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2020 VISIONS

For the first issue of the new decade, *Nature* asked a selection of leading researchers and policy-makers where their fields will be ten years from now. We invited them to identify the key questions their disciplines face, the major roadblocks and the pressing next steps.

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- Shimadzu's products fit Latin America's special needs
- News & Topics from Shimadzu

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2020 VI

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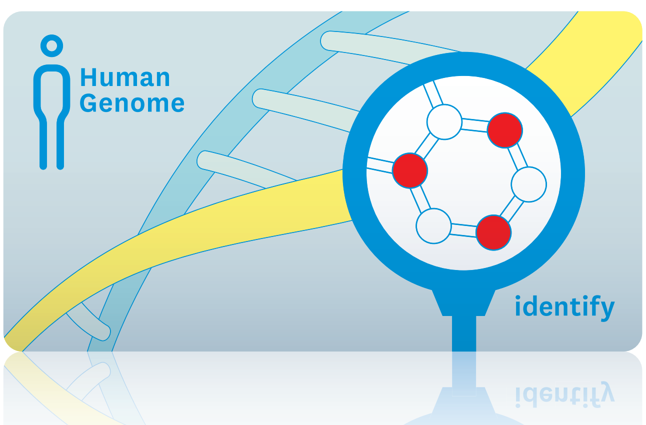

Personalized medicine

David B. Goldstein*
Duke University

Over the past decade, powerful genotyping tools have allowed geneticists to look at common variation across the entire human genome to identify the risk factors behind many diseases. Two striking findings will define the study of disease for the decade to come. First, common genetic variation seems to have only a limited role in determining people's predisposition to many common diseases. Second, gene variants that are very rare in the general population can have outsized effects on predisposition.

For example, rare mutations that cause the elimination of chunks of the genome can raise the risk of diseases such as schizophrenia, epilepsy or autism by up to twentyfold. Some researchers view these major risk factors as aberrations. My guess is that as more genomes are sequenced, many other high-impact risk factors will be identified.

If so, here's one confident but uncomfortable prediction of what personalized genomics could look like in 2020. The identification of major risk factors for disease is bound to substantially increase interest in embryonic and other screening programmes. Society has largely already accepted this principle for mutations that lead inevitably to serious health conditions. Will it be so accommodating of those who want to screen out embryos that carry, say, a twentyfold increased risk of a serious but unspecified neuropsychiatric disease?

Some advances will be relatively uncontroversial, such as the development of tailored therapeutic drugs based on genetic differences that are otherwise innocuous. Others will be transformational, such as the identification of definitive genetic risk factors that provide new drug targets for conditions that are often poorly treated such as schizophrenia, epilepsy and cancers. Over the next decade millions of people could have their genomes sequenced. Many will be given an indication of the risks they face. Serious consideration about how to handle the practical and ethical implications of such predictive power should begin now.

This is part of an OPINION originally published in *Nature* Vol.463 (26-32) / 7 January 2010

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* In the original article eighteen fields were covered. Here six are reproduced.

Lasers

Thomas M. Baer
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Nicholas P. Bigelow
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Those who conceived and invented the laser 50 years ago this year could not have predicted the roles that it has had over the past half-century: from communications to environmental monitoring, from manufacturing to medicine, from entertainment to scientific research.

By 2020, lasers will probably emit beams with spot sizes of the order of 1 nanometre — the size of a small molecule. Objects with dimensions less than a wavelength cannot usually be resolved using lasers or microscopy unless the photons are emitted from an aperture smaller than the object. Microscopes that incorporate laser sources with apertures the size of a single molecule will be useful in fast, direct sequencing of biomolecules such as DNA and RNA. These miniature beams will also provide hard-disk storage at densities 100 times greater than those available today — petabytes of storage in a personal computer.

Ultraprecise, laser-based clocks will measure the drift in fundamental constants as the Universe expands, challenging our theories describing the origin and evolution of the cosmos.

Next-generation lasers will allow the creation of new states of matter, compressing and heating materials to temperatures found only in the centres of massive stars, and at pressures that can squeeze hydrogen atoms together to a density 50 times greater than that of lead. The resulting fusion reactions may one day be harnessed to provide almost limitless carbonfree energy. Enough fusion fuel is present in the oceans to supply the current energy needs of the entire world for longer than the age of the Universe.

By 2020, lasers will generate ultrashort bursts of photons — with pulse widths shorter than the time it takes for light to traverse an atom. These attosecond pulses will allow strobe pictures to be taken of chemical reactions — stop-action pictures of electrons in motion. When amplified to ultrahigh intensities, these lasers will be used as engines to accelerate electrons and protons to velocities close to the speed of light. This will mean that table-top accelerators can be created to generate particles with kinetic energies that rival those in today's biggest particle accelerators at a fraction of the size and cost.

What are the challenges to achieving these remarkable goals? Developing new laser materials, sources, optics that can survive enormously high intensities and new nano fabrication technologies. Will all of this happen in the next decade? We believe so. Like the inventors of 1960, we are probably still underestimating the full potential and impact of lasers.

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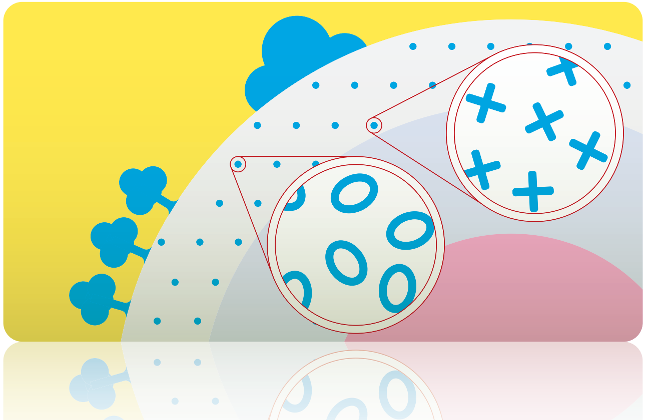


Soil

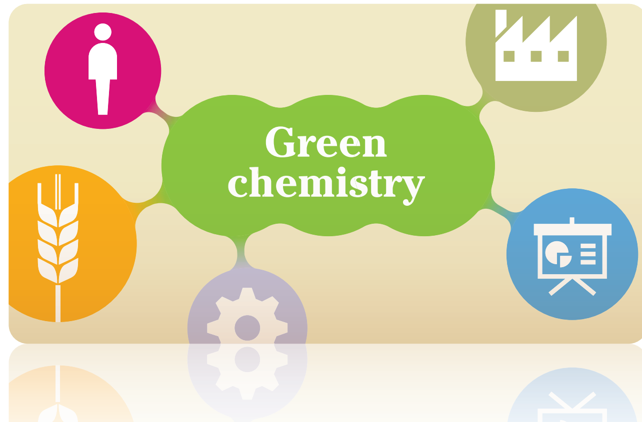
David R. Montgomery
Author of Dirt: *The Erosion of Civilizations,* University of Washington

To avoid the mistakes of past societies, as 2020 approaches, the world must address global soil degradation, one of this century's most insidious and under-acknowledged challenges. Humanity has already degraded or eroded the topsoil off more than a third of all arable land. We continue to lose farmland at about 0.5% a year — yet expect to feed more than 9 billion people later this century.

During the twentieth century, the Haber–Bosch process (allowing the mass production of nitrogen-based fertilizers) and the Green Revolution effectively divorced agriculture from soil stewardship. Increased yields were supported by intensive fertilizer inputs and mechanization that simplified and devastated soil life, reducing native soil fertility. For example, research in some conventional agricultural settings shows that other species such as bacteria have virtually replaced mycorrhizal fungi, which deliver soil nutrients to most plants. In a post-petroleum world, as the era of cheap fossil-fuel-produced fertilizers comes to an end, conventional, high-input agriculture is neither sustainable nor resilient. Ensuring future food security and environmental protection will require thoughtfully tailoring farming practices to the soils of individual landscapes and farms, rather than continuing to rely on erosive practices and fertilizer from a bag.

Towards these ends, governments should aggressively fund research on and promote the adoption of agricultural practices and technologies that cultivate beneficial soil life and sustain soil ecosystems. Over the next few decades, approaches such as low-till and organic methods could restore native soil fertility and store enough soil organic matter to offset global fossil-fuel emissions by 5–15%. Offsets, and soil fertility, could be further increased through adding biochar — charcoal made by heating organic wastes.

The thin layer of minerals, living microorganisms, dead plants and animals blanketing the planet is the mother of all terrestrial life and every nation's most strategic resource. Yet we treat it like dirt. Business as usual is not an option when it comes to soil, food and people. It's time for a greener revolution.



Chemistry

Paul Anastas
Center for Green Chemistry and Green Engineering, Yale University

The future of chemistry should look very different from the past. Traditional, reductionist, highly specialized academic chemistry has transformed food, energy, health, transportation, communications and the quality of modern life. It has also — accidentally — depleted finite and rare resources, endangered workers and contaminated ecosystems. Green chemistry is the way forwards: it combines expertise from synthetic, physical and biological chemists, together with that of toxicologists, environmental health and life scientists, to deliver sustainable chemical design.

Making chemical products and processes that reduce or eliminate the use and generation of hazardous substances is an inherently systems approach. The 'twelve principles of green chemistry' unite all aspects of the molecular life cycle, from obtaining the feedstock and starting materials, through the synthetic and manufacturing process, to the end of commercial life and ultimate disposal of products. These principles are based on the latest fundamental discoveries on the interaction between anthropogenic substances and the natural world.

Scant research funding, and hence insufficient effort, is devoted to sustainable innovation in chemistry. As a first step, chemistry needs to adopt a clearly stated research imperative that researchers in molecular science must maintain their creativity while not doing harm to people and the planet. We need to turn all of chemistry green.

> "Business as usual is not an option when it comes to soil. It's time for a greener revolution."

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Ecology

Robert D. Holt
Department of Biology, University of Florida

The greatest practical challenge facing ecologists over the next decade is that much of what we wish to study may vanish before we can really fathom it. The planet is increasingly dominated by ersatz ecosystems — humansculpted landscapes occupied by haphazard assemblies of introduced species and tolerant natives. These are legitimate objects of study, but there are considerable practical, aesthetic and moral costs of losing natural ecosystems before we can even fully document and understand them.

A key task will be to predict and mitigate this loss of biodiversity and the degradation of ecosystem function. One step is to gauge the resilience of ecological networks such as food webs — in particular, their capacity to withstand disturbance and species loss. This will require insights from many disciplines. Stable isotope analysis and genetic bar-coding should provide a clearer picture of who eats whom in a community.

Change takes place at multiple levels, from individuals to populations, to spatially linked ecosystems. I predict that by 2020, ecological theory will be increasingly concerned with the often subtle biological details of organisms, as well as the implications of evolutionary dynamics. Microbial ecology will become mainstream. At the same time, it will be essential to look at how species and communities fit into Earth's history. In a decade's time, ecology will be viewed both as a core part of biology, and increasingly as an essential dimension of the Earth sciences.

"Ecology will be viewed increasingly as an essential dimension of the Earth sciences."

Metabolomics

Jeremy K. Nicholson
Head, Department of Surgery and Cancer, Imperial College London

The analysis of the chemical fingerprints left by metabolic processes has already started to play a crucial part in personalized medicine, particularly cancer therapy. This stems from the understanding that humans are metabolic superorganisms carrying the genomes of many symbiotic organisms, all of which can affect an individual's physiology. Human metabolism is heavily influenced by interactions between our own genes and the activities of gut microbes, as well as by diet and environmental stressors. The products of this metabolic interplay have a direct influence on susceptibility to disease.

Determining how the body's metabolic processes interact with those of gut microbes is a priority in the coming years, because many conditions, including ulcerative colitis, Crohn's disease, obesity, diabetes and autoimmune disorders, are linked to poor gut health and microbial imbalances. By 2020, personalized health care could involve doctors monitoring the metabolic activities of a patient's gut microbes and, possibly, modulating them therapeutically. The use of mathematical models to interpret metabolic data obtained using nuclear magnetic resonance spectroscopy and mass spectrometry will help us to understand the changing patterns of human disease on a global scale, and generate new targets for drug or nutritional interventions.

*Authors declare competing financial interests: details accompany the article online at go.nature.com/rSQXyc.

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SEEING BRAIN FUNCTION IN A NEW LIGHT

Shimadzu's FOIRE-3000 functional near-infrared spectroscopy system opens a world of possibilities for brain function research, from analysis of emotions to brain–machine interfaces.

Yoko Hoshi
Research Director
Integrated Neuroscience Research Team
Tokyo Institute of Psychiatry

FOIRE-3000 fNIRS System

*f*NIRS

Measurement of brain function using the FOIRE-3000

From blood-flow measurement to brain functional analysis

Yoko Hoshi is one of the leading scientists in the research and development of functional near-infrared spectroscopy (fNIRS) for brain imaging. Hoshi is now research director of the Integrated Neuroscience Research Team at the Tokyo Institute of Psychiatry, but her interest in near-infrared spectroscopy for clinical applications began when she initiated a project for monitoring blood flow in the brain at Hokkaido University in 1987. At that time she had just joined the laboratory of Mamoru Tamura, one of the pioneers of NIRS. Her first target was measurement of the enzyme known as cytochrome c oxidase, which changes oxidation state depending on oxygen supply. "I thought that it could be possible to monitor oxygen in the brain using this approach because the redox state of cytochrome c oxidase changes according to the oxygen concentration in neural cells," explains Hoshi.

The idea of using near-infrared light for brain functional imaging was sparked by a casual remark in a conversation with Tamura. The lab leader, whose research focused on heart muscle at the time, asked Hoshi one day: "When you can't think any more, is it because your brain is suffering a lack of energy?" Hoshi thought that that couldn't be true, but she proceeded to test the idea by monitored the brains of her students using near-infrared light while they worked on some problems she had given them. The measurements showed that blood flow in the brain increased when the students were thinking and decreased when they had stopped working on the problem.

She later turned to the analysis of blood haemoglobin rather than cytochrome c oxidase because the light absorption characteristics of haemoglobin at near-infrared wavelengths change depending on whether or not it is bound to oxygen. "After numerous technical improvements and experiments, we wrote an article reporting that brain function can be measured by monitoring changes in haemoglobin by NIRS," recalls Hoshi.

Joint development with Shimadzu

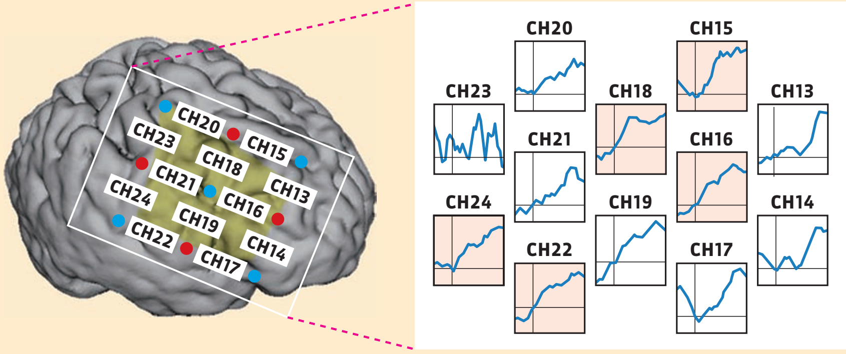
Hoshi's research team at Hokkaido University was later joined by researchers from Shimadzu. The company had already launched efforts to develop a universal model for NIRS under the guidance of Tamura and Hoshi. Eventually, Shimadzu succeeded in developing an NIRS system capable of localized measurements of the head or limbs, and rolled out its first measurement system in 1991. A number of model revisions followed, each with successive improvements, until Shimadzu release the OMM-2001 multichannel fNIRS in 2001. This new model was capable of measuring a more extensive area of the brain, and itself was followed by an improved version, the OMM-3000, in 2003. These instruments began to be used for clinical research, and recognizing this application, Shimadzu launched a research model, the FOIRE-3000, in 2006. Ninety FOIRE-3000 units are now in use for basic brain science studies throughout Japan.

The multichannel fNIRS allows brain function to be monitored on a real-time basis while the patient moves and acts under natural conditions. This makes it possible, for example, to monitor the brain of an infant during interacting with the mother, and to record the function of a brain-injury patient during rehabilitation exercises. "Now, more and more researchers are starting to use fNIRS in the investigation of brain activity for newborn babies and infants. fNIRS is expected to help us understand the mechanism for the development of neural networks," says Hoshi. She also notes a new finding that, during rehabilitation after brain damage, a part of the brain that is inactivate in normal activities becomes involved. Once the damage has been overcome, that same part of the brain no longer becomes active during rehabilitation exercises.

Applied Research on fNIRS in Neuropsychology

Event-related fNIRS shows how cerebral haemoglobin changes during eye movement associated with cognitive tasks.

The graphs below show the changes in oxygenated haemoglobin (oxy-Hb) on the right side as monitored using the FOIRE-3000 fNIRS, averaged over a number of events. Significant increases in oxy-Hb occur in certain channels (CH15,16, 18, 22 and 24) from the first appearance of eye movement (vertical line). Each channel is measured according to a pair of NIR illumination (red) and detection (blue) points.



Data courtesy of Yoko Hoshi, M.D., Ph.D., Tokyo Institute of Psychiatry

Emotion analysis by near-infrared light

Hoshi is using Shimadzu's FOIRE-3000 platform as part of her latest research project. "In my latest work, I am trying to analyse changes in the brain function of a volunteer when viewing images that induce a positive or negative emotional response." Functional magnetic resonance imaging (fMRI) is often used in research involving functional imaging of the brain. However, fMRI is unsuitable for experiments involving real-time emotion analysis because MRI measurements must be carried out while the volunteer is lying inside a narrow tube. With fNIRS, such an experiment can be performed with very little constraint on the volunteers posture or actions.

"Our experiments have revealed that when a volunteer experiences a strong 'unpleasant' emotion, blood flow in a specific part of the brain is enhanced significantly, in as little as 3 to 4 seconds after the onset of the emotion," explains Hoshi. The same experiment also showed that a 'pleasant' emotion reduced blood flow in another part of the brain, consistent with previous reports suggesting that a sense of euphoria reduces blood flow. "Research into affection and emotion often targets the limbic system deep in the brain. However, we think that the parts of the brain that control cognitive activity, like the prefrontal cortex at the front of the brain, may also be involved in the control of unpleasant emotion," comments Hoshi, who is continuing with in-depth analyses.

Unravelling cognitive space

Hoshi has another ongoing project that combines the measurement of eye movement with fNIRS. "When we try to remember something or try to think, we often cast our eyes in a certain direction. I am hoping to find out why," says Hoshi. When we are absorbed in thought, we tend to cast our eyes on something, and the direction of our gaze varies among individuals, even for similar tasks. Children move their heads in a similar manner but with a much broader range, and as they age, the direction and range of their gaze becomes more focused. "Around ten years of age seems to be the critical period when a specific circuit is formed," says Hoshi.

Analysis of the fNIRS data obtained so far by an event-related design approach reveals that two specific areas of the brain are activated as soon as a person starts casting their eyes while engulfed in thought. "One of these areas, called the ventral premotor area, is known to be activated when a person orients their attention toward an object. The other area, called the lateral prefrontal cortex, is known to be activated when a person shifts their attention from one object to another. Psychology and information science both consider the concept of 'cognitive space' in which thinking takes place. Casting our eyes on something during thought may reflect drawing of our attention to this cognitive space and shifting of our attention from one information process to another in this space," she comments.

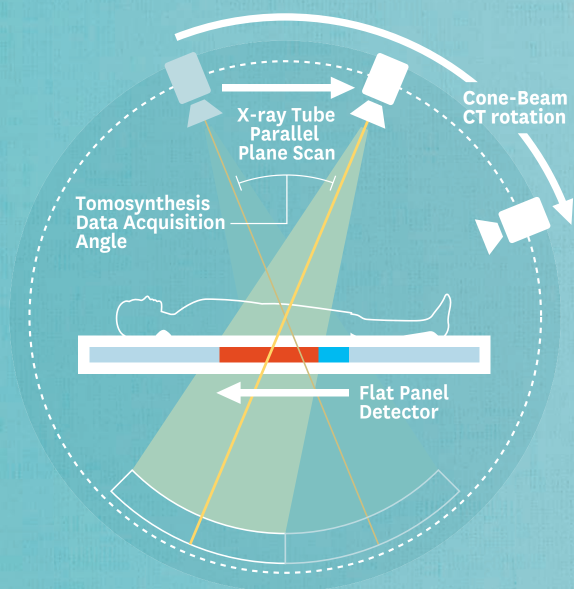
The many possibilities of fNIRS

One of the most valuable features of fNIRS is the ease with which it can be integrated with other analytical methods. It is also a remarkably simple system to use, a factor that has seen the uses of fNIRS extend into a variety of fields, from engineering to teaching, veterinary science and medicine. A particularly exciting area is brain–machine interfacing (BMI). Shimadzu has already began experiments on using BMI to control the famous "ASIMO" humanoid robot developed by Honda. By using fNIRS to characterize the brain function of a volunteer while visualizing manual actions such as moving their hands or feet, the mental efforts of the volunteers could be monitored and processed in real time, and translated into the appropriate signals for robot action.

"fNIRS offers a variety of possibilities. My hope is that researchers will use fNIRS actively in their research projects after learning about the principles of fNIRS and its limitations," says Hoshi. She is one of many researchers who are promoting further development of brain imaging techniques for both basic and applied research.

TOMOSYNTHE
BREAKS NEW GROUND IN ORTHOP

The tomosynthesis functionality supplied as an option in Shimadzu's SONIALVISION Safire X-ray television systems provides rapid and accurate tomography-based diagnosis in outpatient care.



TOMOSYNTHESIS PRINCIPLE

[Limited angle CBCT Reconstruction method / 3D Filtered Back Projection]

Assuming the linear tomographic scan as a part of CBCT rotation, the reconstruction algorithm expanded from FeldCamp 3D Filtered Back Projection is implemented for Tomosynthesis.

With its ageing population, Japan is facing an ever-growing need for orthopaedic care. Sports injuries are similarly on the rise as public interest in fitness continues to grow. According to a study by Japan's Ministry of Health, Labour and Welfare, musculoskeletal pain — including lower back pain, stiff shoulders and knee and wrist pain — is the most frequently reported subjective symptom of health problems in the Japanese population. After internal medicine, the orthopaedics department is the second most in-demand department in hospitals, particularly for outpatient care.

For orthopaedists, who are regularly presented with patients having a wide variety of symptoms and conditions, imaging is central to successful diagnosis. Typically, an initial X-ray is followed up with any of a range of tomography scanning options, including magnetic resonance imaging (MRI) and computed tomography (CT) scanning as necessary for detailed diagnosis.

'Tomosynthesis' is a new technology that is now available as a diagnostic imaging option. A technique for obtaining X-ray tomographic images, tomosynthesis is well suited for outpatient care, yet it can produce high-definition images with useful characteristics offered by no other form of diagnostic imaging. Hiroyuki Tsuchiya, the Professor of Orthopaedic Surgery at the Graduate School of Medical Science of Kanazawa University, is a specialist in orthopaedic oncology as well as limb reconstruction and lengthening surgery. He has already begun using tomosynthesis in orthopaedic diagnosis. "Tomosynthesis is superior to CT in many ways as the technology to obtain tomographic images of bones and joints," he says. Tsuchiya is using the optional tomosynthesis function incorporated into Shimadzu's X-ray television system, the SONIALVISION Safire.

High-resolution tomographic imaging in just 5 seconds

Tomographic imaging is typically performed to observe bones and joints in the hip, back of the hand or foot, and other complex joints. CT is traditionally used in such cases, but tomosynthesis is able to achieve a spatial resolution of just 0.25–0.30 mm — a two-fold improvement over conventional CT in the coronal (front-on) and sagittal (side-on) planes. Moreover, a tomosynthesis image can be captured in as little as 3–5 seconds, resulting in significant reduc-

SIS
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A SONIALVISION Safire X-ray television unit installed at Kanazawa University Hospital

tions in patients' radiation exposure — only twice that of regular X-ray and ten times lower than for CT.

Shimadzu's tomosynthesis solution includes a proprietary 'X-ray sensor direct-conversion system' that allows complete tomographic imaging data to be captured in a single 5-second scan. The final image is reconstructed on the basis of multiple simultaneously acquired image slices. Shimadzu's flat panel detector (FPD), which is installed under the patient-bearing tabletop, converts the projected X-ray data directly into a digital signal.

The diagnosing physician can check the image by extracting any slice, from front to rear parallel to the tabletop, from the data obtained by a single tomographic scan. Any slice parallel to the tabletop can be extracted, and the tabletop itself can be tilted by up to 89 degrees. This makes it a breeze to generate, for example, a tomographic model of a knee joint in the standing position while subject to gravitational load. Along with the short scanning times, the physician can perform scanning with a higher degree of freedom than is possible with CT. Scanning in standing and inclined positions offers unique opportunities for diagnosis and can greatly ease the burden on patients during tomographic scanning.

A clearer view inside bone and bone-forming area

The superior resolution of tomosynthesis is especially powerful in the observation of trabecular bone, explains Tsuchiya. Bone is made up of an outer layer of hard, high-density cortical bone and coarse internal trabecular bone. CT resolves cortical bone clearly, and can generate a good picture of bone contour, but the details of trabecular bone are not visible in CT images. Tomosynthesis allows for the acquisition of detailed images of trabecular bone structure. This can be immensely useful. Take the case of fractures, for example. Following a fracture, bone is regenerated through the formation of immature bone (callus) leading to bone fusion. Using tomosynthesis, it is possible to check that bone fusion is proceeding properly.

Bone necrosis is another key area where tomosynthesis provides unique imaging opportunities. Some rare diseases can cause progressive bone death, or necrosis, and the marginal areas around affected bone are sites of bone formation. Tomosynthesis is capable of capturing a clear image of these regenerating areas of bone, making it possible to use the technique for diagnosis of bone necrosis. Tomosynthesis is also useful for the qualitative diagnosis of bone damage in rheumatoid arthritis and bone tumours.

Less metal interference means better imaging following joint replacement

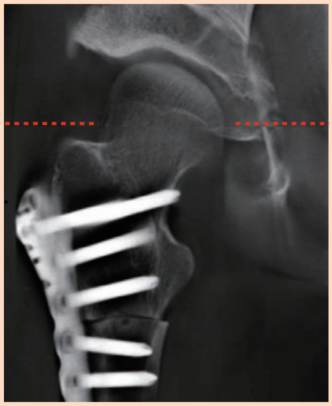
Another important feature of tomosynthesis is that it deals well with metal implants and joints, as well as externally fixed metal frames. In CT scanning, metal can produce false images or artefacts, posing difficulties for accurate diagnosis, and X-ray cannot capture the cross-sectional images needed for enhanced diagnosis. Tomosynthesis is much less sensitive to metal objects, making it easier to observe the bone around artificial metal joints.

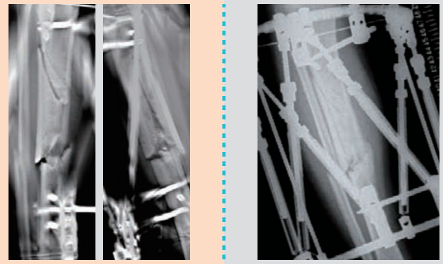
Joint replacement is becoming increasingly common. More than 150,000 joint replacements are performed each year in Japan, and about one million are performed annually in the US. Treatment outcomes is generally favourable, particularly for hip and knee replacements, and increasingly this type of surgery is being conducted on younger patients, not just the elderly. The need for periodic checkups for any loosening around the artificial joint is therefore becoming important. If loosening occurs after long-term use, some necessary components of the artificial joint may need to be replaced. Early detection can provide considerable advantages, including simplification of the necessary procedure for replacement of parts.

Tomosynthesis is extremely effective in follow-up for joint replacement, not only because of the significant amount of metal used in the joint, but also for the technique's ability to clearly image bone fusion and the formation of bone on the surface of the artificial joint. Artificial joints are fabricated to have a surface partially inscribed with microscopic recesses to promote fusion with natural bone. Tomosynthesis is capable of showing the ingrowth of bone into these recesses.

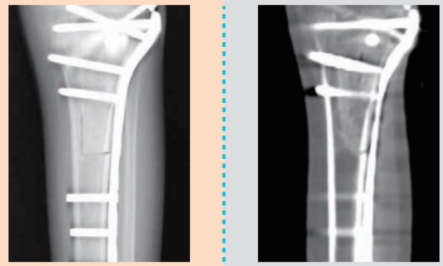
	Tomosynthesis Image		X-ray or CT Image	

Composite tomosynthesis image of sites of bone surgery on the hip and femur.





Tomosynthesis (left) and X-ray (right) images of a fractured lower limb immobilized with an external metal frame. Bone formation and repair is much clearer in the tomosynthesis image.

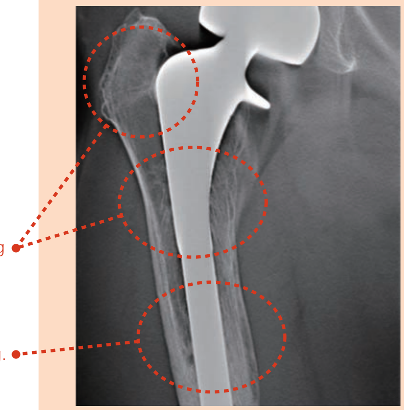


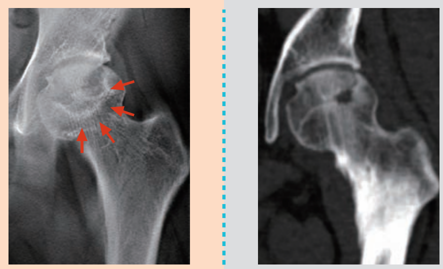
Tomosynthesis (left) handles metal implants more effectively than conventional CT (right), making it possible to monitor bone formation.

Tomosynthesis image of an artificial joint following femur replacement. Bone growth into recesses on the surface of the artificial joint can be clearly imaged.

New bone is growing into the recesses of the artificial joint.

New bone is forming.





Tomosynthesis (left) can clearly resolve the boundary between dead and living bone. Such analyses are not possible with CT (right).

Adoption of tomosynthesis for diagnosis and follow-up

Tsuchiya has been using Shimadzu's tomosynthesis in his practise for some time, so he has developed a good understanding of the technique's benefits. Tomosynthesis allows the practitioner to view any coronal or sagittal two-dimensional slice taken during the scan. He notes, however, that for certain purposes, a three-dimensional (3D) reconstruction, like that generated by CT, can be useful. "A 3D image is more difficult to work with when determining bone fracture, but sometimes a 3D model can be useful when explaining complex joint features to patients," says Tsuchiya. "A person's backbone can also become twisted with age, and in such patients, it would be helpful to synthesize the scanned tomosynthesis images into a single model by computer."

In addition to general orthopaedic care, Tsuchiya is specialised in care for difficult cases, including bone tumours, post-traumatic complications and congenital disorders. He has always focused his efforts on the development of new diagnostic and therapeutic approaches. Some of his successful developments include a therapeutic procedure consisting of surgical removal of the bone part affected by a tumour, followed by the killing of tumour cells using liquid nitrogen and then returning the treated bone to the original state. He has also developed therapeutic procedure designed to promote the formation of new bone following the removal of tumour-affected bone. "What's important in the development of a new procedure is to try out any new idea at once to find out whether the new idea is really helpful," he says. Tomosynthesis holds great promise for accurate determination of bone condition in such cases.

SONIALVISION Safire instruments equipped with the tomosynthesis system as an optional feature have already been installed in many hospitals. "The system is easy to use and will be of great help in everyday orthopaedic care," says Tsuchiya.

Hiroyuki Tsuchiya

Professor and Chairman
Orthopaedic Oncology
Limb Reconstruction and Lengthening Surgery
Department of Orthopaedic Surgery
Graduate School of Medical Science
Kanazawa University

Shimadzu's products fit Latin America's special needs

With Brazil's economy flying again, Shimadzu is well positioned to see its business soar.

This is a good time to be in Brazil, says Akihiko Kato, president of Shimadzu do Brasil Comercio Ltda (Shimadzu Brazil). As one of the most exciting emerging economies, Brazil was among the first to recover from the recent global economic downturn and enjoys an annual GDP growth rate of around five percent. "So the public and private sectors continue to receive healthy investment," says Kato. "We see improvements being made in infrastructure and in health care, in particular, making it a good business environment for Shimadzu."

Kyoto-based Shimadzu Corporation is a leading global manufacturer of scientific instruments, medical equipment and high-precision processing equipment for industry. It first ventured into South America in 1980 when it opened a representative office in Argentina; in 1988 it opened a similar office in Sao Paulo, Brazil, the country's largest city, then a decade later established a full subsidiary there to serve the entire Latin America region.

"In the same year the Brazil company was founded, 1998, we also began direct sales of our medical systems to complement the work of our Brazilian distributor," says Kato. "A couple of years later we started direct sales of certain analytical instruments." The markets in Brazil and in other countries in the region "are particularly price-sensitive compared to developed countries," Kato notes. "So our entry–level and mid-range products are finding wide acceptance, not only for their competitive pricing, but also for the quality and features they provide."

Case in point is Shimadzu's high-performance liquid chromatographs used in biochemistry and analytical chemistry to identify, quantify and purify individual components in a mixture of compounds. "Thanks to their cost-performance and market competitiveness, our liquid chromatographs are our best selling instruments," says Rafael Rossetto, general manager of the Analytical Instruments Division.

Shimadzu is also experiencing success with its analytical X-ray instruments, especially its X-ray diffractometer (XRD) and energy-dispersive X-ray (EDX) fluorescence spectrometers employed in academia as well as mining and other industries in Brazil for elemental analysis. "In fact, both the XRD and the EDX are market leaders, outselling traditional American and European brands, thanks to their cost-performance," says Rossetto. Shimadzu also holds the number-one market position for electronic balances and scales. "Last year we succeeded in selling 3,800 balance units, making it a best-seller," adds Rossetto.

The Medical Division is making inroads throughout the region. "We've won some major volume orders for our fixed and mobile X-ray machines from organizations like the United Nations Office for Project Services in Peru," says Constantino Luiz Di Pipi, general manager of the Medical Systems Division. "In Mexico, we recently won an order to supply over 80 units of our popular mobile X-Ray model, the MobileDaRt Evolution. And Brazilian government ministries and the World Bank also opted to purchase our X-rays because of their reliability, quality, cost-performance and after-sales support." In fact, most purchases from Shimadzu in Latin America, he notes, are made by government organizations.

In Brazil, a new market is opening up that holds great potential for Shimadzu. "To reduce harmful emissions, there is a lot of research and development activity in alternative energy in Brazil, including bio-ethanol and bio-diesel produced from crops such as sugar cane, soybean and palm-tree oil," says Rossetto. "So we're seeking to break into these emerging

markets by promoting our gas chromatograph and gas chromatograph/mass spectrometer systems."

On the medical front, Latin America is now investing more in health care, hospitals and clinics. "So we have high hopes for equipment such as our digital radiography systems," says Di Pipi.

In the 22 years that Shimadazu Brazil has been operating in South America, it has seen the employee count rise from just two to over 80. "Last year our total South America turnover was more than four billion yen, or around US$47 million, up by around 12 percent," says Kato. "And with the Brazilian economy taking off again, we think our business prospects look very rosy indeed."

Akihiko Kato, President

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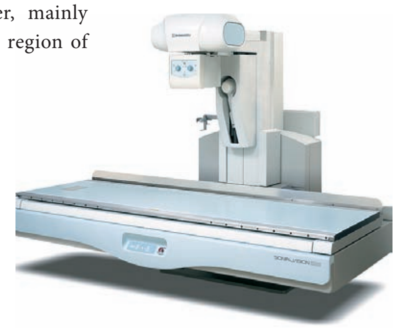
New Medical Instruments Plant Constructed at Head Office Plant Site

The new plant is used to manufacture large medical instruments, such as angiography systems, X-ray tubes, and other products.

In addition, Shimadzu has located the core departments responsible for service and quality assurance within the plant site to facilitate cooperation between the respective organizations and functions. This will allow us to supply high quality products and services tailored to customer needs more efficiently.

Increased Sales of Tomosynthesis Systems in China's High-End Medical X-Ray Equipment Market

The tomosynthesis function incorporated in Shimadzu digital X-ray radiography systems has been highly praised in China for its usefulness in the field of orthopedics and the diagnosis of lung cancer. Consequently, sales of systems equipped with this function to leading hospitals have been brisk. Based on this strong user base of leading hospitals, we wish to promote the tomosynthesis system further, mainly among core hospitals in each region of the country.



New Product Provides Low Exposure Levels and Smooth X-Ray Examinations

The new RADspeed Pro is a film/CR/FPD-compatible diagnostic imaging system that is, for example, used in basic examinations (general radiography) of the chest and abdomen, and in the field of orthopedics. By achieving significantly lower exposure levels and reducing the time patients must remain still, this system provides a safer, more pleasant examination experience for patients of all ages, from infants to the elderly.

Greatly Improved Analytical Efficiency for New Drug Development and Quality Control

We have released the Nexera Ultra High Performance Liquid Chromatograph, which features the ability to withstand pressures of up to 130 MPa, one of the highest levels in its class, worldwide. Reducing the analysis time required for development and quality control of food and drug products to less than a twentieth of the time currently required (compared to previous Shimadzu results), this system promises dramatic improvements in analytical efficiency.

Research Theme Proposed by Shimadzu Fellow Koichi Tanaka Chosen for National Program Supporting Innovative R&D

A joint research project between Shimadzu Fellow Koichi Tanaka (2002 Nobel Laureate in Chemistry) and Kyoto University has been chosen for the "Funding Program for World-Leading Innovative R&D on Science and Technology," a program in which the Japanese government selects and supports research projects by thirty innovative Japanese researchers. Through this research, Fellow Koichi Tanaka aims to develop the world's highest performance mass spectrometer system to help establish methods for early diagnosis and treatment of the underlying causes of cancers, Alzheimer's, and other diseases.

Improved Line of Energy-Saving Products Geared Toward Realization of a Low-Carbon Society

We have started a "Save the Energy Project" that, with a view to realizing a low-carbon society, aims to improve our line of energy-saving products. By reducing the power consumption of our major products, such as analytical and measuring instruments, by at least 25 %, we aim to contribute to reducing our impact on the environment.

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