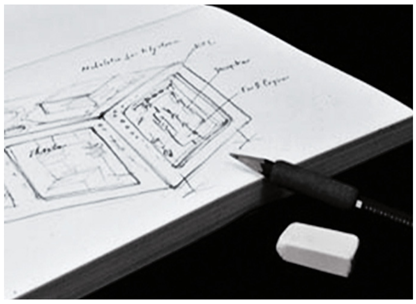
Dr. Shintake was not an avid student. His interest lay in active learning; learning by doing as opposed to passive learning, attending lectures and studying hard. He grew up in the remote countryside of Miyazaki, where his parents raised cattle and planted rice. "My parents demanded more of my involvement in farmwork than in reading," he recounts. At junior high, the physics teacher encouraged young Shintake to enroll in university and take a physics degree given his talent in building things. He followed his teacher's advice and pursued a degree in engineering, working on microwave undulators which are devices that generate X-rays using a high energy electron beam. Upon completion of his degree, Shintake became a researcher at Japan's national high energy physics laboratory, KEK, where he contributed to developing hardware for accelerators. His work ethic as a researcher and engineer was so impressive that his supervisor offered him the opportunity to take a one-year sabbatical at the *Laboratori Nazionali di Frascati, Istituto Nazionale di Fisica Nucleare* near Rome. Shintake affirms that he, as many do when they visit Italy, enjoyed delicious Italian cuisine, drank delicately aged flavor-filled wine and drove around enjoying the wonderful landscape with quaint villages. As an academic scholar, however, his studies were kept to a minimum. This, however, was not an obstacle in his future success.

“One day, after a great Italian lunch at the *Frascati laboratory* canteen, I was sitting in my office staring down into the Roman city,” recalls Dr. Shintake. “My computer had broken down and I was told it would take two months to fix because it had to be taken to Milan. I sat there staring at the dome of Saint Peter’s Basilica, peeking out of the Vatican City. Suddenly the solution to a question that had been troubling me came to mind: The way to accurately measure a nanometer size, high-energy electron beam. This problem was a big issue in the particle physics community, and there was a prize on offer from the Stanford Linear Accelerator Center (SLAC).”

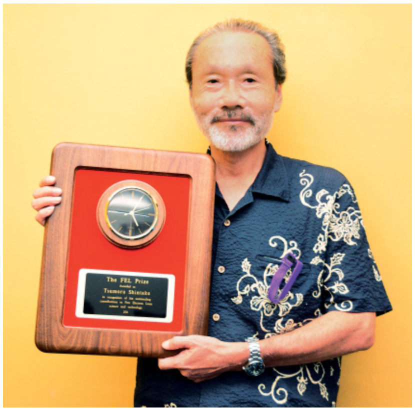
Dr. Shintake identified that one could use laser interference technique as a nanometer scale. He later successfully demonstrated the idea of using a laser interferometric beam size monitor at the Final Focus Test Beam facility at SLAC. This invention saw Shintake publish a number of scientific papers in international academic journals, thus stamping his name in the physics world as a rising star. Upon his return to Japan in 1991, Shintake invented the “Choke-Mode Cavity” also known as the Shintake-Structure. The structure enables electrons from an electron source such as a cathode to be propelled through a linear accelerator without deteriorating quality of electrons, followed by passing undulators in a fairly straight trajectory. The undulators apply a periodic magnetic field on the accelerating electrons resulting in the production of powerful X-ray radiation. The Choke-Mode Cavity idea has been employed in the SPring-8 Angstrom Compact Free Electron Laser (SACLA), X-ray Free Electron Laser.

The prize that sits at OIST

Dr. Shintake came to OIST from the SACLA facility at the RIKEN/SPring-8 institute, where he worked as the main accelerator construction leader overseeing 200 staff who built the C-Band main accelerator. The SACLA facility took 5 years to successfully complete and cost an approximate total of USD 400 million. His scientific research on the study of the phenomena of the Shintake-Structure has overall taken 20 years. It was this accelerator that won Dr. Shintake the Free Electron Laser (FEL) Prize at the 33rd International Free Electron Laser Conference in August 2011, in Shanghai, China. The prize was for his outstanding contribution to FEL Science and Technology.



Known for his artistic sketches of the complex machines he invents, Dr. Shintake says that “by sketching an envisioned facility, people have a better understanding of what that facility is going to look like”.



Dr. Tsumoru Shintake with his prize.

On Tuesday, the 7th June, 2011, at 1610hrs, Dr. Shintake and his staff (A) were able for the first time to detect free electrons going through the 400m accelerator tunnel at the SACLA facility (B), RIKEN.

Building a Quantum Wave Microscope

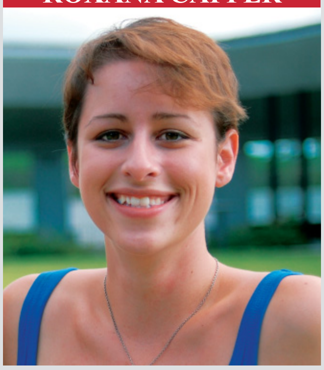
Dr. Shintake is now looking towards the future and has no regrets about leaving behind his award-winning accelerator. "Only when the boss goes can he leave room for the young to grow," he proudly remarks. His vision at OIST is to build a similar but smaller device with a completely different concept that uses the quantum wave effect, hence his OIST unit name: the Quantum Wave Microscopy Unit. The development of such a new type of electron microscope means that it can be used as an imaging tool for nano-technology, bio-molecules and light mass atoms.

In his new office at OIST, Dr. Shintake sits at his computer listening to 'BEGIN' — a band from Ishigaki Island that sings and plays the Okinawa three-stringed musical instrument called the *Sanshin*, akin to the Banjo. In a jovial mood and with rhythm-filled movements, Dr. Shintake describes OIST as a cosmopolitan city where scientists can talk to each other without feeling stressed. "The atmosphere here is free and perfect for science to thrive. It is like having oxygen: without it, we will die. If scientists lose such free atmosphere, we won't survive. This air is invisible and funding cannot buy it. It is people who create this air at OIST."

About X-ray Free Electron Lasers
An X-ray FEL delivers beams that are immensely brighter and with higher energy and shorter pulses than existing synchrotron X-rays. The diameter of a human hair is about 1/300 of an inch. The wavelength of visible light is about 100 times smaller than this, so ordinary microscopes can easily resolve a hair, but a molecule about 10,000 times smaller than a hair such as a protein molecule (~5nm) is too small to be resolved with visible light. X-rays have wavelengths that are even smaller than a protein molecule (down to 2nm). This is ideal for imaging at the atomic scale. *nm: nanometer.

Discovering yourself

ROXANA CAPPER



Ms. Capper is currently one of OIST's short-term student research assistants. She is completing her Ph. D. at the University of Texas, at Austin and focuses on the population genetics of corals. She describes her work at OIST over the last few months and how this experience has changed her view of the scientific research culture.

Before coming to OIST, I had never been to Japan. I heard about OIST from Dr. Sasha [Alexander] Mikheyev who earned his Ph. D. from the Ecology, Evolution and Behavior Department at the University of Texas, at Austin. Dr. Mikheyev leads OIST's Ecology and Evolution Unit focusing on the evolutionary genetics of yeast, the evolution of the advanced sociality of ants, as well as community ecology with an emphasis on microbiology.

I have always been interested in evolutionary biology so when I heard about the types of projects that are possible at OIST, I felt the opportunity to experience a completely new culture, and this scientific trajectory was worth a break from my research back home in Texas. The facilities and the people here are amazing; everyone, including myself, is excited about their research and eager to talk about their work. In the Mikheyev Unit, I am involved in testing out two intriguing theories: the coalescence theory and Muller's Ratchet theory. By using these two theories we want to see if yeast can tell us something about evolutionary history.

The coalescence theory looks backward in time at the patterns of mutations in a population to reveal historical population demographics. Most studies on this theory have used computer simulations, and there have been no formal tests of the current models using yeast. Last year, I grew yeast for over a month, keeping the population size relatively constant by removing excess cells every twelve hours. We sequenced the genomes of these yeast from different time points and now we are looking to see if current models of coalescence theory accurately recover the true evolutionary tree. It will be particularly interesting to see if the models do not work, or if commonly assumed parameters give false results.

The other intriguingly named theory: Muller's Ratchet, basically says that organisms that don't have sex accumulate mutations which lower the organism's fitness. This is intuitive because most mutations are deleterious instead of advantageous and because without the genetic mixing that comes from sex, the mutations persist within a lineage and can't be removed. This has been demonstrated in viruses and bacteria, but to date no experiments have been able to restore sex to a previously asexual lineage. We developed strains of highly mutated, asexual yeast with significantly lower fitness than that of the founding population. We are now trying to restore the ability for these yeast to mate to see if the offspring have the fitness distributions expected by this evolutionary theory.

It is the actual application of these two evolutionary theories in yeast that has been exciting and enabled me to understand how I can merge and apply them in my Ph. D. research on population genetics of corals. I will definitely modify some chapters in my thesis to include what I have learned here.

OIST is a great place to work and my experience here has been even better than I expected. I was able to gain a different perspective of science and to be immersed in a culture of science. Being at OIST has been very influential in giving me an idea of what I want out of a scientific career. In addition, I have learned so much about the Okinawan people, research and myself. I know I will miss all of it when I go back to Texas, especially the view!

DNC2011: Learning how the brain is built

by Micheal Cooper

The 2011 Developmental Neurobiology Course (DNC2011), was held from July 17th to 31st at the OIST Onna Campus and Seaside House. Fifteen lecturers, seven tutors, and twenty-eight students came from all over the world for an intensive course on what co-organizer and Principal Investigator of the OIST Formation and Regulation of Neuronal Connectivity Unit, Dr. David Van Vactor calls "the molecular machinery that makes neural circuitry possible." DNC2011 is the second OIST Developmental Neurobiology Course, and like last year, the lecturers are all leaders in their fields, representing a wide array of nationalities, specialties, and backgrounds.

Developmental neurobiology is intrinsically interdisciplinary, bringing together disciplines like cell biology, developmental biology, neuroscience, imaging technology, molecular biology, genetics, electrophysiology, and behavior to understand what Dr. Van Vactor calls "the wet, messy details of how-biologically and mechanically-neural functionality is achieved." Such an approach falls in line with OIST's mission to create an interdisciplinary research environment.
The two-week course started with a history of the field and then took students through a wide range of hands-on training and lectures. The brain works because brain cells called neurons transfer information between each other, but how does an organism put the right number and types of neurons in place to create a nervous system? How does it connect them so that they can process information? How do these factors affect behavior? In addition to addressing these and other issues, DNC2011 gave students training in practical lab skills and technologies. At the end of the course, students learned about neuronal disease models so that they could consider how defects in the development or maintenance of the nervous system cause abnormality and disease.

Asked to distinguish developmental neurobiology from other brain sciences, Dr. Van Vactor used a musical metaphor: "Just as much of a violin's sound is determined by how it is made, much about the brain is determined by how it developed." Developmental neurobiology wants to understand the most fundamental details of the development of the brain and the nervous system as a whole. Dr. Van Vactor believes that "if a graduate student is thinking about going into neuroscience and understanding the brain, it is important that she or he thinks about how the brain is built."

Students looking at research posters

During a hands-on lab session.

"He said, She said"

"Wow and wow! I wish there had been such opportunities in my postdoc days." - **Elke Stein, Yale University.**

"The DNC has given me a completely different perspective which I hope will enable me to go from studying behavior to understanding what causes that behavior at the molecular level." - **Dongnhu Thuy Truong, University of Connecticut.**

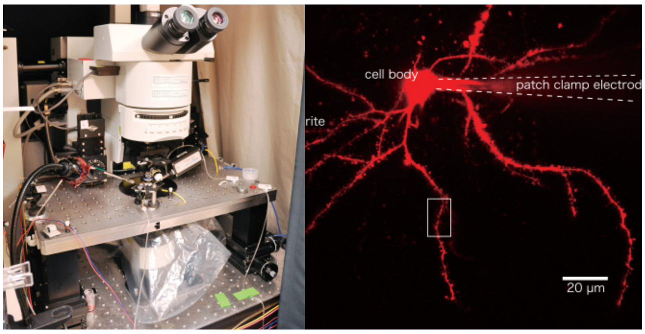
"Beautiful setting, the students are very good, and they ask some very good questions. It has been a very good experience." - **Dr. Yuh Nung Jan, HHMI/UCSF, USA.**

"Instead of just having a paper explained to me, I got to use a microinjector and do the science myself. You can go to a lot of places to hear someone lecture, but this is a good training experience because it will expose me to different lab techniques." - **Laura Mariani, Emory University.**

"These researchers are grad students and postdocs at the beginning of their careers, and I hope that some of them will consider moving into the field of developmental neurobiology. In particular, I hope that more Japanese will participate in the DNC so that they can get to know other young researchers from around the world." - **Dr. Akinao Nose, University of Tokyo.**

Dr. Yuh Nung Jan, HHMI/UCSF, USA.

2 is better than 1



A powerful tool for observing neuronal activity

by Kaoru Natori

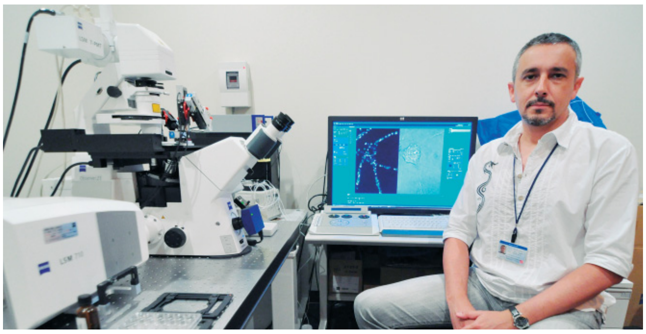
Researchers at OIST are interested in the basic units of which our brains are composed - so called nerve cells or neurons. These cells have a diameter of about 10 microns (.01 mm) with processes that can reach even more than one meter but are thinner than 1 micron (0.001 mm). Billions of neurons, each with tens of thousands of connections to others, engage in non-stop, busy electrochemical conversations. The signals they send result in our thoughts, actions, words and emotions. However, how exactly behavior arises from cellular activity and how information is processed in the brain remains a mystery.

OIST researchers are trying not only to deepen the understanding of the brain, but also to go beyond the current technical limitations.

To study the brain on a cellular level, scientists have developed highly sophisticated microscopy techniques. One of the most advanced microscopy techniques used is two-photon laser scanning microscopy. It is a fluorescence imaging technique that relies on the near-simultaneous absorption of two photons by a molecule to excite fluorescent dyes. A two-photon microscope uses an infrared laser beam that is focused through an objective lens and excites dye molecules only within a tiny focal spot less than 1 micron in diameter. The microscope can then move the focal spot through the sample, and so scan the tissue with great accuracy.

Two-photon laser scanning microscopy permits three-dimensional tissue imaging of up to 1 mm depth. While this may not sound like a lot, it really is for many applications in biology. At OIST, researchers use this technique to study several different questions about the brain and its function. OIST researchers are trying not only to deepen the understanding of the brain, but also to go beyond the current technical limitations.

IMAGE : Two-photon microscope and a whole neuron cell filled with red dye.



Dye, Light and Action

Watching the brain's butlers

by Micheal Cooper

Scientists at OIST are working to illuminate the minute details of how brain cells called neurons communicate. When most people think about the communication between neurons, they think about electrical and chemical signals passing between neurons. However, there is much more to understand about this process. We know that inside neurons and the synapses which connect them, vesicles play the role of the household butler, transporting in and out of the cell, proteins and other molecules required for proper neuron cell function; however, we do not know a great deal about the behavior of individual vesicles.

The laser of the confocal microscope excites vesicles loaded with a specific pH sensitive fluorescent dye enabling images to be captured.

Dr. Laurent Guillaud of OIST's Cellular and Molecular Synaptic Function Unit is developing techniques to track single vesicles as they work within the neuron so that he can fully understand their dynamics and functions.

Dr. Guillaud uses a real time imaging confocal microscope to develop methods to accurately track single vesicles as they move within neurons and synapses so that scientists may better understand their role in neural communication. When vesicles are loaded with a specific pH sensitive fluorescent dye, they emit light when excited by the laser of a confocal microscope. Dr. Guillaud then captures sequential images and processes them to isolate separate views of the cell: one revealing only the light produced by the fluorescent dye; the other, the entire cell. This superimposition makes it easy to distinguish the vesicles from the other parts of the neuron and vesicles.

IMAGE: Dr. Laurent Guillaud and the confocal microscope he uses to view individual vesicles.

Thanks for the Tanks

World's most complicated fish tank
by Kaoru Natori

OIST has an advanced high capacity aquarium system developed for the maintenance of mutant and transgenic lines of zebrafish. The state-of-the-art zebrafish facility houses 4,600 fish tanks, with approximately 400,000 fish swimming around at any given time. The Developmental Neurobiology Unit, led by Dr. Ichiro Masai, uses the zebrafish as a model system to study the mechanisms that control cell development in fish retinas.

Maintaining a zebrafish facility is somewhat like keeping a huge tropical fish water tank. The facility is divided into two areas: one for breeding and raising the fish in tanks, and the other, a pump room for preparation and recirculation of water. Instead of laying gravel at the bottom of a fish tank as is the case in normal aquariums, the OIST zebrafish facility is equipped with multiple water filters to remove debris and toxic chemicals such as ammonia and nitrite contained in fish waste. The water is circulated and purified through porcelain filters until ammonia and nitrite are entirely eliminated. The filtered water is then transported to the adjacent pump room, where it again goes through more fine mechanical filters and the second biological filters made of plastic particles. This room is used for sterilizing and generating aquarium water.

Keeping detailed logs of the information about individual fish strains, from the date of birth, to its genetic information, and current and past health conditions is another important task in maintaining the zebrafish facility. The OIST zebrafish facility possesses around 100 wild type, mutant and transgenic strains. This facility contributes to a bio-resource project by supplying valuable zebrafish strains to international and domestic research communities.

This facility contributes to a bio-resource project by supplying valuable zebrafish strains to international and domestic research communities.

IMAGE: Ekramul Islam checks on the fish tanks containing zebrafish.

The Big Chiller

Ice-to-AC
by Micheal Cooper

One of the advantages of being at OIST is the location - sunny Okinawa, a subtropical island surrounded by coral reefs and translucent blue water. However, "sunny" and "subtropical" usually mean "hot" and "humid," and scientific experiments, offices, and high-performance computing facilities require an environment where temperature and humidity can be carefully controlled.

Ice is one key to saving money on cooling costs. Tucked away beneath the administrative offices and meeting rooms of the Center Building is a tank of over 540,000 liters of water. Every night, two huge "super-coolers" freeze this water, producing a block of ice weighing over 180 tons - more than a fully-grown blue whale.

During the day, three large pumps circulate water through pipes built into this tank. The chilled water is then circulated through radiator pipes in the Center and Lab 1 buildings where it absorbs heat from the air. The pumps start every morning at 8 AM, and usually by 5 PM the ice has all melted, leaving the remaining heat of the evening for conventional air conditioners to handle. The resulting decrease in daytime electricity consumption amounts to approximately 1,000 kilowatts per hour.

OIST's block of ice decreases daytime electricity consumption by approximately 1,000kWh.

Such "heat accumulation systems" save money because the ice is created at night, when electricity is cheapest. By using nighttime electricity to reduce daytime demand, OIST saves money and at the same time helps the power company to operate more efficiently.

IMAGE: a 'super-cooler' that freezes the water in the tanks every night.

Drums, Sanshin and Eisa Dance

By Hisashi Gakiya

"Ilya Sassaa, Haaiiya" shouted members of local Youth Eisa Group, and the sound of the drums and *Sanshin* echoed around the OIST campus. *Eisa* is a traditional Okinawan dance, which is mainly performed during the *Obon* - Festival of the Dead - season to welcome ancestors' spirits. On August 16th, 22 members from the Tancha Youth Association visited OIST to perform *Eisa* dance at the OIST campus center court. Tancha is the local district where OIST is located. The performers consisted of male members who wore a red or purple cloth called *Saaji* around

Drums

Sanshin

katcharsee

their head and female members who wore pink flower-print *Yukata*, a casual cotton *Kimono*. The men drummed and danced athletically while the women's dance added grace and gaiety. When the performance reached its climax, it was the perfect time to start *"katcharsee,"* an Okinawan free style folk dance. All of the performers and the audience joined the *katcharsee* session together and danced along with song, *Sanshin* and the drums until their shirts were soaked with sweat. Thanks to the members of Tancha Youth Association for coming to OIST and putting on a wonderful performance. We are looking forward to seeing you next year!

Graduate University Starts in 2012!!!

Opening in September 2012, the Okinawa Institute of Science and Technology Graduate School* offers students the opportunity to earn a Ph. D. by working side by side with world-class faculty in modern well-equipped laboratories. OIST relies on a cross-disciplinary approach, with an emphasis on creativity and exchange, to create unique, individualized graduate training. Download the OIST Graduate Program Brochure and watch the new OIST video at www.oist.jp.

*The OIST Graduate University is currently undergoing evaluation for accreditation (approval for establishment).

SCIENCE TALK with Dr. Akito Arima

by Kaoru Natori

On August 23rd, seven students from the Okinawa National College of Technology, accompanied by Professor Hideyuki Yamashiro, visited the OIST campus for a "Science Talk" with Dr. Akito Arima, Co-chair of the OIST Board of Governors (BOG), Chairman of the Japan Science Foundation and the President and Chair of the Board of Trustees at the Human Frontier Science Program. Dr. Jonathan Dorfan, President-elect of the OIST Graduate University, first welcomed the students and introduced Dr. Arima, referring to him as an eminent physicist, world-renowned academician, a published master of Haiku, former president of the University of Tokyo, and one of the founding fathers of OIST.

In a lecture entitled "For the Future of Science and Technology in Japan," Dr. Arima encouraged the young students to be confident, saying that what appears to be a large decline in the level of academic achievements by Japanese schoolchildren over the past few decades is in fact an inaccurate interpretation of the survey results. Citing statistics from several international surveys, Dr. Arima pointed out that the number of countries surveyed has increased. He stressed that the decline relative to the increased pool of other countries is only modest and that the actual performance level of Japanese students has in fact improved. He did point out, however, that the flexible thinking ability of Japanese schoolchildren is lower in comparison to their peers in other nations, underlining the importance of self-learning and problem-solving.

In closing, Dr. Arima talked about energy issues, saying that Japan ranks the highest among the Group of Eight (G8) nations in reliance on oil imports. Citing Germany as a model nation, he called for a study into renewable energy resources, such as wind, solar and hydro power.

Images: top - Dr. Arima answers a question, Center - Students listening to Dr. Arima's talk and Bottom - Dr. Arima and Prof. Yamashiro with students from Okinawa National College of Technology.

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