

transformational SCIENCE



Life Sciences in Thailand

Supplement to
TheScientist

Think Asia, Invest Thailand

By the year 2020, it is projected that Asia will comprise almost half of the world's economy. How can businesses take advantage of this emerging Asian Century? They must find the gateway to Asia.



STRATEGIC LOCATION

Thailand's strategic location at the heart of Asia makes it ideal for businesses to capture a huge market. The fast growing Southeast Asian region, to which Thailand belongs, is home to more than 580 million consumers. Add to that, Thailand's friendly trade relations and expanding free trade agreements with such strong economies as China, India, Australia, and New Zealand and you have access to three billion consumers.

STRONG ECONOMIC FUNDAMENTALS

Thailand itself is a big market of 65 million consumers. The overall economy and several key sectors continue to grow.

Thailand is the world's largest natural rubber producer and the #2 exporting country for sugar. It is the world's largest hard disk drives producer with over one third of the world market, and is well on the way to be among the world's top ten auto manufacturing countries. At the same time, it ranks 18th on the world's largest tourist receipts list and the world's 19th largest in purchasing power.

EXCELLENT INFRASTRUCTURE

Thailand has developed the country's infrastructure to world-class standards, which supports the growth of key economic sectors and has led to the development of comprehensive industrial clusters. Modern industrial estates, state-of-the-art transportation, communication facilities, and logistics system help achieve cost-effective business operations.

Today, there are almost 60 industrial estates, industrial zones, and industrial parks spread across every region in Thailand. Many of Thailand's industrial estates are truly world-class, offering a comprehensive range of services and infrastructure such as electricity, water supply, flood protection, waste water treatment, solid waste disposal, communication facilities, and security systems, etc. Some estates also have customs offices, schools, hospitals, shopping centers, and other facilities needed by investors and workers.

SKILLED WORKFORCE

The Thai government understands the need to provide a skilled workforce and has taken vital steps to further upgrade the quality of the country's workforce. Human resources development and



skills training are promoted to enable Thai workers to keep pace with modern technology and competition.

PROACTIVE AND LIBERAL GOVERNMENT POLICIES

Through the Thailand Board of Investment (BOI), the government offers a range of tax and non-tax incentives and support services. Examples of tax incentives offered to BOI promoted companies are three to eight years of corporate income tax holidays, and exemption or reduction on import duties for machinery and raw materials. Non-tax incentives include permission to own land and facilitation in bringing in foreign experts.

In addition to the many incentives offered directly by the BOI, the government also facilitates foreign investment in a number of ways. For instance, there are no foreign equity restrictions in the manufacturing sector, no local content requirements, and no export requirement.

RENOWNED HOSPITALITY

Thailand's culture, service-oriented attitude and renowned hospitality further differentiate the country from other investment destinations. Accommodation and leisure facilities are great and varied and the country is famous for beautiful sceneries, tourist attractions, and colorful festivals. In addition, health care is among the best in the world and the country's international schools are truly world class.

EASE OF DOING BUSINESS

Thailand has maintained an investor-friendly environment. In its 2010 Ease of Doing Business survey, the World Bank ranked Thailand #12 worldwide.

The Thai government supports investors through the Thailand Board of Investment (BOI). The BOI actively promotes and implements fast and efficient services to investors, including promotional privileges that help make them globally competitive.



BUSINESS START-UP

Starting a business in Thailand is easy. For investors interested in investing in Thailand, the BOI offers investors a wide range of investment-related services and maintains the One Start One Stop Investment Center (OSOS), which consolidates staff from 21 investment-related agencies at one permanent location. Through the One-Stop Service Center for Visas and Work Permits, BOI-promoted investors can receive their work permits and visas within three hours, and the BOI can introduce investors to business partners, including parts and component manufacturers and service providers. All of this contributes towards making it easy to do business in Thailand.

HELP AT HAND

Investors interested in learning more about BOI incentives and the application process can contact the BOI through either its main office in Bangkok or its regional offices throughout the country. The BOI also runs a number of overseas offices in the United States, France, Germany, Sweden, Japan, China, Taiwan, Korea, and Australia. ■



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NSTDA

Accelerating Science, Technology, and Innovation Development in Thailand

With the ultimate goal of becoming a knowledge-based society, Thailand sees opportunity in the midst of an economic crisis where science, technology, and innovation can play a vital role in achieving an economic turn-around and sustainable growth over the long term. With an abundance of natural resources coupled with a strategic geographical location, education and research will be the tools used to transform these indigenous resources into products in high demand in the global marketplace.

“Our role is to help our nation prosper in an increasingly competitive global economy by enabling the industrial, agricultural, and services sectors to do things better and smarter through research and innovation,” said Dr. Sakarindr Bhumiratana, president of the National Science and Technology Development Agency (NSTDA), an autonomous state agency that is responsible for building Thailand’s science and technology capacity.

NSTDA’s mission is to promote and bring to fruition research and innovation via competitive R&D funding; effective knowledge and technology transfer; highly qualified human resources development; and building first rate S&T infrastructure.

TRUE VALUE OF INNOVATION

Good innovation must bring added value to existing products and services, while generating a positive socio-economic impact on the wealth and quality of life for the people of Thailand.

NSTDA pursues a cluster-based approach to its funding and management of R&D. The eight national clusters are food and agriculture; medicine and public health; renewable energy; software, microchips, and electronics; automotives and traffic; environment; textiles; and rural communities and the underprivileged. The selection of these clusters reflects national social and economic priorities. The clusters are supported by a range of technology platforms designed to meet the needs of Thai industry. The research output of the various clusters is closely monitored to ensure ongoing industrial relevance. “This new approach to R&D management is fostering a research culture at NSTDA where scientists work closely with a number of key stakeholders including universities, state agencies, and the private sector

to develop innovative products and services that meet the ever-changing needs of industry and society,” added Dr. Bhumiratana.

KITCHEN OF THE WORLD

For most of the last decade, Thailand was ranked among the top 10 of food-producing countries worldwide. The country is currently the world’s largest rice exporter, contributing around 10 million tons of the annual 30 million tons of international rice trade. The country is the world’s largest rubber producer and second-largest sugar exporter, and also Asia’s top exporter of chicken meat, shrimp and several other commodities, thus feeding more than four times its own population.

NSTDA’s R&D stronghold in the areas of agriculture and food through its four National Research Centers ranges from seeds, rice, cassava, algae, post-harvest processing, greenhouse, and longer shelf life food packaging for export to agricultural produce quality assurance. Advancement in biotechnology for probiotics, nutraceutical foods, herbal medicine, and pharmacogenomics is also expected to contribute to the growth of the functional foods industry.

NSTDA’s contributions, in partnership with other governmental and academic institutions, include cracking the code of jasmine rice genes; drought, flood and salinity-resistant rice varieties; smart greenhouse; smart farming; new environmentally-friendly chemicals for processing of liquid latex; and seed improvement technology, and help to boost productivity in the agriculture sector. Some of these technologies have been transferred to the rural agricultural communities for their self-reliance. Others are prototyped products that are made affordable and/or accessible to farmers. Some have been licensed, transferred, and made ready for commercialization.

DEALING WITH CLIMATE CHANGE

As a net importer of hydrocarbons with the gap between demand and supply expected to grow in the future, for the past decade Thailand has advocated energy conservation and initiated programs to develop renewable sources of energy. Biofuels have been increasingly appraised as alternative sources of energy, opening new income opportunity for farmers.



By encouraging the development and investment in biofuels, research on this front is being pursued at NSTDA—from the plantation to production and to quality assurance. NSTDA carefully chooses to investigate oil palm and jatropha as the second generation energy feed stocks. The breeding technology gives higher yield to these crops and makes them more adaptable to different soil surfaces.

Solar energy research is another area promoted by NSTDA. R&D focus is placed on thin-film technology of amorphous silicon, microcrystalline silicon, and dye-sensitized organic solar cells. Emphasis is given to the scale up from laboratory to an industrial scaled prototype. Fast progress has been made in Thailand for its switching to cleaner energy resources, and several active international research collaborations on advanced clean energy technologies are being pursued. “Thailand’s commitment to the mitigation of climate change will not only reduce the country’s carbon emissions but will also contribute to the promotion of Green Energy in the region,” remarked Dr. Bhumiratana.

THAILAND'S HUB OF SCIENCE, TECHNOLOGY AND INNOVATION

Bridging the gap between research and the marketplace, through alliances with universities, industry, and government, NSTDA engages with the private sector through joint R&D, knowledge and technology transfer, and S&T related services in an effort to stimulate the growth of knowledge-based businesses. In “Thailand Science Park”, research tenants have access to NSTDA’s scientists and the most advanced R&D infrastructure including laboratories and equipment, pilot plants, and testing units of NSTDA’s four National Centers.

Today, Thailand Science Park houses NSTDA, BIOTEC, NECTEC, MTEC, NANOTEC, TMC and 60 private companies, whose economic impact is worth US\$ 100 million, while employing a skilled workforce of over 500 (60 percent of whom are directly involved in R&D).

To meet the rapidly growing demands, NSTDA has started construction of Thailand Science Park, Phase II, which will be called Innovation Cluster II (or INC II). This new phase is expected to be fully operational by 2011. By encouraging closer interactions within the research community, Thailand Science Park will accelerate the establishment of knowledge-based enterprises, create new markets, and drive economic growth forward through cooperation between the public and private sectors.

ABOUT NSTDA

NSTDA helps Thailand prosper in the global economy by enabling the industry, agriculture, and services sectors to do things better through superior capabilities utilizing science and technology. Research contributions and capability building are accomplished by promoting and pooling our strengths together through four National Research Centers: BIOTEC, MTEC, NECTEC, and NANOTEC, and one Technology Management Center: TMC. Close collaboration with other government agencies, universities, and the private sector leads to valuable strategic partnerships and innovation alliances NSTDA and its Centers are operated by more than 2,500 scientists, researchers, and support staffs. The goal is to accelerate and streamline the transition from research to a marketable product. ■

NSTDA has four affiliate National Centers and one Center dedicated to Technology Management. All are focused on building Thailand’s S&T capacity where research becomes the foundation for the country’s future. Key areas of research focus for these Centers are:

BIOTEC - Genomic Technology & Cell Factory Technology

MTEC - Design and Simulation for Materials and Manufacturing & Materials Design and Production

NANOTEC - Nanocoating, Nanoencapsulation, & Functional Nanostructures

NECTEC - Sensor Technology, Knowledge Engineering Technology, & Information Security Technology

TMC - Technology Transfer & Commercialization of Discoveries and Technologies



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ON THE COVER

The four paintings reproduced here and on each section page are the creation of three elephants—Japati, Prathida, and Look Gob - trained in Thailand's Elephant Art Project. The project is a nonprofit organization dedicated to saving the diminishing number of Asian elephants. Funds for this mission are raised partly through the sale of art created by elephants.

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BIOTEC

Excellence in Science, Relevance to National Agenda

Established in 1983, BIOTEC is one of four centers under the umbrella of the National Science and Technology Development Agency (NSTDA), an autonomous government body. The Center serves as an effective channel for biotechnology transfer and development, supporting the industrial, agricultural, ecological, economic, and social development of Thailand.

FORGING STRONGER RESEARCH CAPABILITY

BIOTEC has three thematic research programs focusing on the industrial sector, namely Agriculture and Food Biotechnology, Bioresources Technology, and Medical Biotechnology. Platform technologies have been created to strengthen capacity in certain technologies and subsequently provide knowledge platforms for the thematic research programs.

Agriculture and Food Biotechnology

Focus is on research and development of food, plant, and animal biotechnology, with a special emphasis on using biotechnology to improve yield and quality. Plant Biotechnology focuses on three economically important plants: rice, cassava, and oil palm. Animal biotechnology at BIOTEC focuses on shrimp and dairy cow. The aim of this research is to understand the molecular biology of reproductive maturation, growth, and the immune system of the black tiger shrimp in order to improve farming sustainability, including genetic improvement. Food Biotechnology aims to improve and upgrade the processing and quality of fermented food. Three main research areas are food safety and risk assessment, food chemistry, and starter culture technology.

Bioresources Technology

Bioresources Technology focuses on research and development for the preservation, utilization, and conservation of bioresources. The program has a special emphasis on the utilization of biotechnology as a core technology to increase the value of commercial products, such as food and feed products, enzyme products, drug and bioactive compounds, and biocontrol products. Research topics include:

- Taxonomy of microorganisms especially fungi, yeasts, and actinomycetes

- Developing throughput biological assays
- Natural product chemistry
- Pre-pilot scale production of commercially valuable bioproducts
- Enzyme discovery
- Recombinant expression systems
- Biodiversity and ecology of plants, animals, and microorganisms

Medical Biotechnology

Focus is on research and development to advance knowledge on neglected diseases such as malaria, tuberculosis, and dengue fever, which are still prevalent in Thailand. Malaria research aims to understand the mechanisms of drug resistance and synthesize new drugs. The main strategies involve rational drug design and the synthesis of new effective antimalarials based on the structures of the drug targets. Tuberculosis research focuses on drug target identification, validation, and drug screening. Dengue research focuses on the molecular and immunological processes involved in the pathogenesis of dengue hemorrhagic fever (DHF) and its more severe form, dengue shock syndrome (DSS), and its future application for better diagnosis and prevention of the disease. The two main approaches are the development of dengue infectious cDNA clone models to generate mutant viruses and the application of these models, such as dengue diagnostic technology. In addition, the live attenuated vaccines generated by mutation of selected polyprotein cleavage sites using site-directed mutagenesis are being tested in animal models for their vaccine potential.

Platform Technologies

Platform technologies focus on building capacity in technologies and subsequently providing knowledge platforms for the thematic research programs. Platform technologies include:

- **Metagenomic technology.** Metagenomics provides a new way of examining the microbial community by using the power of genomic analysis and bypassing the need to isolate and culture individual bacterial community members. In order to search for microbial producing enzymes from the unusual environment for enzyme discovery, metagenomics



technology has been recently established to provide a facility for research, especially for a bioresource utilization theme.

- **Gene expression system for recombinant protein production.** BIOTEC aims to develop heterologous gene expression systems in various hosts, such as *Bacillus*, yeast, and filamentous fungi for production of recombinant proteins, including enzymes. Currently our researchers have successfully developed a *Pichia pastoris* yeast expression system for surface protein expression. In addition, a multi-copy expression system in yeast is also being developed. This expression technology will play a significant role for the production of valuable products from newly discovered genes.
- **Genomics technology.** The objectives of the Genomics Technology platform are to improve the capacity of genomics and post-genomics research in Thailand, to strengthen the infrastructure and human resources and to facilitate the application for agricultural, medical, industrial, and environmental solutions. Founded in 2007, the Genome Institute focuses on research and development of technologies related to genomics, high-throughput sequencing, proteomics, bioinformatics, and systems biology. The GI also provides scientific assistance in high-performance computing (HPC) as an infrastructure for scientific communities in Thailand. Currently, GI houses the following genomic EST and genomic databases: rice, shrimp, cassava, spirulina and ThaiSNP, accessible through the Internet.
- **Microarray technology.** Microarray is the latest additional technology to complete the study at both gene and gene function levels. BIOTEC's microarray laboratory is equipped with technologies to fabricate array chips in-house, as well as applying them in various aspects of research and development.

HIGH-CALIBER SCIENTISTS, HI-TECH FACILITIES

BIOTEC has established laboratories for research and/or for providing technical services. Some act as independent research centers while others are collaborative ventures with government agencies and universities. Currently, BIOTEC employs almost 150 researchers, with doctorate degrees in core technologies from overseas, and 200 technicians and laboratory staff. All work in close collaboration with academic staff and experts across the country through any of the following units:

- BIOTEC Central Research Unit
- Bioresources Technology Unit
- Genome Institute
- Biochemical Engineering and Pilot Plant Research and Development Unit
- Excellent Center of Waste Utilization and Management (ECoWaste)
- Cassava and Starch Technology Research Unit
- Rice Gene Discovery Unit
- Medical Biotechnology Research Unit
- Biomedical Technology Research Center
- Center of Excellence for Marine Biotechnology
- Center of Excellence for Shrimp Molecular Biology and Biotechnology
- Center of Excellence for Molecular Biology and Genomics of Shrimp
- Shrimp Genetic Improvement Centers
- Peat Swamp and Rainforest Research Station

MEMBER OF THE GLOBAL SCIENCE COMMUNITY

With well-equipped infrastructure and capable researchers, BIOTEC has actively participated in several international scientific networks and consortia, for instance the International Rice Genome Sequencing Project, Pan-Asian SNP Consortium, Generation Challenge Program (GCP), WHO-TDR South-South Initiative for Tropical Diseases Research (SSI), Medicines for Malaria Venture (MMV), Asia-Pacific International Molecular Biology Network (A-IMBN), and Asian Consortium for the Conservation and Sustainable Use of Microbial Resources.

Although the majority of the research funding is provided by the Thai Government, BIOTEC also obtains support from international funding agencies such as the World Health Organization, Medicine for Malaria Venture (MMV), Howard Hughes Medical Institute (HHMI), the Generation Challenge Programme (GCP), The Wellcome Trust, Medical Research Council (MRC), UNESCO-L'OREAL for Women in Science Program, UNESCO Man and Biosphere (MAB) Program, and the Swedish Research Council, demonstrating that the quality of BIOTEC's research is on a par with international standards. Two scientists were awarded the Grand Challenges Explorations (GCE) grant from the Bill & Melinda Gates Foundation in 2009. ■

East-West Seed

Better Seeds for Better Yields



East-West Seed has grown from a young vegetable seed company, established in 1982 in the Philippines, into the market-leading supplier of tropical vegetable seeds in just 25 years. As a result of its strong emphasis on plant breeding research and seed quality, East-West has helped transform the traditional, trading-oriented vegetable seed markets of South-east Asia into a major market for quality seeds. The reliability and quality of the East-West Seed product range has had a direct impact on improving the lives of millions of small farmers. The more than 200 billion seeds East-West Seed sells annually are planted by an estimated 30 million farmers.

The two-pronged approach of intensive interaction with farmers, traders, and consumers and developing varieties adapted to local conditions has been the key to East-West Seed's success. The company's hands-on exchange of knowledge and experiences with farmers has benefitted both the farmer-customers and the business. Through a network of field representatives, the company is able to understand firsthand the challenges farmers face, and at the same time assist growers in achieving better results with East-West seeds.

Teams of experienced plant breeders, supported by experts in plant pathology, cell biology, and molecular biology, focus on improving disease and pest resistance to increase yields and to reduce excessive chemical inputs. The company's new research

center in Chiang Mai, Thailand houses the central biotechnology laboratory, providing support to the various research units of the East-West Seed group. The company has one of the foremost tropical vegetable germplasm collections in the world, an important foundation of the company's plant breeding programs.

East-West Seed's recent acquisition of shares in Dutch biotech company, Genetwister Technologies BV, is expected to provide a strong impulse to further develop innovative technologies and applications for the benefit of its breeding programs. East-West Seed's present research network includes facilities and projects in the Philippines, Thailand, Indonesia, Vietnam, India, China, and Tanzania. Market development specialists are exploring opportunities to repeat the company's success in other geographical areas in the tropical and subtropical belt.

Bittergourd (*Momordica charantia*), an important tropical Asian cucurbit, is the flagship crop in the East-West Seed product range. The crop is not just a healthy vegetable but is also known for its medicinal properties, particularly its anti-diabetic properties. Development of new hybrid markets started in many countries with successful introduction of hybrid bittergourd varieties: Jade Star and Galaxy in the Philippines, Palee in Bangladesh and India, and hybrids 241 and 242 in Vietnam. Main breeding objectives include improved fruit quality and resistance to major diseases such as Fusarium wilt, various viruses, and powdery mildew. ■

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Thailand's Transformational Science

There's no arguing that Thailand is emerging as a world-class player in the arena of biotechnology research. Last September, the country made international headlines for hosting the world's largest HIV vaccine trial. Based on HIV strains that commonly circulate in Thailand, the RV144 vaccine trial involved 16,000 participants and demonstrated a lowered rate of infection by 31 percent. Another milestone was reached last year when a government agency produced a local version of the H1N1 vaccine, now in trial (see "Spreading Influence," p. 60).

The exciting news is that these aren't random or lucky outcomes, but results based on strategic planning. The best and brightest of Thailand's biotechnology community established the National Biotechnology Policy Framework in 2003, covering business development, agriculture, medicine, renewable energy, a self-sufficient economy, and human resources. The success of the Framework depended on supporting a young generation of professionals (see "Mapping the Terrain," p. 12). Remarkably, it worked: now Thailand is a leading research center for diseases that plague developing countries—e.g., malaria, dengue fever, tuberculosis, HIV, and thalassemia.

Not to mention strides in agriculture and fisheries (see "The Future of Farms," p. 28). For example, a young biologist recently employed microarray technology to develop a more disease-resistant and faster-growing black tiger shrimp—an export vital to the Thai economy. And not only the latest biotech has put Thailand on the map, but also old-fashioned grassroots experimentation. Using tools no more sophisticated than a needle, scissors, and paper, a local farmer developed a blast-resistant rice strain that has seen widespread use throughout the countryside.

As might be expected, there have been missteps along the way. "Leakage" of genetically modified papaya created a firestorm of public protest and threatened the nation's food supply, public health, and the future of scientific research in Thailand. The government initially responded with denial and attempts to manipulate the truth. However, with legislation currently pending, strict controls and oversight will likely be implemented to reassure the public and give

scientists the tools they need to move on to the next generation of R&D.

This episode and other politically charged incidents have challenged this newly robust industrial nation and highlight the importance of environmental concerns. Sustainable energy and the protection of Thailand's biodiversity are perhaps the two most critical issues. As climate change threatens the fragile countryside, scientists are hard at work trying to lessen its impact (see "Biotechnology in the Era of Climate Change," p. 78). Changing weather patterns, water shortages, and the shift from a predominantly agrarian society have all contributed to the disruption of an ecosystem. However, scientists are trying to understand these changes to devise new ways of reducing fossil fuel consumption and the resulting CO₂ emissions.

One such preventive measure has been strict laws against deforestation. While this has been a boon to the surviving wildlife, it left over 4,000 elephants that had worked in the lumber industry homeless and unemployed. This spurred the founding of the Thai Elephant Orchestra by Richard Lair and performer/composer Dave Sulzer, a neuroscientist at Columbia University. And conceptual artists Komar & Melamid founded the Asian Elephant Art and Conservation Project. Three of their most talented prodigy—Japati, Prathida, and Look Gob—are featured in these pages.

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Science-Driven Innovation for Food Safety

One Player Leads the Way in Thailand

More than forty years ago, what is today the Betagro Group, one of the leading players in Thailand's integrated agricultural business, began life a short distance from Bangkok as an animal feed producer and distributor. Today some 31 companies operate under the group's umbrella in areas that include regional and feed business, poultry business, swine business, food business, and animal health business.

More recently, Betagro has also turned its attention to expanding its joint-venture Japanese restaurant chain in Thailand and establishing a foothold in the retail market with own-brand products. That the Betagro story is one of continuous success over a forty-year-plus period is evidenced today by the scale of the group's operations and its clear ability not only to survive the slings and arrows of economic misfortune, but to thrive. This is exemplified by new factory and processing plant openings and expansion of overseas markets, whilst continuing to serve its home base customers.

However, there is more to this success story than wise stewardship and entrepreneurial acumen. The application of science

driven technology, especially in the all important area of food safety and product traceability, has long been at the heart of the group's growth strategy, leading to pioneering innovations in its various operations that continue to show the way for others in the industry.

For example, Betagro's SPF (Specific Pathogen Free) pig production joint venture with the Japanese company Sumitomo, established in 2004, was in fact the culmination of a previous Betagro SPF program of breeding and finishing technology that aimed to meet the strict Japanese import regulations for pork meat. Achieving fully compliant SPF pig production is no easy task, and at Betagro's special facility in Lop Buri province, meticulous procedures are followed that begin with the culling of parent sows after one litter and ensuring piglets are raised free from antibiotics.

Some 600 farms within a 200 Km radius supply the Lop Buri plant with pigs raised in strict accordance with the SPF criteria and provided with full 'traceable' documentation. A comprehen-

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Left: The Betagro Group's headquarters set in lush surroundings.



Right: Betagro's pioneering ventilation system.

sive and thorough disease inspection process prior to slaughter includes precluding atrophic rhinitis, Aujeszky's disease, swine dysentery, toxoplasmosis, and brucellosis. Handling up to 1,600 pigs per day, the Betagro facility is able to provide meat for the Japanese market, which after cooking, is sold as Chashu, Sliced Chashu, Buta Kakuni, Kushi Katsu and Tonkatsu. Other pork meat, marketed under the "S-Pure" brand is reserved for the top-end local Thai market.

Betagro currently has 45,000 breeders in its wholly operated farms and contracted farms, and 350,000 breeders being raised by farmers hired by contract. The "S-Pure" concept also applies to Betagro's massive poultry operations in which S-Pure Chicken products are produced under international standards of assured chicken production (ACP) and regulations of the Royal Society for the Prevention of Cruelty to Animals (RSPCA) laid down by the United Kingdom. Objectives of these schemes are to monitor and drive continuing improvement in animal welfare standards and food safety. With the additional criteria that all chicken meat must be produced free from antibiotics and growth promoters, poultry is raised in accordance with carefully defined rules on stocking density and that a system of total traceability must be in place.

All Betagro S-Pure Chicken products are also Halal certified that the birds are slaughtered in the most humane way, with no unnecessary pain and suffering.

An integral part of Betagro's longstanding commitment to food safety has been its pioneering application of a practical and effective traceability system.

Responsible food manufacturers and producers around the world have long made food safety and hygiene a top priority as a matter of principle and to increase customer confidence in their products. Regulatory authorities too have established a raft of controls and standards that apply both locally and internationally in an effort to achieve the same goal.

Since the advent of computer-based technology and the huge technological developments it has driven, the concept of "traceability"—first introduced by the European Union in 2002 but implemented as a practical tool in 2005—is playing an increasingly important role in many aspects of the food production chain. The EU defines "traceability" as "the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing, and distribution."

Although costly and time consuming to fully implement, especially across a wide range of food products and operations, traceability's many benefits have led to its recognition as an indispensable aid to improving food safety throughout the industry.

When in 2002 Betagro developed and installed its own e-traceability system, its significance was quickly realized by the industry, both locally and internationally, by regulatory bodies ▶

1. Start & upgrade herd by SPF procedure only.
 Betagro carefully selects the world's finest breeds to be developed into top-grade breeders under the clean farming



SPF

Specific Pathogen Free

Double fence line
 Net setting
 Area separation is very clear



2. Specially constructed to seal it off from other animals.



Evaporative Cooling System (Evap)



Farrowing House



Mating House

3. Strict hygienic conditions Bio Security System



Feed transportation and unloading



Disinfection and shower before entering raising area

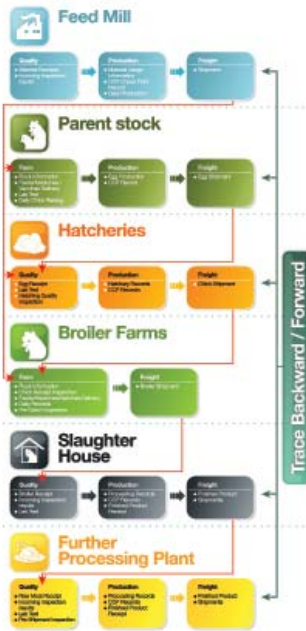


Truck Sanitizer before inside farm

4. Health Check Program



e-traceability



Above: The Betagro 'Spy on me' system allows point-of-purchase verification.

Left: The Betagro SPF (Specific Pathogen Free) program is at the heart of the company's market success.



One of Betagro's newly completed feed mills.

and eventually by the agreeably surprised end consumer. Today, its significance is even greater as food safety regulations become more internationalized under concepts such as “farm to table”.

In the overall context of food safety, strategies employed by Betagro include complying with a comprehensive range of international standards and systems all of which support the effectiveness of what is now a wide-ranging and highly efficient e-traceability system. Ultimately, consumer confidence in relation to food safety has to be the deciding factor, and with this in mind, Betagro took its e-traceability system a step further in 2008 when, working closely with the Bangkok Metropolitan Authority (BMA), it literally placed a version of the system in the hands and at the finger tips of local consumers in a one-year pilot project that has now been extended. Specially designed “Spy-on-Me” kiosks in major retail outlets in the nation’s capital allow customers to monitor Betagro’s entire production process and discover the source of origin or information about the breeders, farms, animal feed, meat processing and cutting, transportation, and storage at retail points. Meat processors who participate in this traceability program must meet industry standards on meat processing, transportation, and distribution. Once they are certified, the BMA will allow them to display a symbol attesting to the high quality of the meat on their product packaging.

This “see for yourself” approach not only increases buyer’s confidence at the crucial point of sale, but clearly demonstrates

that Betagro’s much vaunted commitment to food safety is more than just words.

That same commitment is seen in other areas throughout Betagro’s operations where, often fuelled by scientific and technological research, new technologies, systems, and methods are adopted whenever they are likely to result in clear advantages and benefits.

The successful collaboration between Betagro’s B. International and Technology and the National Science and Technology Development Agency (NSTDA) in developing the “Ventech” ventilation controller is one such example. Introduction of the equipment led to a national award for outstanding research project in 2007. The system helps animal farming operators to reduce costs and gain better produce. Betagro has also applied it to fresh markets to cool the air and reduce energy costs as an alternative to air-conditioning.

As the Betagro Group looks to a future in which an ever increasing world population is predicted to reach more than nine billion by 2050, it does so with a scientific research based strategy of growth and development. Scientifically speaking we are indeed what we eat. The safer and more nutritious producers such as Betagro can make our food, the healthier and better fed we will all be. ■





1. policy

Mapping the Terrain

Thailand's first National Biotechnology Policy Framework served as a roadmap for significant progress, but it had a rocky start. A look back at the Framework provides signposts to guide the way forward.

by Thana Poopat and Nantiya Tangwisutijit



During the past 3 decades, Thailand has increasingly prioritized biotechnology investment. From medicine to food to plastics to energy, Thailand has emerged as a key player in biotechnology research and development in Asia. Well before many countries paid any attention to the role biotechnology would play in their institutions, economies, and lifestyles, Thailand realized the importance of getting organized or being left behind.

Today's Thailand has a vast pool of trained researchers and technicians with wage rates among the most competitive in the world, a rich reservoir of untapped biodiversity resources, a legal framework supportive of creative research, and among the most generous biotechnology investment incentives of any country in the world.

Thailand's biotechnology strategy aims to make the country a global leader, but it does so with a philosophy that is inherently Thai, says Sakarindr Bhumiratana, president of Thailand's National Science and Technology Development Agency (NSTDA).

"Where possible, we emphasize research that will improve the livelihood and quality of life of our citizens across the board. That is why we've become a key player in infectious disease research, agricultural biotechnology to help farmers, and alternative energy from abundant biomass," says Sakarindr. "We really do want to see the whole society benefit as we grow this segment of our economy."

THE EARLY DAYS

When United Nations consultants traveled to Bangkok in the early 1980s searching for a location for the International Center for Genetic Engineering and Biotechnology, the country's scientific community was abuzz. Thailand's status as a high-tech research hub was validated when the country was shortlisted for the new facility. But once the search committee chose India, principally because Thailand lacked a dedicated national biotechnology agency, the euphoria turned to despair.

"That was the clinching moment," recalls Yongyuth Yuthavong, NSTDA's senior advisor. "Top policy makers and chief scientists decided right there and then that Thailand must have its own National Center for Genetic Engineering and Biotechnology."

When it opened in 1983, the National Center for Genetic Engineering and Biotechnology (BIOTEC) already had at its disposal established scientific institutions and researchers active in the basic life sciences, medicine, and agriculture.

In fact, the roots of the pioneering thalassemia research Thailand is engaged in now go back to groundbreaking work begun 2 decades before BIOTEC's conception. In 1964, Prawase Wasi discovered the genetic mechanism of hemoglobin H disease, proving that it is related to α -thalassemia. His work was published in the British scientific journal *Nature*, and two genes are now known as Wasi's α -thalassemia-1 and Wasi α -thalassemia-2.

By the early 1980s, Thai scientists had already mastered the basics of plant-cell culture technique and clonal propagation,



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which they applied to improving orchids and other cut flowers. Rapee Sagrik's work on the art of hybridization in orchids helped launch Thailand's orchid export industry, which now generates \$60 million annually.

Rapee's creative use of natural and human resources exemplified BIOTEC's mandate to further Thailand's economic and social development through the application of science. In its first decade, BIOTEC focused on establishing networks of experts to facilitate collaboration, while also supporting the development of laboratories at academic institutions. In the 1990s, relevant policy and regulatory frameworks were strengthened, and increased attention was paid to intellectual property management, biosafety guidelines, and public education and outreach.

While BIOTEC was getting organized during its first 2 decades, a lot of valuable research was already under way, says Yongyuth, notably the development of new crop varieties with resistance to a wide array of biotic and abiotic stresses, medical research into tropical diseases, and studies of new ways to turn biomass and agricultural byproducts into biofuels.

A VISION FOR BIOTECHNOLOGY

Leading figures in Thai biotechnology convened intermittently over 6 months in 2003 to develop the country's first National Biotechnology Policy Framework. Spanning the years 2004–2009, the Framework included goals in six main categories: business development, agriculture, medicine, renewable energy, self-sufficient economy, and human resources. A retrospective shows that in the 5 years covered by the Framework, the country made significant strides, although there is clearly work left to be done.

Business Development

Thailand hoped to see the emergence of no less than 100 new biotechnology companies established by 2010, but it came up a bit short. Ninety new companies were established during the period covered by the Framework, bringing the country's total to approximately 170. Many companies have taken advantage of the incentives BIOTEC has arranged through Thailand's Board of Investment (BoI), including an 8-year exemption on corporate income tax, exemptions on machinery import duties, and deductions for energy, transportation, and facility construction fees.

"Biotechnology is classified as priority activity, which has special importance and benefits to the country," says Ajarin Patanapanchai, BoI's deputy secretary general, adding that the agency pays special attention to investment in R&D in the areas of the seed industry; plant and animal improvement; biopharmaceutical agents; diagnostic kits for health, agriculture, food, and the environment; and bimolecular and bioactive compounds using microorganisms, plant cells, and animal cells.

Debate remains about whether the government has done enough for the business of biotech, but clear progress has been made. "The efforts of Thailand to foster the scientific education during the last 2 decades resulted in a new generation of young

and highly talented scientists with a broad experience in natural products research and beyond," says Frank Petersen, executive director, Natural Products Unit, Novartis Institutes for Biomedical Research. "Such a decisive governmental objective is an ideal situation for an industry partner to initiate sustainable capacity building in a respective country."

NSTDA's Sakarindr had hoped his agency's recruiting efforts would encourage more of the industry's multinational players to consider Thailand as the base for their regional activities, but he says the country's unsettled political climate, with one coup and three changes in government since the Framework was launched, has often been a deterrent. "Once the (political) situation improves, things could take a turn for the better in no time," he says. "One thing we've got in the pipeline is utilizing the procurement process to provide additional incentives for large international suppliers that are also willing to invest in biotechnology R&D here."

Additional benefits are available to companies that set up operations at NSTDA's Thailand Science Park, a high-tech campus that opened in 2002 and houses BIOTEC, three other technology agencies, and more than 60 private companies. A 120,000-square-meter second phase will be opening next year and is expected to house 200 companies.

Agriculture

Employing 40 percent of the country's workforce and generating \$20 billion in export earnings, agriculture is a major target for biotechnology resources in Thailand. Under the banner "Kitchen of the World," the Framework outlined strategies to improve output from the country's core crops as well as to stimulate increased investment in the production and export of value-added products like mineral-enriched rice and processed fruits.

A visit to any one of the specialized rice, shrimp, cassava, or sugar research stations dotting the country would reveal that scientists have been productive fulfilling the first aim. Using gene pyramiding, researchers have created new rice varieties that are more disease resistant and flood and drought tolerant, and those products are making their way to the fields. Through nucleus breeding, efforts are now under way to keep Thailand a leader in shrimp exports by developing the world's highest-quality black tiger shrimp. Some researchers are developing new sugar cane and cassava varieties, while others are finding ways to more efficiently extract energy from the byproducts generated when these crops are processed for their sugar and starch.

One concern, says Morakot Tanticharoen, vice president of NSTDA, is that restrictions on field testing, cultivation, and export of genetically modified organisms have been limiting Thai scientists' progress. "Other major agricultural producers have been working with GMO crops for years," says Morakot. "Thailand needs to join them. The door may be open for case-by-case GMO field trials, but the Biosafety Bill needs to get out of Parliament."

A HUB IS BORN: TIMELINE OF KEY EVENTS IN THAILAND'S DEVELOPMENT AS A GLOBAL BIOTECH CENTER

1982

Thailand is short listed to become the developing country site for the International Center for Genetic Engineering and Biotechnology.

1983

Thailand's National Center for Genetic Engineering and Biotechnology (now BIOTEC) is inaugurated. The ASEAN Working Group (now the Subcommittee on Biotechnology) is formed.

1985

The Science and Technology Development Board is launched with a \$50 million loan from USAID to provide grants for biotech research projects and other cutting edge science.

1990

Thai Government Science and Technology Scholarship Program is initiated, providing scholarships to talented students to obtain a college education overseas all the way through PhD—mainly in North America, Europe, Japan, and Australia—in five major fields, namely: biotechnology, material science, computer science, nanotechnology, basic science, and technology management.

1991

The National Science and Technology Development Agency is inaugurated. BIOTEC moves from the Ministry of Science and Technology to operate under the newly formed agency.

1992

The Thailand Research Fund is established, with a significant portion of its grants earmarked for biotechnology. The annual Prince Mahidol Awards debut to recognize achievements in medicine and public health for developing countries.

1993

The National Biosafety Committee is formed with BIOTEC as secretariat, followed by the establishment of Institutional Biosafety Committees at a number of research institutes. Mahidol University's Center for Vaccine Development creates the world's first single-vaccine candidate to fight all four types of dengue virus. (The vaccine candidate is subsequently licensed to Sanofi Pasteur, which drops development after a phase II clinical trial.)

1995

The Biodiversity Research and Training program debuts with support from BIOTEC and Thailand Research Fund.

1997

The Thailand Tropical Diseases program is launched with support from BIOTEC, the Thailand Research Fund, and the WHO Special Program for Research and Training in Tropical Diseases.

1999

The Thai Society for Biotechnology is established, in part to help forge partnerships between academic researchers and industry.

2001

The Rice Science Center and Rice Gene Discovery Unit are founded in a bid to make Thailand a global leader in rice genomic technologies.

2002

BIOTEC and the nine other members of The International Rice Genome Sequencing Project announce the sequencing of the entire rice genome. Thai scientists discover a drug target (dihydrofolate reductase) that enables the design of new therapies to combat drug-resistant malaria. Thailand Science Park opens for business as an R&D hub, with BIOTEC among its tenants.

2003

Thailand becomes the first country in Southeast Asia and the sixth in the world to successfully clone an animal when scientists at Suranaree University of Technology clone a cow. The National Biotechnology Policy Framework (2004–2009) is released as a roadmap for developing Thailand as a global biotechnology center.

2004

The Thailand Center of Excellence for Life Sciences is established for the purpose of commercializing biotechnology research and promoting biotechnology-related businesses.

2006

A Thai research team introduces a novel method of detecting the severity of dengue infection, leading to the development of a diagnostic kit that is patented in the United States, Germany, and Thailand.

2007

The Board of Investment creates tax breaks and other incentives for biotechnology R&D. BIOTEC and Innova Biotechnology jointly develop a biosensor-based diagnostic kit for avian influenza H5N1.

2009

The world's largest AIDS vaccine trial takes place in Thailand, showing 31% efficacy and providing hope for more effective vaccines. The results are rated the second most important medical breakthrough of 2009 by *Time* magazine.

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New value-added products from Thai agriculture were initially slow to develop under the Framework, but recent developments in the area of bioplastics ramped things up. The 2008–2012 bioplastics road map has stimulated research on sugarcane, cassava, and corn.

“With global plastic production at 250 million tons a year, less than a million tons now come from biosources. There is a lot of room for bioplastics to grow to penetrate this market,” says Wantanee Chongkum, director of the Innovation Management Department at the National Innovation Agency. “As the world’s eighth-largest plastics manufacturer, with high agricultural productivity, we’re well positioned to fuse these two ingredients to become the center of the world’s bioplastics production.”

Medicine

Over the past decade, Thailand has become a leader in research on diseases that plague developing countries such as malaria, dengue fever, tuberculosis, HIV, and thalassemia. “It does seem to be a niche market that we now occupy,” says Komkrit Sajjanantakul, managing director of I+MED Laboratories. “Increasingly,

however, tropical diseases are being found in northern latitudes, so we may find huge markets overseas in the years to come.”

A major growth area under the Framework has been the development and production of diagnostic test kits, principally for the domestic market, fueled largely by government R&D and financial support. Thailand has the manufacturing competitiveness to grow this industry overseas, but so far there’s been little effort toward developing a medical device certification process that would give confidence to international buyers, says Komkrit.

Thailand has also emerged as a competitive location for large-scale clinical drug trials. Most recently, the world’s largest HIV vaccine clinical trials were conducted in Thailand in 2009. “As the cost for trials continues to escalate, I think we are going to be seeing a lot more companies looking to Thailand as among the most competitive locations to conduct this research,” says Sutee Yoksan, director of Mahidol University’s Center for Vaccine Development.

Surrounding all this activity is a medical care infrastructure that is among the best in Southeast Asia, attracting 1.2 million medical tourists in 2009. The National Institute of Development Administration found that the combination of treatment quality, ▶

THE NEXT GENERATION

by Weena Yoswangjai

When Jariya Sakayaroj first peered into a microscope during a biology class, she had no idea she was looking at her future. The thought of a girl from her rural village becoming a serious scientist was too farfetched for her to imagine. But 20 years later, as one of BIOTEC’s principle microbiologists, Jariya is leading efforts to unravel the secrets of local microorganisms for pharmaceutical applications in collaboration with Novartis.

Thailand’s research institutes are full of stories like Jariya’s, the result of an expanding network of programs across the country that are designed to nurture the brightest scientific minds to increase the talent pool for the life-sciences industry.

Starting in 1990, the Royal Thai Government set up a Thai Government Science and Technology Scholarship Program, with an objective to generate a critical mass of scientists and academics in 6 major fields—biotechnology, material science, computer

science, nanotechnology, basic science, and technology management—to supply to universities, research institutes, and government agencies, including NSTDA. Talented high-school students were recruited from all over the country to receive overseas university education, all the way to PhD, mainly in North America, Europe, Japan, and Australia. More than 3,000 scholarships were granted through 2009. So far, the program has produced over 100 PhD graduates in biotech-related fields.

“Grooming young talent to become scientists is the best way to secure Thailand’s positioning in the era of science-based economies,” says Morakot Tanticharoen, vice president of the National Science and Technology Development Agency (NSTDA). “The country’s demand for scientists is growing in both government research institutes and within private-sector R&D.”

Jariya is among more than 1,000 participants to enroll in the NSTDA-initiated

Thailand Graduate Institute of Science and Technology program since it began in 1998. Overall, NSTDA awards 3,000 scholarships annually for students pursuing science degrees, many of whom come from the country’s special science-focused high schools.

For younger scholars, NSTDA operates Sirindhorn Science House at its Thailand Science Park campus, where students from across the country participate in short-term immersion programs with working scientists. The facility includes a laboratory and a live-in center for 200 participants.

In addition, BIOTEC has initiated the Human Resource Development Program in Biotechnology for Neighboring Countries. The program, which is funded by The Association of Southeast Asian Nations (ASEAN) and the New Zealand UNESCO Commission, has trained a steady stream of researchers from ASEAN countries and provides a networking platform for ASEAN researchers.

THAILAND SCIENCE PARK

by Weena Yoswangjai



Not long after Thailand Science Park (TSP) opened for business in 2002, one of its tenants began making international headlines for a biotechnology breakthrough. From their labs at TSP, researchers at BIOTEC spent days answering phone calls and emails about their groundbreaking work on an immunochromatographic strip test for alpha-thalassemia-1.

While the roots of that achievement were in more antiquated facilities elsewhere, the discovery drew attention to the ultra-modern, 32-hectare TSP campus and the research quality and intellectual rigor that can be found there.

TSP, which is run by Thailand's National Science and Technology Development Agency (NSTDA), is also home to the National Metal and Materials Technology Center, National Electronics and Computer

Technology Center, and National Nanotechnology Center. Three of Thailand's leading universities are nearby, contributing to a creative synergy that has attracted 62 private tenants to TSP, 30 of which are headquartered in other countries.

"The atmosphere here is excellent. Everyone talks about science, which continuously motivates our R&D team," says Vanus Taepaisitphongse, CEO of Betragro, one of Thailand's leading agribusiness groups.

Pramote Techasupatkul, President of Siam Cement Group, is also enthusiastic about the scientific climate at TSP. "The establishment of our Green Nanomaterials Research Center at Thailand Science Park reflects our research and development mission and offers SCG researchers [the chance] to work among Thailand's leading scientists," he says.

A core objective for TSP management is to offer both lab-to-market and market-to-lab services to tenants, according to Chatchanat Thebtaranonth, Director of TSP's Technology Management Center. "If companies have problems introducing their products to the market, we help them get these problems solved," she stresses.

The fully-integrated R&D hub has proved so popular that NSTDA has broken ground on an additional 120,000m² complex scheduled to be completed next year. When the new doors open, much of that space is expected to be occupied, given the special tax breaks and other incentives offered to companies that occupy the Park. It will be interesting to see which one of them makes headlines first.

price, and atmosphere attracts more foreign patients to Thailand than to its two regional competitors, India and Singapore.

Renewable Energy

The past 5 years have seen a huge increase in the number of biogas and ethanol plants across Thailand, which are aimed at getting the most power possible from agricultural products.

“Bioenergy has probably been among the most impacted by biotechnology under the Framework,” says energy expert Suvit Tia of King Mongkut’s University of Technology Thonburi. “As a relatively new sector, there’s been a lot more room for science to affect change as compared to something researchers have been experimenting with for generations.”

However, care must be taken to ensure that this progress doesn’t come at too high a cost, Suvit maintains. “Like many other countries, the one issue we need to watch out for is that our alternative energy generation does not take food off our table. Assistance for the further expansion of this industry should not come at the expense of higher domestic food prices,” he says.

Self-sufficient Economy

Thailand’s rich biological diversity is a major attraction for biotechnology companies. The country is home to about 10 percent of the world’s total plant species and microorganisms, and drug makers in particular are keen to explore these resources. While

still new to scientists, many of these species are quite familiar to the locals in Thailand’s rural communities, so it’s not surprising that the biotechnology framework paid special attention to sustainable development.

The Framework included biodiversity protection programs to minimize the likelihood that species will disappear. It also focused on opportunities for local residents to partner in the collection and exploration of plants and to share their indigenous knowledge, creating new ways to support rural livelihoods.

In addition, the Framework called for the development of organic fertilizers specific to local areas, methods for biogas generation, and the development of new crop and aqua culture varieties to help small farmers maintain competitiveness.

“For example, in areas where there are huge quantities of agricultural waste such as rice, straw, and maize husk, certain enzymes can be used to speed up their decomposition so that they can be used as biofertilizers instead of being disposed of by burning,” says Kanyawim Kirtikara, BIOTEC’s executive director.

Human Resources

Thailand aims to become a “knowledge-based” economy. The continued growth in the scientific capabilities of its students and workforce is seen as paramount, not only for biotechnology but for technology generally, says Morakot Tanticharoen, vice president of NSTDA. The government is opening new colleges every few ▶

SUCCESS STORIES

by Pennapa Hongthong

For international companies seeking to establish a base for biotech R&D or manufacturing in Thailand, the pharma giant Novartis and the East West Seed Company offer success stories that may serve as models.

Alexandre F. Jetzer, a member of Novartis’s board of directors, says the company created an R&D partnership with Thailand’s National Center for Genetic Engineering and Biotechnology (BIOTEC) to explore natural substances derived from the country’s rich microbial diversity, which have great potential to be developed into new drugs.

“Thailand has a fantastic potential. You have a pool of great scientific talents and a strong knowledge base,” Jetzer says. “I believe in the country’s strong future as an investment destination for R&D.”

From 2005 to 2008, Novartis worked to develop the capacity of Thai scientists in two areas: the application of microbiological technologies and concepts, and natural-products research to produce new molecules from novel microorganisms of high diversity for drug discovery. Now in its second 3-year tranche, the partnership is working to expand the acquisition of strains to increase access to the diversity of the microbial substances.

The East West Seed Company has been taking advantage of Thailand’s research climate for nearly 3 decades. The company’s vice president of R&D, Simon Jan de Hoop, says Thailand’s central location in Southeast Asia, the size of its domestic market, the availability of good seed-producing farmers, and the country’s business incentives have served his company well.

“Thailand has some good agricultural universities and research institutes that we can work with in identifying good people and knowledge exchange,” de Hoop says. But he notes that practical, applied plant breeding is not as well developed as it should be in an agricultural country of Thailand’s size.

East West Seed president Joost Pekelharing says Thailand should invest in a university program for plant breeders. “With the current university graduates, the company has to work from scratch to train them to become good breeders, which takes at least 6 to 7 years,” he says.

Both Novartis and East West Seed benefit from government incentives that include exemptions for import duty on machinery and tax holidays with no exemption caps on investments in biotech R&D.

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years, working closely with foreign scholars in overseas research institutes, and providing more scholarships to science students.

With the proliferation of graduate programs at home, fewer students need to attend foreign universities, says Uthaiwan Grudloyma, manager of BIOTEC's Policy Studies and Biosafety Division. "We are still supporting students going abroad, but they are on the whole pursuing higher-caliber studies and more specialized research."

"Brain drain" is a problem for Thailand, as it is for most developing countries. Many talented scientists take posts overseas, and within Thailand, researchers often migrate out of public laboratories and hospitals to the private sector, where the wages are higher. But an increasingly larger pool of scientists should help counteract the problem, says BIOTEC's Uthaiwan. In fact, the agency supports its researchers moving to the private sector to strengthen the link between public and private entities, he says.

THE ROAD AHEAD

Despite the gains made under the Framework, many feel some of its elements were overambitious and detracted from its integrity. For example, agriculture revenues skyrocketed, propelling Thailand from 12th place to fifth among the world's leading agricultural exporting nations in just 6 years. During the same period, hospitals and medical care in Bangkok became the most sought after in Asia.

The Framework also suffered from insufficient dedicated funding. Biotechnology programs relied mostly on the annual budgets of the relevant government agencies to achieve the Framework's objectives. The supplemental public funds that many agencies and research institutions believed would be forthcoming did not materialize. "Some perfectly good plans become unrealistic because of limited resources available to us," Sakarindr says.

These issues will almost certainly be discussed when the nation's scientists convene in June to begin planning the next iteration of a national biotechnology strategy. While the work will begin with a clean slate, BIOTEC's Uthaiwan says some of the priorities will undoubtedly remain the same.

"The big sector is agriculture. Food always comes first," stresses Uthaiwan. "Bioenergy and the environment are also high on the agenda. The direction to go is to make the best use of our rich biodiversity for the well-being of our people and for environmental protection. We will also see a convergence of technologies around biotech for better handling of these key issues of national importance under the new framework."

The process cannot start soon enough, say some scientists. They feel it's time for the scientific community and policy makers to recognize the gains made under the Framework but to accept that not all of its goals may have been achievable. "Absent the Framework, we would not have come this far," says Uthaiwan. "We're definitely ready to embark on another planning process to take us further." ■

PUBLIC FEARS MAY FUEL REGULATION

by Kamol Sukin

In 2004, the "leakage" of genetically modified (GM) papaya from test fields aroused public concern among Thais about the potential social and environmental impacts of biotechnology. During field trials in a state-owned research center in Khon Kaen province, the GM papayas managed to migrate more than 1,000 kilometers to take root in many provinces across the nation.

When GM papayas started showing up in public markets unbeknownst to buyers and sellers, the public questioned the state's capability to oversee biotech research. It didn't help that the Department of Agriculture denied any responsibility and attempted to use the judicial system to silence those who exposed the leak.

"The potential damages could be huge if we introduce GM crops with improper pre-

paredness," warns Saree Ongsomwang, secretary general of the Foundation for Consumers. "Not only [does it have] potential health impacts on consumers, [but] GM material contamination may also threaten the country's food security and biodiversity resources."

Public outcry has led to the drafting of biosafety legislation now under consideration by the Council of State. If the legislation is passed, a new system of controls and oversight would apply to research, testing, deployment, and exporting of GM seeds and crops.

In the health care arena, stem cell research has also been the subject of public debate, with concerns being raised about safety as well as marketing claims. "Although stem cell technology opens the door for treatment of some health problems, it's not a magic wand. Absent any protec-

tion, the public could be exposed to exaggerated marketing," says Yot Teerawattananon of Thailand's Health Intervention and Technology Assessment Program, citing private hospitals' marketing of costly cord blood banking for future stem cell treatments.

The Medical Council of Thailand recently released recommendations that stem cell use in Thailand be limited to research purposes. Saree would like to see a more comprehensive approach similar to the health technology assessment bodies in Europe. "What Thailand needs is an independent body to oversee, screen, and control the research and application of biotechnology," she asserts.

Miles to Go

Stronger policies are needed if Thailand is to reach its full potential as a global center of biotechnology.

by Somsak Chunharas



Thailand has been working with support from various international agencies to develop its scientific and technological bases in biotechnology for more than 3 decades, but the country is still badly lacking the strong government policies that will effectively bridge the demand and the supply sides of science and technology.

Explicit governmental policies in biotechnology started with the establishment of the National Center for Genetic Engineering and Biotechnology in 1983, which aimed primarily at capacity building. The Office of Science and Technology Development Board was established in 1985 with initial support from USAID to ensure that biotechnology would contribute to the country's development in agriculture, health, and energy. However, Thailand has yet to fully benefit from that vision.

Much of Thailand's growth as a biotech hub is the result of the scientific community's advocacy, spurred by the belief that the future of the country depends on a strong foothold in advanced life-science technology. But industry has yet to match the enthusiasm of the scientific community. Although overall investment in R&D from the private sector has increased gradually, the three areas of potential application for biotech have not followed the same pattern. Agriculture has the strongest ties to private industry, but the biotech energy and health industries are still in their infancies in Thailand compared to other developing economies.

Conventional wisdom dictates that advances in science and technology need to be linked to the private business sector for meaningful economic return, but Thailand also faces the challenge of reorienting its scientific bases and capacity to better serve the needs of the relatively disadvantaged. In the areas of agriculture and energy, farmers and communities are in need of help. In the health care arena, biotech can yield treatments for neglected tropical diseases.

Whether it is to create a high-tech private business sector or to meet the needs of the disadvantaged, development of biotechnology can hardly be left to market forces for three simple reasons: the relative unpreparedness of the private sector; the working culture of the scientific community; and weaknesses in research management. Strong government policies need to be put in place, and management must be continued through multiple

government terms. This seems to be the most fundamental and crucial challenge when it comes to political support for long-term development in science and technology.

Political commitment and continuity aside, there is a need for improved capacity and mechanisms to move scientific products down the value chain. Currently, the private sector appears reluctant to take risks, and scientists are not willing or able to take further steps towards "research translation." Existing research incentives for the private sector have not been effective enough to bridge this gap.

One option for the future is the establishment of "semi-governmental agencies" to move promising scientific products forward. For example, the Government Pharmaceutical Organization has recently been revitalized to take up this challenge as it relates to pandemic flu. However, clear and effective policies have yet to be identified to both stimulate private industry and ensure the development of treatments for diseases that may not deliver enough financial return for the private sector.

Public investment and management in research is still far from ideal. On one hand, it needs to help direct efforts towards selected areas of development in addition to "general research supports." It is time for public research funds to strike a balance between "goal-oriented" and "researcher-initiated" research. On the other hand, public investment should aim to stimulate private investment in research. This can be realized through improvement in research management at all levels, from policy development to budget and grants management to oversight of research institutions and support for the private sector. A technology policy-making body is needed to strategically analyze and identify specific areas of great potential and then to mobilize existing partners to work together, while also working towards building new capacity and finding new partners.

Strong and continuous political support, along with clear technology policy direction with proactive and professional management of both the supply and demand sides, are badly needed if Thailand is to reap the full potential of its natural and human resources in biotechnology. ■

Somsak Chunharas is the Chairman, Medical and Health Cluster of NSTDA.

SPONSOR PROFILE

Mahidol University

Wisdom of the Land

With its goal of being the “Wisdom of the Land,” Mahidol University continuously strives for educational excellence, outstanding research, leadership in healthcare services, and global outlook.

Mahidol University originates from Thailand’s first hospital, Siriraj Hospital, founded in 1888. Later becoming the University of Medical Sciences in 1942, the University was renamed with great honor in 1969 by H.M. King Bhumibol Adulyadej after his own father, H.R.H. Prince Mahidol of Songkla.

In Thailand, Mahidol University was ranked top for research and teaching in 2006 and was selected as one of the nine National Research Universities in 2009 by the Thai Commission on Higher Education. In the THE-QS World University Rankings, Mahidol University has been ranked as one of the top two universities in the country from 2007 to 2009. The University’s prominent strength lies in its research excellence, and its staff members have not only won numerous awards at the national level, including 18 Outstanding Scientist of Thailand Awards, but also several awards at the international level, including the Magsaysay Award and the Rolex Award for Enterprise.

Mahidol University has been at the forefront of Thailand’s scientific and medical research from the beginning. Postgraduate training also plays an important part in this research, not only in producing the researchers of the future, but also the research publications of today. Thus Mahidol University has also initiated strong master’s and PhD. programs since 1948 and 1960 respectively, many of which are international degree programs.

RESEARCH EXCELLENCE

Mahidol University has been a key player in the fight against worldwide infectious and neglected diseases such as malaria, and was the first to raise awareness of drug-resistance in malaria, and to develop artesunate-mefloquine drug combination therapy as the first line of treatment for uncomplicated falciparum malaria. Mahidol University has also been a leader in the development of new vaccines, and has served as an important vaccine trial center for more than 25 years, conducting trials of vaccines for



cholera, rotavirus, poliomyelitis, malaria, varicella, human papilloma virus, and HIV.

In the sciences, Mahidol University has been instrumental in introducing novel technologies to Thailand, including genetic engineering almost 30 years ago and protein crystallography eight years ago. In addition to our research groups, our Centers of Excellence on chemistry, mathematics, environmental toxicology, and physics perform forefront research, many with potential applications. Research in food biotechnology, nutraceutical foods, herbal medicine, nanotechnology, and pharmacogenomics are also our R&D strengths. Among many outstanding projects, our research on shrimp biotechnology is of particular significance, as it has led to the improvement of test kits for viral diseases and the enhanced reproductive performance of shrimp, resulting in the stability and growth of the shrimp industry in Thailand. Our research on the conservation of hornbills and promotion of community involvement in wildlife preservation has also brought great benefits to our country, and our work has received the Chevron Conservation Award.

Mahidol University has several campuses, with one suburban campus, two older inner campuses and a downtown high-rise office site in Bangkok. The University is also expanding to other parts of the country, with new campuses in Kanchanaburi, Nakhon Sawan, and Amnaj Charoen provinces.

Mahidol University’s motto *attanam uppamam kare* in the ancient language of Pali, translates into “One should care about others as one cares about oneself.” This philosophy is the underlying theme pervading the university’s activities as it endeavors to imbue graduates with the conviction that, apart from academic achievement, they have equal responsibility to improve the quality of life of their fellow human beings and make the world a better place to live in. ■

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Cell Signaling Research

A Key to the Future of Medical Sciences

Remarkable achievements in biosciences during the past decade have increased our understanding of the disease process and opened new ways of therapeutic intervention. Identification of the human genome and new developments in nanotechnology and stem cell technologies have offered new solutions to improve the quality of life. Mechanisms involved in intercellular and intracellular communication have largely formed the basis of modern medical research, which is a confluence of both basic and applied research to help in the development of new drugs and improve their safety and efficacy.

Rapid advances in basic and clinical sciences and the vast number of publications in these areas may create a delusion that we understand everything about cells and their interactions, but the reality is that we know only a fraction of what we want to know. In spite of the remarkable progress in diagnosis and treatment of cancer, diabetes, and hypertension, the incidence of these diseases have increased significantly in the industrialized world.

Merck, KGaA/EMD (with its Calbiochem® and Novagen® brands), a global leader in developing bioscience research products, has made significant contributions to facilitate the progress of signal transduction research. Their *Inhibitor SourceBook*, *Antibody SourceBook*, and the recently published book, *Signal Transduction: A Short Overview of Its Role in Health and Disease*, on the are unique sources of information for scientists working on various aspects of cell signaling. Based on the number of publications reporting the use of inhibitors from the Calbiochem® brand of Merck/EMD they are regarded as one of the top suppliers of cell signaling research products. Although activation of enzymes has been exploited therapeutically, most drugs are based on enzyme inhibition that normalizes an overactive pathway. Years of research has shown that inhibitors are useful for mechanistic studies aimed at understanding how enzymes interact with their substrates, the role of inhibitors in enzyme regulation, and the structure–activity relationship of enzymes that forms the basis for developing drugs to inhibit aberrant biochemical reactions.



Novagen®
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Novabiochem®, another important brand of Merck, KGaA/EMD, has set the standard for quality and innovative reagents for peptide synthesis, high-throughput organic chemistry, labeled peptides, and custom manufactured products. Their catalog offers over 960 products with detailed protocols, applications, and practical advice. Hence, it is considered an essential resource for many researchers involved in peptide synthesis and combinatorial chemistry.

The future of biosciences holds great promise. The convergence of genomics, proteomics, and kinomics and the promise of regenerative medicine and stem cell research offer significant opportunities and challenges. Merck/EMD products are utilized by researchers all over the world to conduct research and develop new drugs to treat cancer, diabetes, hypertension, cardiovascular complications, and other debilitating diseases. Their contributions to the bioscience communities continues with the introduction of state of the art technologies, such as their new Wide-Screen™ assays for multi-analyte analysis, and inhibitor libraries and inhibitor panels for various protein kinases. ■

Merck KGaA of Darmstadt, Germany wishes to clarify that it has no connection with Merck & Co. of Whitehouse Station, New Jersey. The historic roots of both companies are the same and began 340 years ago in Germany. Although the two companies still share the same name, they are no longer associated with each other. Merck KGaA owns worldwide rights to the name except in the USA and Canada, where it uses EMD. Merck & Co. uses the name in North America and MSD in the rest of the world.

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Investment Strategies

Boosting Thailand's investment of public funds in biotech will take educating political leaders, and rice farmers, too.

by Thana Poopat

Chief scientists, policy makers, and key stakeholders in science and technology development agree that biotechnology has the potential to transform every aspect of Thailand's economic and social life for the better. But the promise of biotechnology cannot be realized, they argue, unless it is guided by a clear vision, a strong sense of purpose, and broad public appeal.

Most critical is the paltry level of government investment. Thailand's public expenditures on research and development rank fifty-first among 53 countries surveyed by the *World Competitive Yearbook* in 2008. Total Thai expenditures on R&D are 0.24 percent of GDP, about a third of Malaysia's levels and a tenth of Singapore's.

"Thailand has been investing in biotechnology research as if we were a small-time player," says Pongthep Akrotanakul of the Center for Agricultural Biotechnology. "We're one of the world's agricultural powerhouses. There must be something seriously wrong about our self-perception or self-esteem."

"It's actually somewhat impressive what we are achieving despite this relative indifference by the government toward what we are doing," observes Prasit Palittapholgarmpim, vice president of the National Science and Technology Development Agency. "Especially in the area of emerging diseases research, our scientists are second only to Japan and China in Asia."

Thai scientists have been advocating for years that R&D expenditure be increased to 1 percent of GDP, or about US\$2.1 billion. Prime Minister Abhisit Vejjajiva has expressed support for such growth, but stresses that any increase would be gradual and requires private-sector participation.

Science and Technology Minister Kalaya Sophonpanich, herself a nuclear physicist, believes increased collaboration with the private sector is key. "We have had scientists working on biotechnology research for many years. They are now starting to produce good results. But much of the research is not exploited commercially because of weak linkage with the private sector," she says.

While partnerships are beneficial, there is the caveat for many government leaders that additional public funds must only flow

following a thorough assessment to ensure that the publicly financed research will benefit society at large, not just the balance sheets of the private partners.

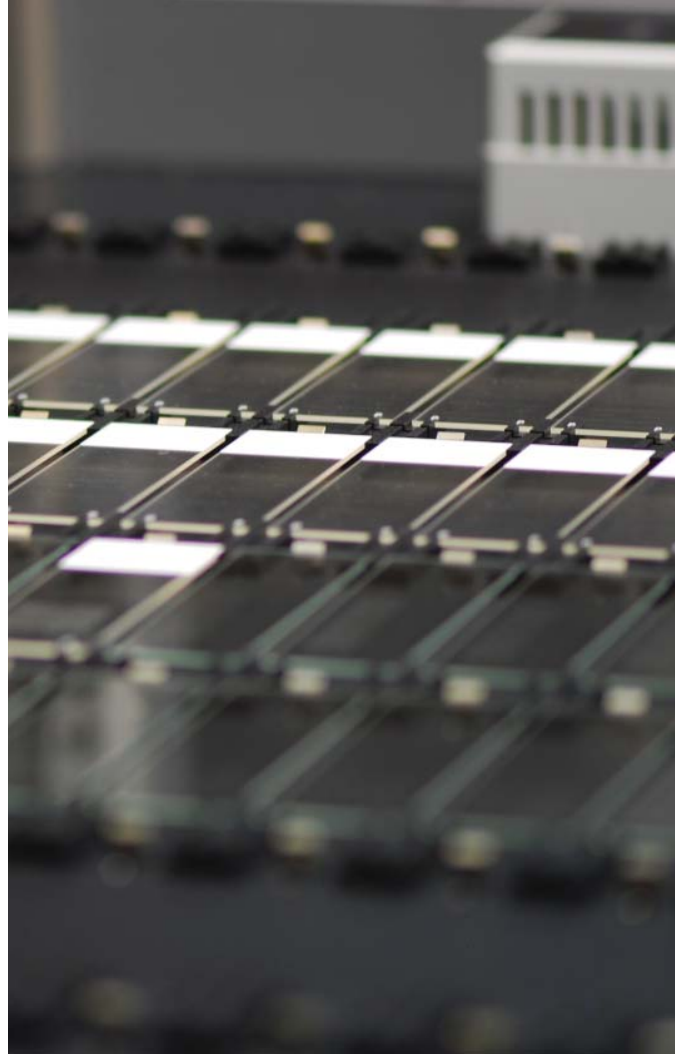
Rutjawate Taharnklaew, director of Betagro Group's R&D Center, maintains that it is not just government officials but also scientists themselves who need to increase their commitment to growing Thailand's biotech industry. "Until very recently, to many scientists, getting scientific articles published in international peer-reviewed journals appeared to be more important than producing research that is actually useful and commercially viable," he says.

The 2008 *World Competitiveness Yearbook* reinforces Rutjawate's concerns. Researchers from Thailand published 1,249 scientific articles in international journals that year, while the number of international patents granted to Thai residents was only 59. In contrast, Taiwan published 10,841 articles and obtained 36,538 international patents.

Striking the right biotechnology investment balance, says Yongyuth Yuthavong, senior advisor at the National Center for Genetic Engineering and Biotechnology (BIOTEC), will enable Thailand to go beyond its aging agricultural export economic model to develop a much broader set of products and services beneficial to both domestic and international markets.

"Politicians in particular need to recognize that our agricultural society must also adapt to the demands of a changing world. The government must send a clear signal of its intention to shift toward a bioeconomy to enable Thailand to deliver the ecological-sensitive products and services that both markets and regulators demand," he says.

However, additional research support may be insufficient on its own. Strengthening the country's capacity to get a product to market is also important. Currently, the country has a limited ability to scale up new discoveries to the manufacturing stage. Bioprocessing and manufacturing require huge investments in equipment and manpower that Thailand cannot yet be relied on to deliver consistently.



Education also needs attention. While continuing to encourage Thai science students to study abroad is important, Thailand must boost its own capacity to produce enough scientists at the masters and doctorate levels, as well as revamping its approach to early education, urges Pongthep.

“If we really want to compete and innovate, we must be nurturing curiosity and teaching creative thinking at an early age,” Pongthep says. “Our education system needs to abandon the ‘repeat after me’ approach to learning, and start encouraging our children to learn problem-solving skills and rational discussion.”

Scientists must also get better at educating the public about the importance of their work, says Yongyuth. “Many scientists are too self-absorbed with their work and do not pay enough attention to the society around them. If they want society to support them, they need to spend more time developing solutions to urgent problems, and letting the public know how and why they are doing it.”

A more outspoken scientific community and scientifically literate populace would go a long way toward addressing another constraint, says Samruay Padphol, head of Joko Community Learning Center, an NGO working with subsistent farmers in the northern province of Nan. He spends much of his time helping

farmers get comfortable with the technology coming out of scientific laboratories.

“Part of our effort recently is geared to help farmers gain access to new technology, including marker-assisted breeding of new rice varieties with resistance to diseases, insect pests, and drought...and letting them decide for themselves whether they would like to adopt them,” says Samruay, who describes himself as a social entrepreneur.

With farmers and scientists working side by side, Samruay stresses, farmers more quickly familiarize themselves with the science behind new breeding techniques, and scientists learn more about local plant varieties and cultivation practices they might want to incorporate into their research.

Kanyawim Kirtikara, executive director of BIOTEC, says education all around is what’s needed. If the government recognizes the value of bioscience, and public demand increases as well, the level of public investment may change. “So it really does fall back on us to be doing a better job of getting these messages out to stimulate the rational public discourse, which can, in turn (influence) politicians, scientists, and the business community to do the right thing,” she asserts. ■

Amaret Bhumiratana

An accomplished academic scientist believes innovation in the private sector is the key to Thailand's future.

by Klomjit Chandrapanya



Amaret Bhumiratana believes that one of the key factors missing in Thailand's advancement in science and technology is the lack of entrepreneurial spirit among young Thais. A product of American education, Amaret admires the can-do American character and the new ideas and businesses it spawns.

"Thai students think about where they can apply for work, while American students ask themselves what they can do or create that they can call their own," says Amaret, who has spent 36 years teaching and conducting research at Mahidol University's Faculty of Science.

Amaret, who received his PhD in microbiology from Michigan State University when he was only 26, knew he wanted a career in science and chose Mahidol because of the science that was being done there. One of his research projects focused on the physiology and genetics of the bacterium *Bacillus thuringiensis*. His work on improved strains of this bacterium has been developed into the manufacture of effective biopesticides.

However, he is best known for his research on *Aspergillus oryzae*, a fungus used to ferment soybeans for Thai soups, stir fries, and sauces. A typical Thai cupboard has at least one sweet soya sauce, one salty, and one with chunks of soya beans floating in the bottle. Amaret is credited with improving the quality of soybean fermentation and manufacturing techniques for these products.

The soybean industry, dominated by family-run, small-to-medium-sized producers, used to rely on manufacturing techniques that were passed down from generation to generation with little or no improvement. The lack of personnel and financial investment meant that little was put into research and development. Results from Amaret's work were transferred to businesses through the Quality Control and Training Center for Soybean Fermentation, a consortium of small- and medium-scale produc-

ers. The initial stage of the project was supported by the Thailand Research Fund, a governmental agency, with the consortium contributing more funding later on.

Amaret believes the success of the soybean project illustrates the importance of collaboration between Thailand's public and private sectors, and he'd like to see more of it. "The Thai private sector has been too reliant on imported technology," he says. "They should be investing more in research and developing homegrown technology. If they aren't ready yet, then this is where the government can intervene and get things started: lower taxes for research material and equipment, provide research grants, or co-fund research with private companies."

The 62-year-old professor is doing his bit. He was instrumental in creating a new course offered by his Biotechnology Department this year called Biotechnology Commercialization. He wants to encourage a business culture and push his students to start thinking about creating new business sectors based on their innovations.

The course covers the evolution of the biotechnology industry, its impact on existing Thai industries and society, and building a business based on intellectual property. It touches on technology licensing agreements, business development, and starting up companies.

Until recently, Amaret served as dean of the Faculty of Science, but he says university regulations that prohibit professors over the age of 60 from holding administrative positions have freed him to do the work he has always wanted to do. He still oversees some research projects along with teaching basic genetics and the physiology of microorganisms to undergraduates. However, it was while talking about plans to get students to be more creative and think like entrepreneurs that he was positively beaming. ■

Kanyawim Kirtikara

A young scientist leads Thailand's premier biotechnology organization with a mix of passion and practicality.

by Klomjit Chandrapanya

Friends and family members tell Kanyawim Kirtikara, the head of the National Center for Genetic Engineering and Biotechnology (BIOTEC), that she has changed since she became the leader of the country's premier biotech research institute in mid-2008. "They all say I'm much more willing to negotiate than I was before," the 46-year-old geneticist-turned-policy maker says wryly.

Kanyawim joined BIOTEC in 1998 after receiving a PhD in genetics from the University of Connecticut and spending post-doctoral stints studying oxidative stress in a fungus and complex regulations of genes involved in prostaglandin synthesis. After only seven years on the research bench at BIOTEC, she was promoted to director of the group's Central Research Unit in 2005. A few short years later, she rose up to head the entire organization.

For someone who once loved nothing more than being in the lab and left alone to concentrate on her projects, Kanyawim now finds her days filled with meetings and balancing the needs of her scientists, collaborating with other institutions, and leading an organization quite different than the one she grew up in as a researcher.

BIOTEC was established in 1983 under the Ministry of Science, Technology and Energy. It later became one of the scientific centers under the National Science and Technology Development Agency (NSTDA), operating outside the normal framework of civil service and state enterprises and acting as a funding agency as well as an implementing agency with its own labs. In 2006, NSTDA introduced a cluster-based approach to its operations to foster closer cooperation among government, academia, and the private sector.

"I feel like sometimes people don't even think about biotechnology as a possible solution to problems they're working on," Kanyawim notes, adding that government line ministries, in particular, are too constrained by their year-to-year annual

budgets to fully utilize their assets for science. Even with their treasure trove of accumulated knowledge gathered from country-wide branches and young staff sent abroad to learn new technology, they might not be able to invest enough on infrastructures to support these people when they return. "That fire they have can just die out pretty quickly," says the young and energetic Kanyawim.

Being the head of BIOTEC means Kanyawim has to spend a good amount of time dealing with not terribly science-savvy politicians, but she has developed a positive approach. "I just try to see them as who they are: literally representatives of the wider population that are not science-literate, and it is my duty to interact with them and educate them that science is valuable," she says.

Despite the challenges, Kanyawim believes Thailand's reputation as an up-and-coming biotechnology player is well earned. The country might not be able to invest in scientific equipment and other infrastructures as lavishly as other countries, but its wealth lies in its accumulated knowledge, she maintains.

"In addition to our rich biodiversity, we have so much knowledge from long years of research in the country. Our breeders and researchers in government agencies or universities have collected so many different breeds of animals and types of plants. So, when we work together and apply new technology into these resources, we can really speed up the learning process," she says with conviction.

Being so young in a position with term limits, Kanyawim is looking forward to a long career back in her lab at the end of her tenure. She says administrators of research centers like BIOTEC need to have done scientific work of their own to understand the researcher's spirit, which she believes is like an artist's. "Without creativity, there won't be anything new in science." ■

Khon Kaen University

From Isan Wisdom to Globalization:
Health Scenario

Khon Kaen University (KKU), the first public university to be established in the Northeast of Thailand, has the vision of being a learning-based, research-based, and quality-based university that is focused both on regional and national development.

Over the past 46 years, the university has been following a strategy to drive its operations to achieve objectives according to this vision. Research, in particular, is seen as a crucial task that the university emphasizes in order to create work or new knowledge in each field in response to the needs of communities and society.

KKU is one of nine institutions selected to pioneer the Thailand National Research University project which has the aim of raising the standard of Thailand's universities to an international level through research and development. This marks an important milestone in the history of higher education for Thailand.

Various activities have been vital in driving KKU to become a research-based university. A major project has been the establishment of the 40-year Khon Kaen University Research Fund along with 12 specialist research centers in 2002. An additional 24 research centers and 15 research specialist groups were later

established to cover three major fields: science and technology; health sciences; and humanities and social sciences. In addition, some research centers have been collaborating with other universities and private organizations.

Utilizing the results of research is regarded as a crucial activity, and for KKU this has played a great role in its operations. The university has set up a department to take responsibility for each mission, such as: the Academic Services Center, the Khon Kaen University Science Park, and the Srinagarind Hospital, which is the largest hospital in the region.

KKU has entered into collaboration with over 200 organizations, educational institutes and international research institutes, in more than 25 countries. This includes cooperation with international organizations such as: the Mekong Institute, the Greater Mekong Sub-region Academic and Research Network (GM-SARN), and Greater Mekong Sub-region Tertiary Education Consortium Trust (GMSTEC).

Cooperating with communities in projects that promote sustainable development is another crucial role that the university continues to perform. KKU cooperates with

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communities in the Northeastern region and communities in other regions of the country. KKU has also transferred knowledge and research experience to promote sustainable development with neighboring countries.

Life Science is one of the strongest research fields of Khon Kaen University. Several research projects and technology transfers have been conducted in order to continuously fulfill the needs of the northeastern part of Thailand's population, as well as those of the Greater Mekong Sub-region's (GMS's). Furthermore, researches aiming to discover new knowledge have also been explored for future development. Examples of researches mentioned are as follow:

Plant Breeding Research Center for Sustainable Agriculture (PBRCSA)

Although Thailand is the cradle of agriculture covered with high diversification of useful plants for basic necessities, it is not perpetual. Research on plant breeding of these plants is urgently needed to ensure farmers have a sustainable way of living by developing new varieties which are higher-yielding, resistant to pests and diseases, drought-resistant, or regionally adapted to different environments and growing conditions. Plant breeders are trained and encouraged to use locally available techniques with self-sufficient resources and awareness of environmental protection.

PBCSA was established in 2002 by academic staff members of the Faculty of Agriculture, Khon Kaen University. It was the result of a meeting among the academics to share ideas and exper-

iences on plant breeding research for people in the Northeast region of Thailand, aiming to enhance sustainability and self-reliability of the people and support the local agro industry.

The Centre for Research and Development Medical Diagnostic Laboratories (CMDL)

The CMDL was developed in 2002 from a consortium of research groups at the Faculty of Associated Medical Sciences, aiming in research and development at both basic and applied levels. Based upon basic knowledge gained locally on local health problems, it is anticipated that targeted medical diagnostic kits could be produced and finally manufactured in the country, reducing imported products and leading to self-sustainability and an excellent research center for the region.

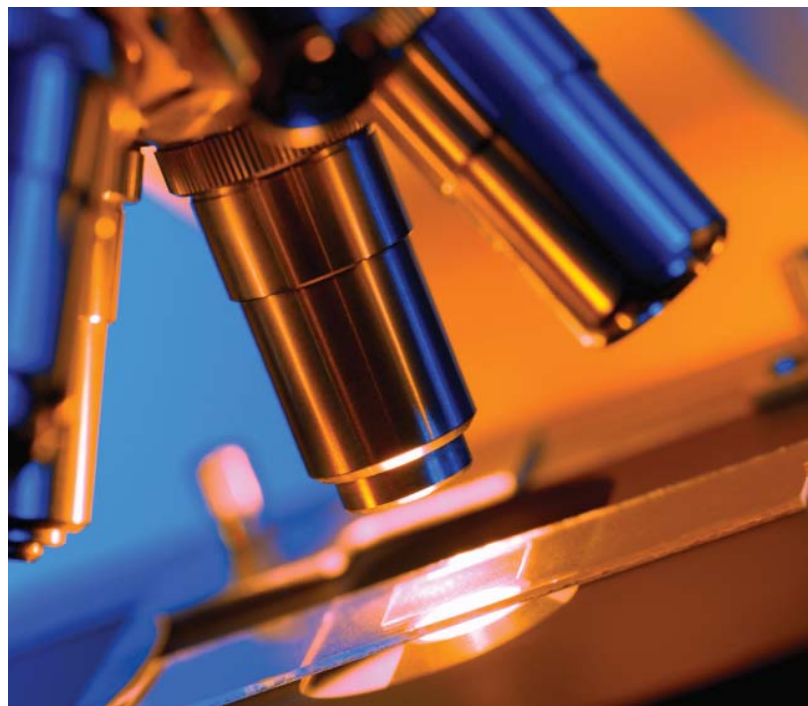
With the good track record of the research groups at the Faculty of Associated Medical Science, the CMDL emphasis is on four areas of research and development: prevention and control of thalassemia, cancer, transplantation, and molecular immunology and laboratory diagnosis of infectious diseases.

Tropical Feed Resources Research and Development Center (TROFREC)

Feed is an important factor attributing to livestock production systems to increase efficiency and/or to lower cost of production. In Thailand, there are many kinds of feedstuffs with diversity in quantity and quality. Their uses in producing meat, milk, and eggs can be exploited efficiently. Moreover, development of value-

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added feed products can be further exported to foreign markets as a means to obtain national income. Thailand is situated in a tropical area and shares many similarities with a number of tropical countries. Research works generated in Thailand can be transferred and modified for application in other countries. The main objective of establishing TROFREC is to conduct relevant research activities with feed development and utilization improving livestock production in tropical areas, and to foster and strengthen collaborations with other institutions in Thailand and other countries. Therefore, the Department of Animal Science, Faculty of Agriculture, Khon Kaen University has deemed necessary and promoted the importance of TROFREC in accordance with increasing needs of feed resources and their uses for efficient animal production.

Fermentation Research Center for Value Added Agriculture (FerVAAP)

Fermentation technology is one of the core technologies, which plays an important role in agro-industry, especially the biomanufacturing industry. It requires multidisciplinary collaboration across disciplines aiming at the improvement of the production processes, and the innovation of bioprocesses and products to obtain high value-added products with high efficiency.

Thailand is an agro-industrial-based country, while “fermentation technology” is an important technology for the production of diverse commercial products. Envisaging this vital and significant role, FerVAAP was established in 2002 with the main objective to become one of the “excellence centers” among the 12 research centers initiated. FerVAAP has been currently mandated to focus on R&D activities in the areas of fermented foods, alcoholic beverages, fine biochemicals and other bioproducts, and renewable energy.

Applied Taxonomic Research Center (ATRC)

Thailand’s tropical forests are the biologically diverse habitats of approximately 20,000 species of plants and 87,500 species of animals. However, to date only 8,000 species of plants and 18,000 species of animals have been identified, i.e., the majority of these living organisms are waiting to be studied. The results obtained are certainly vital for the existence of people not only in this region but for the entire environmentally deteriorating world.

The ATRC was established in 2002. One of the center’s missions is conducting basic and applied taxonomic research on medicinal herbs and fungi, identification of human allergy-causing pollen, classification of bioindicators (zooplankton, aquatic insects, and algae) for environmental assessment, and characteristics of DNA fingerprinting for agricultural crops. ■





2. agriculture and food technology

The Future of Farms

How Thai scientists, policymakers, business leaders, and farmers are feeding the world.

by Thana Poopat

Ming Saree-on has never heard about genomics or quantitative trait loci. What he is all too familiar with, though, is blast, a fungal disease that wilts his rice and income along with it. So when agricultural researchers showed up in his village asking if he wanted to test a new variety of rice with blast resistance, he felt he had nothing to lose.

He and subsistence farmers like him have long been the backbone of Thai society. But they are now struggling against a myriad of forces—such as the rise of commercial agriculture, and the migration of young people away from farming—which are threatening their way of life and a critical segment of Thailand's economy.

Thailand may be a medium-sized, middle-income developing country, but it's among the agricultural heavyweights. Led by agricultural and food products—such as rice, natural rubber, tapioca, shrimp, and chicken—farmers like Ming help Thailand remain among the world's top 15 agricultural and food-exporting countries, contributing \$20 billion per year in export earnings.

For decades, Thai farmers' traditional skills and their judicious application of science and technology, pragmatic public policies, and a forward-looking private sector have been the agricultural sector's recipe for success. Unfortunately, this formula is rapidly becoming unbalanced. Biotechnology solutions like blast-resistant rice are increasingly seen as the pivotal variable to ensure that Ming and other Thai farmers continue to thrive.

A LONGTIME TOOL

Science has played a valuable role in Thai agriculture for nearly a century. In 1914, one of the first students dispatched by King Rama V to study agriculture abroad, Phraya Phojakara, returned from Cornell University with a head full of new ideas to share with farmers. The rediscovery of the genetic theories of Gregor Mendel

were a major contribution to the world's agricultural science at the time, and Phraya Phojakara applied them when he assumed the role of chief breeder at the Rangsit Rice Experiment Station.

In 1917, the country's top rice-producing regions submitted samples with desirable traits for use as potential parent varieties for subsequent breeding. The first target was regular table rice. After years of perseverance experimenting with open-pollinated breeding (traditional breeding that relies on natural mechanisms, like insects, birds, and wind in an isolated patch to produce seeds that can be saved for replanting), Phraya Phojakara's efforts were recognized on the international stage. Thailand took first prize and swept 10 other prizes for grain quality at the World Grain Exhibition Conference in Regina, Canada, in August 1933.

To this day, Thai rice—particularly jasmine—is world renowned. What's less known is Thailand's contribution to maize—specifically, the discovery of a gene that provides resistance to downy mildew that led to the development of the Suwan-1 maize variety.

“Developed by Thai researchers for Thai farmers, Suwan-1 went on to become a major Thai contribution to the world,” Pongthep Akratanakul, chief of the Center for Agricultural Biotechnology, part of Kasetsart University, says. “Virtually all maize varieties grown in the world's tropical areas today carry the downy mildew-resistant gene that traces back to Suwan-1.”

Now, under the direction of the 2004–2011 National Biotechnology Policy Framework, science is playing an even stronger role in Thailand's agriculture and food industries. The Framework emphasizes applying core technologies such as genomics, bioinformatics, and breeding using DNA markers to select desirable traits to improve productivity. ▶



**Rice farm nestled
between mountain
peaks**
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After nearly a decade of debate, the government is poised to release clearer guidelines for researchers to more aggressively pursue field trials of genetically modified crops. Given the ongoing uncertainty as to the direction GMO products may take in the global marketplace, and the integral role the agricultural economy plays in Thai society, policy makers have proceeded cautiously. For the time being, main food products, especially rice, will remain off limits to GM technologies, but a host of other products such as genetically modified maize and soybean, which are used mainly as animal feed, can be grown locally as well as imported. The National Biosafety Bill now winding its way through the legislative process will generate strict controls on laboratory research and open-field trials of GMOs.

“GM-crop development is important if Thailand’s competitiveness as one of the world’s major agricultural and food exporters is to be maintained,” says Morakot Tanticharoen, senior advisor of the National Center for Genetic Engineering and Biotechnology (BIOTEC).

FOOD 3.0

In recent years, the rise of modern commercial agriculture has threatened to squeeze out subsistence farming. New entrants

to the agricultural labor force are dwindling as children from farming families spend more years in school, then secure employment in industrial and services sectors, never to return to their farming roots. Thailand’s agricultural workforce has shrunk from 60 percent of the country’s total labor force in 1982 to only 40 percent in 2007. Meanwhile, the average age of a Thai farmer has increased to 51 years.

In response, government policy makers, members of the private sector, and the scientific community have reached a consensus that an export-oriented agricultural production system and subsistence farming shall not be mutually exclusive. The full force of Thailand’s biotechnological capabilities should be brought to bear on protecting local farmers, says Theerayut Toojinda, a leading plant breeder from BIOTEC.

Several years ago, Theerayut began working with farmers in the rain-fed lowlands of the North and Northeast. Their fields had become less fertile and their world-famous jasmine rice, Khao Dok Mali (KDML 105) and glutinous jasmine rice (Kor Khor 6), were frequently impacted by diseases and pests. Main scourges included blast, bacterial blight, and abiotic stresses such as flooding, drought, and salinity.

WHITE KNIGHT

How Thailand's organic marketplace is being saved by an unlikely ally—biotech.

by Kamol Sukin

Not so long ago, the mere utterance of the word “biotechnology” amid Thailand's organic farmers evoked a call to arms because of the general negative public perception against products like genetically modified organisms (GMOs). But with rapid growth of the organic farming market and leadership from the Thai government, biotechnology is now seen as a critical ingredient to a promising future for the country's domestic and export organic markets.

The global organic market is booming—worth US\$30 million in 2009, and growing by 10 percent each year. Taking its lead from the adoption in 2008 of the country's first national organic agriculture plan, “Think Organic, Think Thailand,” the National Innovation Agency (NIA) is committed to demonstrating how biotechnology can benefit organic farmers.

“Without NIA's biotechnology, my business would not have survived to realize the good fortune we're experiencing today,” explains Khongkaphan Siriwan, owner of Poothon Agriculture Industrial Company, a biofertilizer factory.

In just 2 years, Khongkaphan's company has transformed \$30,000 of debt into some

\$300,000 in annual profit thanks to the fertilizer technology provided by NIA's network of biotechnologists. Three species of bacteria were applied to his company's biofertilizer production to increase productivity and reduce input costs: photosynthetic bacterium group and two other bacterium species—*Azotobacter sp.* and *Azospirillum sp.*

“Since 2008, we have generated 25 new investment projects worth \$6.1 million related to organic farming from the \$700,000 we [originally invested],” explains NIA director Supachai Lorlawhakarn, who expects he can sponsor 10 new organic businesses annually.

Wanlop Pitongsas, president of the Thailand Organic Farming Association, throws his full support behind NIA. “The situation has changed. Organic production can no longer rely strictly on traditional farming methods. Biotechnology can play a significant role if it adheres to strict international standards, especially GMO-free criteria,” Wanlop offers.

Supachai confirms NIA's farming technology is non-GMO. Apart from the biofertilizer, other NIA-assisted innovations include high-antioxidant organic honey production; production protocols for organic

beef with enriched conjugated linoleic acid, a potent cancer-fighting substance; and the cultivation of organic pomelo, passion fruit, and coconut flour. NIA is also helping with nonfood items such as ecofriendly herbal soap and diapers.

Khongkaphan's organic fertilizer is an excellent example, says Supachai. Once biotechnology had identified the organic fertilizer ingredients to improve the previous production process, local wisdom and expertise were relied on to develop the production process, and NIA assured that a solid business model was put in place.

However, both Supachai and Wanlop agree that additional government leadership is urgently needed to fully realize the goals of “Think Organic, Think Thailand.” Specifically, they believe that the priorities should be to develop financial incentives for conventional farmers to transition to organic production methods and a domestic organic certification system.

“Most of all, the national direction of biotechnology research and development must realign its support to emphasize pro-organic agriculture. [The NIA] is not enough. Political will, with foresight, is needed for this industry to thrive,” Supachai says.

Theerayut's team applied a decade's worth of research to the problem, during which they identified genomic regions associated with important positive traits targeted for improvement, such as cooking quality, aroma, and tolerance to pests and diseases, as well as flooding, drought, and salty soil. They then proceeded to locate the positions of these genes based on their respective functions in the rice genome with the help of DNA markers.

“We found that most of the genes that determine cooking quality, aroma, and the targeted traits can be manipulated without causing negative impacts on grain yield and its components,” Theerayut says.

Apichart Vanavichit, director of the Rice Gene Discovery Unit, is confident that the “Super Jasmine” variety that Theerayut and the Rice Gene Discovery Unit are developing jointly will be

resistant to flood, diseases, insects, salinity, and drought, while at the same time retaining cooking quality/aroma, and be ready by 2015, if not earlier.

Ming Saree-on is plenty happy with the results so far on his tiny (0.2-hectare) plot. In July 2008, his village in Nan Province's Chiang Klang district was abuzz with rumors about an “upgraded” blast-resistant Kor Khor 6 variety that Ming had planted. Three months later, when an outbreak of blast occurred, there was no hiding the outcome. Much of the conventional variety rice surrounding Ming's plot either wilted or fell flat to the ground.

“I never expected that the experiment would pay off big time, the first time I did it,” he says. “One neighbor described my crop as the only sober person left standing in a room full of drunkards.” ▶

OVERVIEW

Researchers are also exploring varieties that might offer higher nutritional value and more bioactive ingredients. For example, nutrition experts at Mahidol University, in cooperation with the Rice Science Center, have identified varieties rich in antioxidants and iron. These are being targeted for further development as “functional food” to promote good nutrition, as well as to address specific health requirements, such as anemia.

“These programs are exactly what we need. In the past, all we did was wait for the government to tell us what rice variety is good

for us and what we should be planting in our fields,” says farmer Pitak Yapuang, who like Ming is known as a community researcher. “Now we get to try new varieties and decide for ourselves.”

MORE CASH PER CROP

While propping up small farmers is important, Paiboon Ponsuwanna, Vice Chairman of the Federation of Thai Industries and Executive Director of Transmut Food, a major seafood exporter,

HOLD THE PORK

With its seal of approval, a unique science center helps millions of Muslims determine what is safe to eat.

by Kornchanok Raksaseri

Although rum raisin has been a longtime favorite flavor among ice cream aficionados, it sounds considerably less scrumptious to devout Muslim consumers, who do not drink alcohol.

So Sajja Sujjapornamest, an export marketing executive at ice cream and frozen food company Bouno (Thailand), turned to the Halal Science Center at Bangkok’s Chulalongkorn University for help in marketing the flavor to Muslims.

The center has equipment to test and assure that Bouno’s rum raisin ice cream contains no alcohol. “Also, we used to use gelatin from pigs. The Halal Science Center gave us information and told us to switch to gelatin from plants,” Sajja says.

The center was established with the world’s first independent Halal-testing laboratory to ensure that Muslims anywhere can be certain in telling the difference between what is Halal (allowed) and what is Haram (prohibited).

As a Muslim and former Halal food auditor in a major food exporting country like Thailand, Winai Dahlan, founder and director of the center, wants to protect Muslims “to the spiritual level.”

Muslims do not always refrain from rum raisin ice cream, as it is widely made with artificial flavor, Winai says. But there are more concerns in other food.

“When it is in the form of non-red meat food, people in Muslim countries have no way to know if imported food is contaminated with Haram. The complexity in production processes makes it hard to tell what are the seasonings in canned pineapple, tuna, and sauces,” Winai says.

To address these concerns, the center introduced the use of science to determine if the food is pure Halal.

The center’s experts can trace the ingredients of products, food and non-food, to their origins with advanced analytical techniques such as combination of high-performance liquid or gas chromatography and mass spectrometry to detect and identify animal fatty acids, animal proteins and DNA, and alcohol.

It also examines the hormones present in meat to find out whether an animal was slaughtered without torture, as stated in the Qur’an.

Examination by the Halal Science Center is part of the procedures for obtaining the Halal logo and Halal slaughtering certification in Thailand. The center is also accepted by Muslim countries around the world.

The Halal Science Center, which already boasts the first Halal laboratory in the world, also premiered a Halal assurance mark, the HAL-Q.

HAL-Q was developed from Halal-GMP/HACCP (Good Manufacturing Practice/Hazard Analysis and Critical Control Point) to ensure that Halal food or products are prepared, processed, transported, and stored properly.

“HAL-Q is one of a kind, as it combines standards, regulations, and the production system together. While standards and regulations can be compared to a recipe, HAL-Q is like sending a professional chef to teach someone to cook with real understanding,” Winai says.

It takes from 4 to 8 months to get HAL-Q assurance.

Bouno is one of over 80 manufacturing plants that have already earned HAL-Q assurance, and more than 100 factories have joined the program.

Sajja says consumers in Malaysia and Indonesia, where Bouno has been exporting for 3 years, trust the HAL-Q certificate. He is expanding the market to the Middle East and believes having both Halal and HAL-Q signs is to his benefit.

HAL-Q is now accepted in Asia, South Africa, Canada, Jordan, Palestine, and Israel. Scientists from Turkey, Bangladesh, and Brunei participated in the HAL-Q’s official launch last year, Winai says.

stresses that to stay competitive, Thailand must transform a portion of its agriculture into industrial-scale farming.

Contract farming, or agricultural production based on an agreement between farmers and buyers that sets conditions, usually at predetermined prices, is the way to go, not just for staple cereal crops, but also for cassava, a promising new source of biofuels, according to Klanarong Siroth, head of the Kasetsart Agricultural and Agro-Industrial Product Improvement Institute.

“Once the cassava ethanol industry takes off, the producers need to be able to control the whole production process, including deciding from whom to buy and what production method is required in order to ensure quality consistency and optimal production efficiency,” he stresses.

At the current output of 30 million metric tons per year, Thailand’s cassava-related products, including flour and tapioca, account for 75 percent of the world market. Applied biotechnology has resulted in new varieties with enhanced starch yield, starch quality, earlier harvests, and greater tolerance to pest and diseases.

Thai researchers are looking at the enzymes involved in starch biosynthesis in different cassava cultivars with varying storage starch levels as a way to increase starch content.

In addition, Thai scientists have adapted and refined an existing fermentation process used to turn cassava into ethanol, which significantly decreases the costs and increases the efficiency. “While the fermentation efficiency and conversion ratio is comparable to conventional methods, the production time of the new process is about 25 percent faster, which translates into considerable savings in energy consumption and production costs,” Klanarong says.

Thailand is currently ranked number 2 in the world in sugar exports; Thai scientists are also exploring novel methods to increase profits from this crop. Prasert Chatwachirawong, head of Kasetsart University’s Sugarcane Research Station, is working on new varieties with harvest intervals of 8 months, 2 months shorter than average. Prasert is also trying to nearly double the amount of bagasse, a byproduct of sugar production that can be used in feed for power plants and ethanol production, as well as pulp and paper products and building materials.

“We are probably most interested in improving the sucrose content as well as sugarcane yield,” says Prasert. The current program is aimed at increasing refined sugar output from 106 kg to 130 kg per ton of raw sugarcane.

Another goal of the sugarcane research station’s BIOTEC-funded work is to uncover the molecular details of sugarcane germplasm (protoplasm of the germ cells that contains genetic material), based on microsatellite markers, morphology, agronomic traits, reaction to certain diseases, and pedigrees. The process is crucial given the highly polyploid nature of the sugarcane genome. The greater the number of informative markers, the greater the impact they can have on breeding.

His team has also been applying marker-assisted selection to increase efficiency of conventional breeding to develop new vari-



Damnoen Saduak
Floating Market
© DAVID JOYNER



Rice terrace field in Chiangmai, Thailand
© THANATHAM PIRIYAKARNJANAKUL

eties with desirable qualities and sweetness as well as resistance to diseases and insect pests.

PRIVATE SECTOR POWER

Pipat Weerathaworn, Director of the Sugarcane Research Center at Mitr Phol, Thailand’s leading sugar producer and exporter, has been pleased with the longstanding commitment the government has made to develop sugarcane varieties. But he’s also aware of the constraints under which public sector researchers work.

“We continue to cooperate with government scientists on certain programs of mutual interest,” Pipat says. “However, we realize that public sector research institutes have to serve many stakeholders, and with intense competition in the international market, we know we need our own R&D capability.”

Mitr Phol grossed \$1.5 billion in 2009. Its research center operates with a staff of 55 working on high-yielding, high-sugar-content, disease-resistant sugar cane varieties to suit its own farms as well as those of its contract farmers.

“In collaboration with BIOTEC, we are now in the process of planning to use molecular biology, particularly marker-assisted selection, to develop new varieties with resistance to smut, a fungal disease,” says Pipat.

Similar research and development is being conducted by Betagro Group, one of Thailand’s largest integrated agro-industrial companies, with \$1.35 billion in annual revenue.

Biotechnology research has been recognized as one of the most important factors contributing to the company’s competitiveness, says Rutjawate Taharnklaew, General Manager of Betagro Science Center.

“Biotechnology offers many ways to keep production cost down and to improve quality while at the same time to meet the highest standards in the global marketplace,” says Rutjawate.

He cites Betagro’s recently completed microarray technology for food microbial analysis designed to detect and identify specific serotypes of salmonella. The procedure is part of the company’s preparation to ensure compliance with more stringent EU regulations for salmonella control that will come into force in 2012.

“In partnership with our micorarray manufacturer, we have gained valuable knowledge for customizing a platform that is suitable for our chicken export operations,” says Rutjawate. The company now plans to develop microarray platforms for other food-borne pathogens as well.

The country cannot increase its production by bringing additional farmland online, since the government has capped agriculture land use at 20.8 million hectares to maintain sufficient forest cover and ensure watershed conservation. Regardless of whether research and development comes from the public or private sector, Thailand is now fully reliant on R&D to sustain its position among the world’s top agriculture exporters.

To stay ahead of the competition, says Sakarindr Bhumiratana, President of the National Science and Technology Development Agency (NSTDA), a vigorous and systematic application of science and technology, particularly biotechnology, in agriculture is imperative.

“It’s not just a question of the what, when, and where biotechnology should be utilized for the greatest good, but also how wisely it is applied,” Sakarindr says.

Farmer Ming and his neighbors are quite happy with the direction the science is headed now, adding, “We certainly know how nature works, and that some day new problems we’ve never experienced before will pop up. It’s good to know we can count on scientists to help us overcome them.” ■

Private Sector Power

R&D, and our competitive strategy for the future economic growth and sustainability.

by Rutjawate Taharnklaew



“...At the macro level the role of R&D can be viewed as a basis of competitive advantage, which is the basis of international trade. At the firm level, the objective is to change the market conditions in its favor under which it operates. This plays an important part of the competitive strategy of the firm. It may also help the firms to grow and diversify (Hay and Morris, 1991).”

The above statement is quite true for developing countries, including Thailand, which need to rethink the country's economic strategy, as well as its positioning in the global market. Globalization makes international trade competitive and exporting countries have to face cost competition and uncertainty.

Thailand's economy depends very much on our core competency: agriculture. Many governments try to transform our competency into industry, to make Thailand a manufacturing base of choice for investors as an original equipment (OEM) contractor or business partner. However, what the government should consider very seriously is how to turn OEM to original design manufacturing (ODM), and then to brand name products before shifting ultimately to a total system and services. The transforming process requires innovation through research and development.

R&D is an important component of competitive advantage, as long as it involves the creation of marketable innovations. The incentives of R&D activities are better quality, lower cost, and faster time to market. The combination of these three outcomes will boost the country's competitive position, and eventually profits and stability.

Expenditure on R&D is a key indicator of government and private sector efforts to obtain competitive advantage in science and technology. The parameter used for international comparisons is gross domestic expenditure on R&D. The amount of GDP spent on R&D in Thailand during 2001–2006 was quite stable, from 0.24 to 0.26 percent. However, that figure is much smaller than the percent of GDP spent on R&D by Japan (3.39), Korea (3.22), Malaysia (0.64), and most other countries in the region. Furthermore, in 2007, the amount of GDP dedicated to R&D by Thailand decreased by 16 percent, to 0.21 percent. In developed countries, however, business expenditure on R&D is always higher than the government's, so an investment in R&D from the private sector is key to driving the country's competitiveness in science and technology.

For Thailand, the money spent on R&D by the private sector is relatively small compared to developed countries in Asia. Therefore, the private sector must increase R&D expenditures in order to gain back competitive advantages that we have lost due to globalization, free trade, and competition from early innovators such as Vietnam. Investments can be short- or long-term, internal or by partnering with a university.

Founded in 2005, Betagro Science Center (BSC) was the brainchild of the Betagro Group in collaboration with the National Science and Technology Development Agency (NSTDA). The objective was to create a think tank on R&D in science and technology, as well as establish a first-class laboratory capable of testing food and feed quality, monitoring animal health, and diagnosing infectious diseases. Knowledge and outputs created in this center help improve production procedures, their efficiency, and the production of high-quality and safe food.

R&D in the private sector has totally different objectives and uses key performance indicators (KPIs) that will reflect the return on investment. Simply put, it must be aligned with business policies and directions, and focused on specific outcomes. One of BSC's strategies for establishing R&D capability within the firm is to build up networking with well-known research institutes and universities. That is why BSC is located at Thailand Science Park (TSP)—to show other private companies in Thailand that commitment to R&D is one of the factors that will help the firm grow and maintain competitiveness.

“Locating at TSP is also a very good corporate image and we strongly believe that the ‘science’ atmosphere and ‘learning’ environment in TSP will motivate our R&D staff to be able to deliver innovative outcomes within a timely manner.”

— Mr. Vanus Taepaisitphongse, President of Betagro Group ■

Rutjawate Taharnklaew, DVM, EMBA, is the General Manager, Betagro Science Center Co., Ltd, and R&D Director, Betagro Group.

KMUTT

Working with Biotechnology Industry



The main campus of King Mongkut's University of Technology Thonburi (KMUTT) is located in an industrial area on the Thonburi side of Bangkok. The university has a history of working closely with industrial partners since first being established 50 years ago. In addition to collaborative research, major companies such as Castrol and Mercedes Benz chose to locate their training facilities on campus. KMUTT is also active in Practice School programs, using industrial partners for on-site education.

More recently, there is an increasing trend for this collaboration to feature the life sciences. KMUTT made the breakthrough for the commercial production of *Spirulina* in Thailand, in addition to a long history of assisting the food industry in waste treatment and recovery. This led to the establishment of a new campus at Bangkhuntien, which in turn led to higher interest from major research institutes and eventually the establishment of an Industrial Park. KMUTT is the only university in Thailand to invest in an industrial park, providing incubator units, facilities, and research and training support.

The Bangkhuntien campus sits on a piece of reclaimed land on the very outskirts of Bangkok. Already a number of impor-

tant bioscience centers have been established, including the Biochemical Engineering and Pilot Plant Research and Development Unit, as well as an Excellent Center for Waste Utilization and Management (ECoWaste). The Industrial Park provides excellent facilities for bioentrepreneurs including pilot plant fermentation in addition to testing and analysis services. To date, the focus has been on microbial bioprocess development and algal biotechnology. The National Center for Genetic Engineering and Biotechnology (BIOTEC) is a major partner in many of these activities. Bangkhuntien is also home to KMUTT's School of Bioresources and Technology. The combination of scientists and engineers helps to provide ideal solutions for private sector partners, while developing pilot plants reduces the risk and high investment normally required for establishing a bio-business.

The KMUTT Industrial Park welcomes inquiries from foreign investors who are considering establishing a bio-business or joint venture in Thailand and are looking for support through facilities and research. KMUTT sees the future focus as being biopharmaceutical science and engineering and is actively seeking international collaboration in this area. ■

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Biopharmaceutical cGMP Pilot Plant



KMUTT has watched with keen interest as more universities in the United States and other countries invest in cGMP (current Good Manufacturing Practice) facilities. These facilities not only provide for education and research, but help save industry-significant investment and testing costs, while at the same time providing an important source of revenue for the university. The benefits for education are significant as cGMP provides hands-on facilities for students who will help to fill the increasing manpower needs of the biopharmaceutical industry.

Thus, in partnership with BIOTEC, KMUTT has decided to invest in a cGMP plant to service the needs of the biopharmaceutical industry in SE Asia. When completed in 2010, it will be the only university-based facility of its kind in the country. The plant will provide for scale-up study and production of recombinant proteins for clinical trials (phases I and II), as well as for training manpower. Students will have the unique opportunity of working with a large-scale manufacturing facility, from design to operation and management. Because of the considerable investment costs involved, the university can provide services that can be shared by industry at a fraction of the costs they would need to invest themselves or to make use of private contract facilities. For

a country such as Thailand, government support to the fledgling bio-industry is crucial considering the high cost of investment required for a bio-business start up. Appropriately, the Biopharmaceutical cGMP plant will be located in the KMUTT Industrial Park on the Bangkhuntien campus, where best use can be made of KMUTT's strong industry linkages. Companies interested in advanced biotechnology and products can avail themselves of services via collaborative research and development, contract R&D, process optimization, and contract manufacturing according to the client's needs. The plant will ensure that international standards for good manufacturing practice and safety are met.

KMUTT's cGMP Bioprocess Pilot Plant will be composed of two suites, each dedicated for microbial and cell culture fermentation systems up to 500L and 100L bioreactors, respectively. Both are supported by separation and purification processes and the plant has been designed to comply with international standards. KMUTT is already collaborating with other biopharmaceutical research groups within the country, such as the Government Pharmaceutical Organization, which will lead to the formation of multidisciplinary teams making use of the facility. ■

For more information on Biopharmaceutical cGMP Pilot Plant, contact the Biochemical Engineering and Pilot Plant Research and Development Unit at KMUTT at bec_info@pdti.kmutt.ac.th.

A Better Shrimp

Seeking seafood that's fitter, healthier, and more productive.

by Anchalee Kongrut

Bunjonk Nissapawanich's shrimp farm appears no different from the tens of thousands of similar operations found in and adjacent to Thailand's aquatic areas. But were one to take note of the constant stream of researchers who regularly visit his 18-hectare facility, it's clear that something significant is under way here.

Indeed, nothing less than the maintenance of Thailand's worldwide leadership in shrimp exports, valued at \$2.64 billion in 2009, is tied up in Bunjonk's rows of concrete tanks and earthen ponds located 100 km east of Bangkok. Specifically, efforts are under way to produce black tiger shrimp (*Penaeus monodon*) that are faster growing, more disease resistant and of more uniform size than anywhere else in the world.

"Our dream is to have other countries depend on us when they look for good disease-free black tiger shrimp," says Morakot Tanticharoen, vice president of the National Science and Technology Development Agency (NSTDA).

The NSTDA Shrimp Research Program provides Bunjonk's domesticated stock that originates from the Gulf of Thailand and the Andaman Sea. The shrimp that reach him have gone through extensive selection and breeding to ensure SPF (specific pathogen-free) stock and growth quality.

First, workers quarantine the candidate breeding stock at a research facility in Nakhon Si Thammarat province, where they are screened and reared to produce SPF shrimp. The Nucleus Breeding Center, another laboratory in Surat Thani province, evaluates the genetic traits of the SPF stocks. Currently, there are 30 distinct SPF breeding stock (broodstock) families, and BIOTEC (the life science research arm of NSTDA) plans to expand the collection to 200. Cross-breeding is aided by genetic analysis and DNA markers. SPF broodstock prototypes are then sent to another facility in Chanthaburi province, where they reproduce, before arriving at Bunjonk's in Chacheongsao and a companion's farm in Surat Thani province in the South, and Chantaburi and Chachoengsao provinces in the East, for rearing and circulation to commercial farmers.

Since 2007, these two hatchery farms have helped distribute more than 3,000 broodstock and 30 million postlarvae. "So far the feedback from the local farmers is not great, as the shrimp are

smaller than wild species," said Bunjonk. But Morakot is pleased that the shrimp remain healthy and is confident that further efforts will yield a desirable size.

FINDING A NICHE

Also known as giant or jumbo tiger shrimp, black tiger shrimp are the largest in the world, growing up to 36 cm long, and weighing up to 650 grams. They were once the mainstay for Thai shrimp farmers until disease and declines in natural broodstock brought production to a standstill in 2002.

This forced farmers to switch to Pacific White shrimp (*Penaeus vannamei*) and to use broodstock imported from Hawaii. Smaller and less expensive to raise, Pacific White shrimp now represents 98 percent of shrimp farmed and exported from Thailand.

However, fierce competition among shrimp exporters from other countries has caused BIOTEC to emphasize research on the pricier black tiger shrimp as a strategy for Thailand to stay one step ahead. While Thailand's yield per hectare in both Pacific White and black tiger shrimp remains one of the highest in the world, the sector is facing increased competition from Vietnam, China, India, and Indonesia.

"In the long run, Thailand will be unable to sell shrimp as a commodity because competitors will have lower labor costs. We have to sell a premium product to a high-end, niche market," says Morakot.

Pacific White shrimp currently commands \$6–\$7 per kilogram, while black tiger shrimp can fetch upwards of two to three times this price.

The Thai government also hopes that BIOTEC's shrimp program will strengthen the country's food safety image, something that is becoming increasingly important to importers. BIOTEC's broodstock will have an advantage should countries place bans on wild shrimp due to environmental or disease concerns, since it's much easier to test domesticated farmed shrimp broodstock for food safety.

"In the future we hope farmers can open a catalogue that highlights our black tiger shrimp broodstock and order shrimp that represent the quality, size, and weight they want," adds Morakot.



Shrimp Farm, Sam Roi Yot National Park

RESEARCH LEADERS

Biotechnology has been at work in Thailand's shrimp industry since the 1980s. Notably, the outbreak of yellow-head virus (YHV) in the early 1990s dramatically reduced production nationwide, and prompted scientists to ramp up research programs to better understand the species. In 1996, Chulalongkorn University started the genetic work on shrimp, with the study of DNA of black tiger shrimp in the Gulf of Thailand and Andaman Sea, along with their migration patterns and mating behavior.

The same year, biologists at Mahidol University produced the first diagnostic kit to test for YHV by employing PCR to magnify the viral DNA up to one billion times. Last year, a less expensive and simpler diagnostic kit emerged that uses loop-mediated DNA amplification (LAMP) and gel strips.

BIOTEC researchers at the Center of Excellence for Marine Biotechnology, a BIOTEC satellite lab at Chulalongkorn University, have recently begun extracting and commercializing hormones from sea worms (Polychaetes) as a dietary supplement to enhance gonad development in both male and female shrimp, resulting in more rapid fertilization and spawning frequency.

In 2007, BIOTEC researchers at the Center of Excellence for Shrimp Molecular Biology and Biotechnology (Centex Shrimp), based at Mahidol University, isolated the protein PmRab7 in shrimp that can block the White Spot Syndrome Virus's entry

into shrimp cells, dropping mortality rates from 100 percent down to 15 percent.

Combined, Thai researchers have secured 15 patents on shrimp technology on such things as diet, diagnostic kits, and wastewater treatment systems that can treat nitrogen and facilitate water recycling. Only the United States, European Union, and Japan have more patents related to shrimp aquaculture.

But not everyone views such developments as positive. Too much emphasis is being placed on black tiger shrimp, says Sathit Panich, an independent supplier to shrimp farmers. "In future, shrimp will become an increasingly important protein source worldwide and Pacific White Shrimp can fill that need more easily, at less cost, and utilizing less land," asserts Sathit. He wants to see the government develop products and technologies for Pacific White shrimp farmers as well.

Morakot acknowledges Sathit's concern, noting that the government is not avoiding efforts that might improve the competitiveness of Pacific White shrimp farmers. Indeed, most of BIOTEC shrimp technologies such as diagnosis kits and wastewater treatment can and are being used for Pacific White shrimp farms. "It's just that in the long run, we feel the industry as a whole will benefit most by leading the world in black tiger shrimp production," she asserts. ■

Wan's Wonders

How one farmer with little education and no tools developed (and named) two prize-winning rice strains.

by Vasana Chinvarakorn

Most farmers would only dream of growing a rice variety that is both scrumptious and robust. But that's not enough for farmer-rice breeder Wan Ruengtue, who has developed new strains and had them named after him.

Among the small-scale farmers in Thailand's northern and northeastern regions, the names of *Wan 1* and *Wan 2* have in recent years become a trustworthy brand for glutinous rice, a staple crop consumed in every household for generations. *Wan 1*, a mix of government-promoted jasmine rice known as *Kor Khor 6*, and an indigenous variety named *Hom Thung*, is known for its chewy, fragrant grains and resistance to blast, a common rice disease. *Wan 2*, boasts the breeder from Nan province, has even surpassed the *Kor Khor 6* in its aromatic appeal. In two local taste competitions, both varieties have beaten the prevalent *Kor Khor 6* without much difficulty, he quickly adds.

For all his efforts, Wan seeks no patent rights for his "inventions" and even offers to teach fellow farmers how to breed the varieties of their choice.

"I just want to share [knowledge] more than to make money out of it," says the 40-something-year-old farmer. "It is a [source of] pride for breeders if their works have been used by others who take a liking to them."

Wan's achievement is intriguing, considering that he has only 6 years of formal schooling and has received neither state funding nor state-of-the-art technology to help in his experiments. In 1998, a nongovernmental organization named Hak Muang Nan sponsored him and two other farmers for a study trip to the Philippines, where Wan learned a simple rice breeding technique from a local NGO. Back home, the enthusiastic man immediately tried it out on his fields at Ban Had Khed.

The breeding process, says Wan, is actually very simple. You need a pair of scissors, a needle, a piece of white porous paper, and dexterous hands. For Wan, the best time of the year for the "rice matching" is October 20 since the crops will usually be flowering simultaneously then. (He has, however, set up a special demonstration site at his farm where he can show the technique to visitors all year round.)

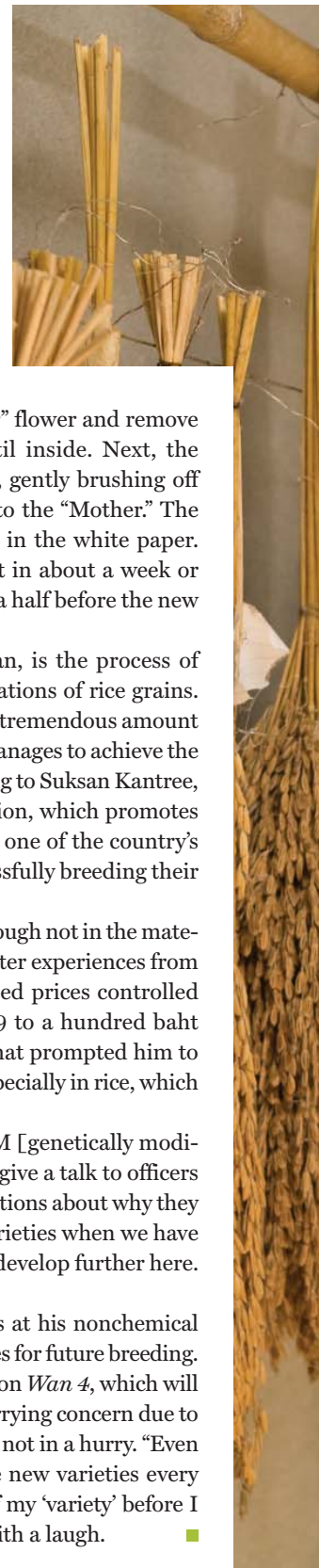
The first step is to cut open the "Mother" flower and remove the stamen, leaving only the solitary pistil inside. Next, the "Father" inflorescence flower is introduced, gently brushing off the stamen's pollen so that it falls right onto the "Mother." The pollinated flower will then be wrapped up in the white paper. Usually the germinated grain will come out in about a week or two, but it may take as long as a month and a half before the new seedlings are ready for transplant.

More daunting and laborious, says Wan, is the process of sifting and screening the subsequent generations of rice grains. It takes about seven to eight seasons—and a tremendous amount of patience and determination—before he manages to achieve the stable, desirable traits of his choice. According to Suksan Kantree, technical specialist of Kwao Kwan Foundation, which promotes sustainable agriculture in Thailand, Wan is one of the country's extremely few farmers who have been successfully breeding their own rice seeds.

Wan's efforts have apparently paid off, though not in the material sense (he does not sell his seeds). His bitter experiences from growing maize commercially—when the seed prices controlled by agro-conglomerates jumped from \$0.09 to a hundred baht (\$3.03) per kilogram—are another factor that prompted him to seek ways to be self-reliant in seed supply, especially in rice, which he says is far more important than maize.

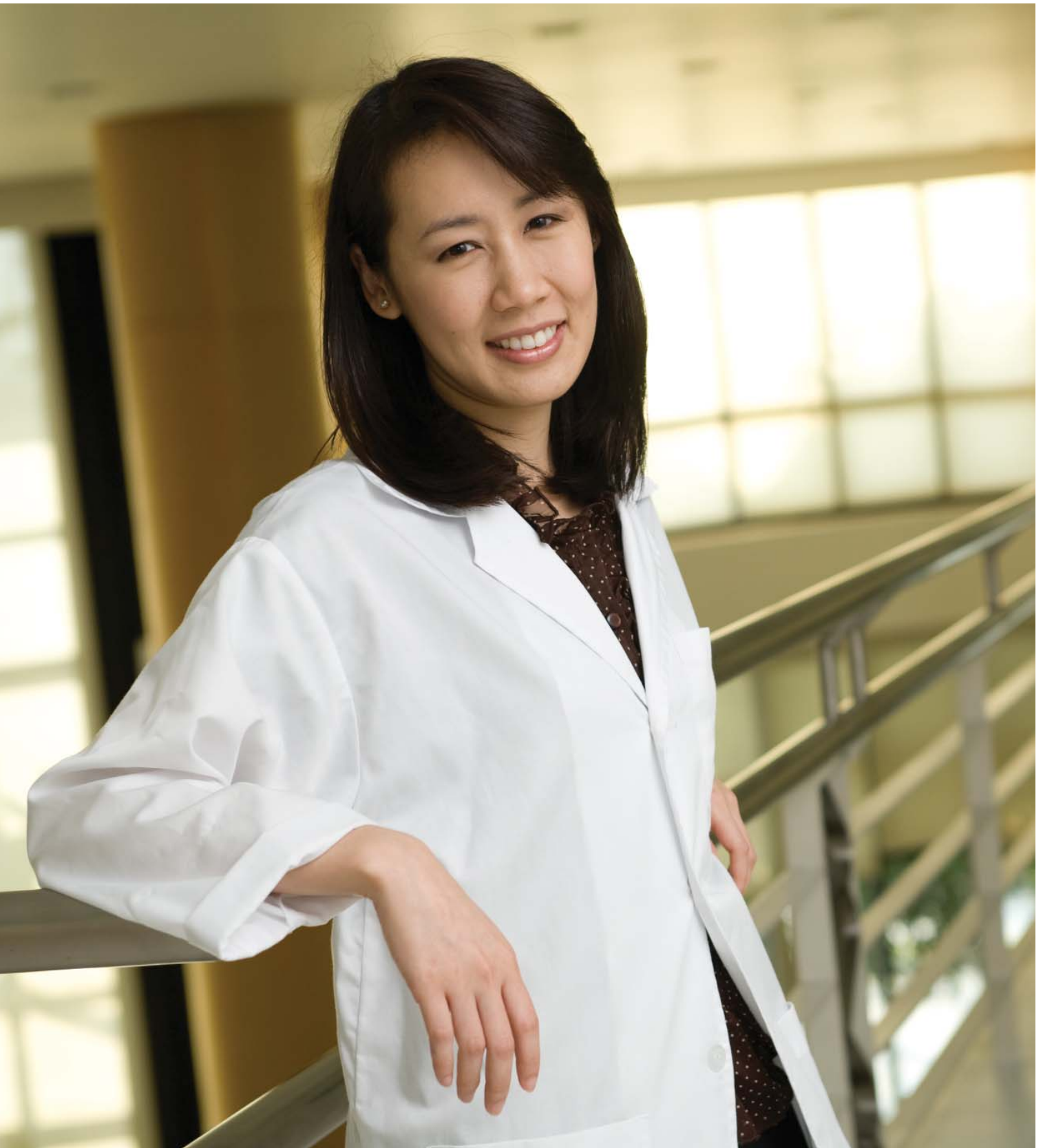
"I personally don't think much about GM [genetically modified] rice," Wan adds. "I was once invited to give a talk to officers from the Rice Department, and I raised questions about why they even had to bother with introducing GM varieties when we have so many indigenous varieties that we could develop further here. Everyone in the room just went quiet."

With about 20-plus indigenous varieties at his nonchemical farm, Wan says there are countless possibilities for future breeding. Over the last few years, he has been working on *Wan 4*, which will address the problems of drought, a more worrying concern due to climate change, he notes. At any rate, Wan is not in a hurry. "Even the fully fledged researchers cannot release new varieties every year. I want to make the utmost certainty of my 'variety' before I let her walk onto the public stage," he says with a laugh. ■





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One to Watch

She is just a few years out of school, and already Nitsara Karoonuthaisiri is head of the government's first microarray lab, and helping the next wave of even younger scientists achieve the same success.

by Klomjit Chandrapanya

At 32, Nitsara Karoonuthaisiri is already 3 years into heading the Microarray Laboratory at the National Center for Genetic Engineering and Biotechnology (BIOTEC), has filed five patents, and been invited by the Inter Academy Panel, a global network of the world's science academies, to mentor other young scientists in the world.

In this last capacity, Nitsara was first selected to attend an inaugural young scientists meeting in 2008, which ran parallel to the World Economic Forum summer meeting in Tianjin, China. She has now been elected to be one of the founding co-chairs of the Global Young Academy (GYA) whose members will be from the top 200 young scientists from around the world. The goal is to be "the voice of young scientists around the world" by creating a forum for young scientists to better interact with each other to promote knowledge sharing and networking opportunities, especially for those in countries where science currently receives low support.

Nitsara, however, is quite happy with conditions in Thailand, giving credit to understanding executives at BIOTEC and the Ministry of Science and Technology's aggressiveness in raising public awareness about science in everyday life.

"Thai children are much more aware about scientific research than when I was a kid. They know to seek scientific solutions to their problems. I think a country can only grow if its people can think rationally and not be so superstitious," says Nitsara, a recipient of a prestigious government scholarship.

She spent 10 years in the United States studying chemical engineering and obtained a BS with honors from Columbia University. She later completed her MS-PhD from Stanford, conducting research on the antibiotic-producing bacterium *Streptomyces coelicolor*, using DNA microarray technology.

Back in Thailand in 2004, she felt welcomed, but the culture shock of switching from studying to working and living in Bangkok was rough. Nevertheless, she was soon thriving. BIOTEC had a policy of nurturing new researchers by first putting them in established groups; Nitsara helped make DNA chips for teams working on malaria and shrimp. Without the microarray spotting machine, however, in the beginning she had to trek back to her alma mater at Stanford and Columbia to make the chips.

Now that the Microarray Laboratory is established here, Nitsara's group is busy using array technology as a platform to serve different kinds of research needs for the country. Her team of seven is making arrays as a diagnostic kit to detect food-borne pathogens, "because to be the world's kitchen, we have to ensure people that our food is safe."

Another project is focused on the reproductive system of black tiger shrimps, an important Thai export. According to the Thai Shrimp Association, shrimp exports earned US\$2.2 billion in the first 10 months of 2009, and are expected to rise to \$3.01 billion this year. However, the industry is plagued with various problems, including disease outbreaks, slow growth, and sluggish maturation of breeders in captivity.

With the lack of genome sequencing of shrimps, Nitsara says the project is still in its early stages, trying to get as many genes as possible on the microarray. "The good thing about this is we're creating new knowledge all the time because not many people in the world are studying shrimps."

When she heard that she is being touted as one of Thailand's brightest stars, Nitsara professed that a lot of that had to do with more senior scientists' kindness, something she hopes to replicate now. "I want to do the same for younger scientists—treat them with respect, support them, and sincerely wish them well." ■

Kasetsart University

An International Agricultural Education Hub

Kasetsart University (KU) established in 1943, was the first higher educational institution with the primary goal to promote the study of agricultural sciences in Thailand. *Kasetsart* literally means “agricultural sciences”. In addition to its academic functions, the university prides itself as a working university for the betterment of Thai farmers’ livelihood and the augmentation of productivity/quality of their produce. Throughout the years, it has firmly developed facilities and human resources, with satellite campuses and research stations strategically located in all parts of the country to synergize efforts toward its vision/mission.

By the genuine visionary guidance of the university leaders, Kamphaeng Saen Campus (KPS) was established 30 years ago in the heartland of Thai agriculture, 80 km west of Bangkok in Kamphaeng Saen district, Nakhon Pathom province. The area is well-known for its abundant and diversified agricultural practices, ranging from rice and sugarcane to famous tropical fruits, vegetables, orchids, and decorative plants; from swine, poultry, beef/dairy cattle, and goats to aquaculture including ornamental fish. Most importantly, it is primed by the most intensive irrigational system and good logistic infrastructure with easy access to both national and international markets. With these excellent supporting environments, Kasetsart University, Kamphaeng Saen Campus (KU-KPS) has attracted renowned scholars, scientists, staff, and students who dedicate themselves to propelling KU-KPS to swiftly become a leading university for agricultural sciences.

KU-KPS occupies an area of approximately 1,272 hectares, carefully divided to serve and promote academic excellence in parallel with quality campus life. Academic buildings, sophisticated research facilities, vegetable and field crops including animal pastures, indoor and outdoor sport complexes, and staff and student housing, are all a part of the picturesque landscaping, with a wonderful blend of plants, animals and wild bird species.

KU-KPS is one of the major educational incubators for research and graduate study in all aspects of agriculture sciences: animal husbandry, novel disease diagnostic technology, and fruit/



vegetable/field crop sciences, including advance molecular biotechnology. As such, the university has attracted funding and partnerships with government and private sectors enabling the continual flow of outstanding academic achievement. The success is stemmed from strong networking of national and international peer institutions allowing excellent opportunities for students to partake in every facet of the academic process.

In the late 1980’s, the Thai government chose to promote research and graduate study by initiating seven centers of excellence. KU-KPS was chosen to host the only center for agriculture, the Agricultural Biotechnology Center (CAB). Since opening, new discoveries, publications, patents, and awards have been made year after year. The center has seen hundreds of students graduating with MSc and PhD degrees, who have then moved on to further contribute not only in scientific communities but the agricultural community at large.

The Advance Rice Research Center and Rice Gene Discovery Unit is not only a research facility but acts as Thailand’s prominent rice gene bank. The center’s research spans to cover a wide range of domains, from fragrance control gene identification and drought-flood tolerance varieties to special nutritious varieties, including but not limited to rice rich in antioxidant, iron, iodine, and complex starches for diabetic patients.

Another KU-KPS hallmark, Kamphaeng Saen Beef, is a result of decades of research and development. This beef cattle is the only Thai breed developed for the tropical environment and production system in the country. The meat is lean and of high quality, with acceptable growth performance without the aid of hormones.

Kasetsart University has traditionally been deep rooted in agriculture, however, it offers its students opportunities to study in a variety of disciplines such as engineering, architecture, liberal arts, humanities, social sciences, economics, education, etc. Whether academic functions, research, or community outreach, KU strives to maintain its position as an internationally recognized educational hub. ■

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CAB

Center of Excellence on
Agricultural Biotechnology

The Center of Excellence on Agricultural Biotechnology (AG/BIO-PERDO) is a consortium of 10 universities with a mission to foster a collaborative research between state universities and the agricultural production sector, and to upgrade higher education in agricultural biotechnology. It is financially supported by the Sciences & Technology Postgraduate Education and Research Development Office, Commission on Higher Education of Thailand. The Center for Agricultural Biotechnology (CAB) at Kasetsart University, Kamphaeng Saen is the flagship coordinator.

CAB strengthens the cooperation among researchers and provides teaching and research capabilities. The research activities focus on basic and advanced biotechnology and aims to alleviate production bottlenecks in the agricultural sector. Clusters of specialized laboratories are set up in six areas:

Plant Biotechnology. The research includes the study of genetic diversity in germplasm, introducing traits from wild relatives, molecular markers, cells and tissue culture, and genetic engineering. Economic crops such as rice, legumes, solanaceous crops, eucalyptus, and oil palm are intensively studied. This cluster is collaborating with the Global Partnership Initiative Project in Plant Breeding (GIPB) project in launching short- and medium-term trainings in plant breeding.

Animal Biotechnology. The Faculties of Veterinary Medicines and Agriculture work closely in developing vaccines, techniques in detecting pathogens, and marker-assisted animal breeding. Laboratories are equipped for research on embryo technology and artificial insemination of wildlife such as elephants, tigers, and deer, along with felids and domesticated animals.

Fisheries Biotechnology. This group offers expertise in molecular marker and genomics technologies for fish breeding and disease diagnostics. DNA markers are used in the assessment of genetic diversity, sustainable management of fisheries resources, and management of hatchery brood stock.

Plant Biophysics and Biochemistry. This cluster bridges disciplines of plant biophysics and biochemistry in verifying the limitation factors that control the growth and development of



plants under field settings. Research results help solve the fruit quality problems of mangosteen and salacca, yield increase in oil palm, and minimizing chlorosis in eucalyptus on alkaline soils and bottlenecks in several other crop production.

Plant-Microbe Interactions. Facilities are available for evaluation of the molecular basis of plant defense and the identification and detection of plant pathogens and symbionts. Emphasis is on the monitoring of disease epidemic and pathogen surveillance.

Biosafety. The recent outbreaks of SARS and H5N1 bird flu verify that early detection and effective monitoring is essential for their containment. Researchers in the group are at the forefront in this rapidly changing field. Biosafety assessments are currently conducted in genetically modified papaya for resistance to the papaya ringspot virus and low ethylene production in genetically modified orchid plants.

RESEARCH PUBLICATION

Research outputs are published in peer-reviewed journals, and reported at local and international conferences. At present more than a thousand communications have been disseminated by CAB researchers.

GRADUATE STUDY AT CAB

CAB offers MSc and PhD degrees in agricultural biotechnology. CAB has a well-equipped central teaching laboratory facility that can host up to 50 students, where students can try their hands at a variety of protocols of modern molecular biotechnology during an intensive 4-week training. The facility has also been used for training of external parties such as the International Seed Testing Association (ISTA) with support of FAO and the Future Harvest Project of Biodiversity International/CGIAR.

CAB and its member institutes have awarded degrees to the largest number of students in the field of agricultural biotechnology in Southeast Asia. Close to 900 MSc and PhD students have been admitted up to the present. ■

DNA Technology for Agribusiness



DNATEC was established in 2001 as the first government-funded key service center providing advanced diagnostic tools using DNA technology. The service center, located at Kasetsart University (KU) Kamphangsaen campus, was collaboratively founded by the National Science and Technology Development Agency (NSTDA) and Kasetsart University.

GENETICALLY MODIFIED ORGANISM (GMO)

GMO has become the big issue for the “kitchen of the world”, Thailand. Taking into consideration the fast turnaround time and its low detection limit (0.1%), DNATEC laboratory was the first and the most reliable laboratory for the quantitative analysis of GMO testing services in Thailand.

DNA MARKER DEVELOPMENT

For plants and animals with no molecular marker information, DNATEC also provides full-scale services for developing DNA

markers, especially micro-satellite and AFLP markers. DNATEC also provides fast and reliable services in marker-aided selection (MAS).

DNA FINGERPRINTING

DNATEC provides certificates of purity for hybrid seeds and its parental seeds. The verification of plant or animal species, especially species of tuna fish, have become the major trade barrier. Recently, DNATEC plays an important role in prohibited importing of cattle produced from BSE infected countries.

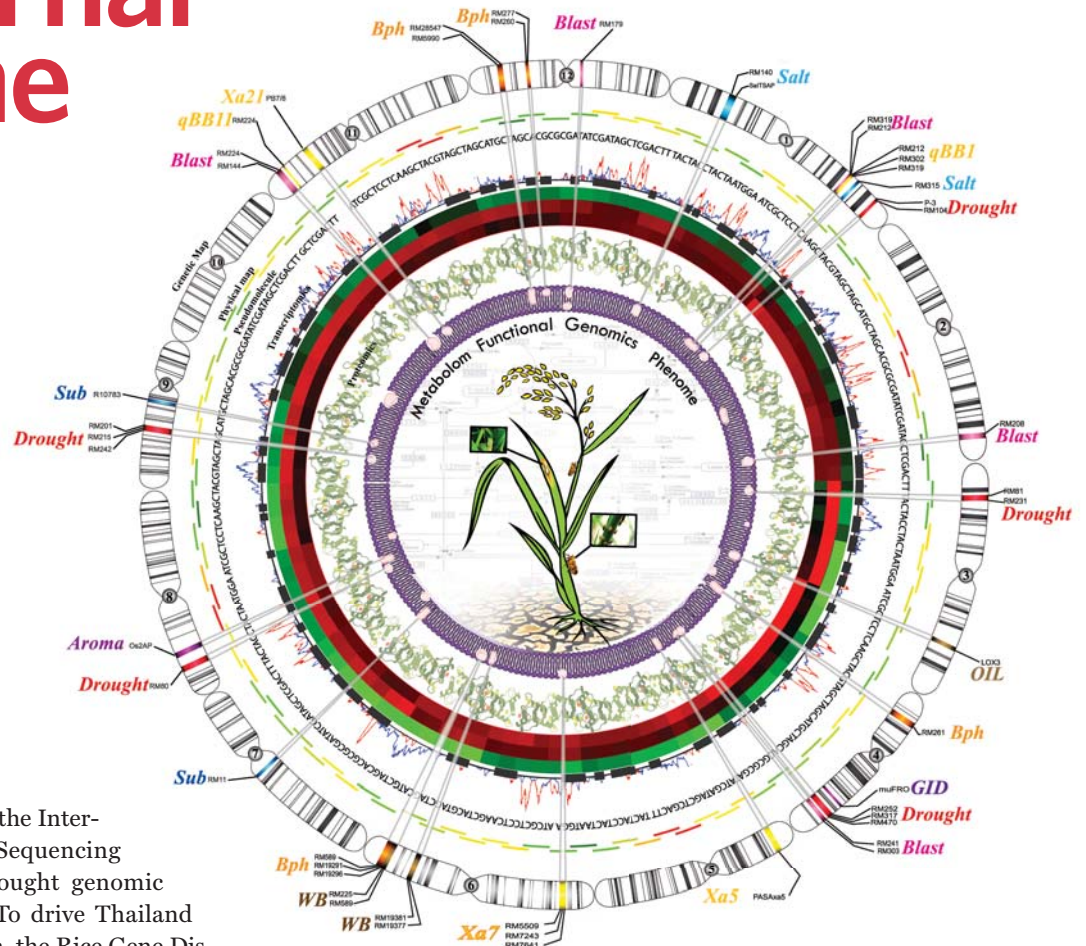
PURITY TESTING OF AROMATIC RICE

In order to keep a premium standard of all aromatic rice exported from Thailand, purity testing for the exported Thai Hom Mali (Jasmine) and Thai Hom Pathum rice is rigid. DNATEC is one of the national assigned laboratories associated with the Department of Product Standardization. ■

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The Guardian of the Thai Jasmine Rice



Thailand's participation in the International Rice Genome Sequencing Project (IRGSP) has brought genomic innovation into rice breeding. To drive Thailand further into the post-genomic era, the Rice Gene Discovery (RGD) Unit was established in April 2001, a collaboration between NSTDA and Kasetsart University (KU); seven years later, the Rice Science Center, KU's research network at Kamphaengsaen campus, was established. The ultimate goal of the twin centers is bridging functional genomics and rice breeding. We start from genetic map position to map-based cloning in order to design the most efficient marker-assisted selection. The highlight is the map-based cloning of aromatic gene from Jasmine rice that eventually became the universal aromatic gene of the entire plant kingdom.

The technology has been granted a US patent to protect its intellectual property. The breakthrough discovery has a signifi-

cant implication for the country's rice breeding programs and genetic conservation. Now, rice breeders can make a "cosmetic" improvement of Thai Jasmine rice without disturbing the superior grain quality. Even more ambitious is to recombine all kinds of resistance into the so-called "Super Jasmine". We are re-engineering the new aromatic rice to become more nutritious, in trend with the new lifestyle of modern society. The innovative rice strains will support Thailand's rice industry from grassroots to the competitiveness of the global market. ■





3. health and infectious diseases

Spreading Influence

As the source of many mosquito-borne diseases, Thailand is becoming a source of new treatment strategies as well.

by Pennapa Hongthong

Every year, Juthatip Mongkolsapaya packs up her research from Bangkok's Mahidol University and heads to London's Imperial College. "In Thailand we have an excellent repository of specimens and associated clinical information, but London has better labs," says the immunology researcher.

Juthatip is one of a new generation of Thai scientists who find themselves globetrotting more and more as the country's capacity in infectious disease research gains recognition. But Thailand's contributions toward battling so-called "neglected" diseases such as dengue fever and malaria goes even further, to tackling HIV, tuberculosis, and thalassemia.

Dengue hemorrhagic fever won't be found outside Juthatip's London lab, but the tropical disease infects 170 Thais every day, and remains a health threat to 40 percent of the world's population. Her work is just a small part of Thailand's effort to address such diseases, whether through improved diagnosis, treatment, or vaccine development and production.

Thailand's commitment to these diseases is driven by a desire to improve the quality of life for its own population, the benefits of which may find their way to other developing countries, and even some wealthier nations.

Many mosquito-borne diseases—including malaria, dengue, and West Nile virus—are endemic to tropical countries, but are increasingly appearing in northern latitudes and reappearing in countries where they were eradicated, the result of growing urban

population density, international travel, and global warming, among other factors.

"Malaria is a global threat, especially since we are running out of effective drugs," says Yongyuth Yuthavong, senior biochemist of the National Center of Genetic Engineering and Biotechnology (BIOTEC), who works on malaria research. "What we're doing does not only benefit Thais."

MOSQUITOES MALADIES

No insect causes greater human suffering than the mosquito. More than one million people die from mosquito-borne diseases annually. Topping the list are dengue fever and malaria. Fifty million people are infected with the dengue virus every year, approximately 20 percent of whom develop dengue hemorrhagic fever/dengue shock syndrome (DHF/DSS), which causes internal bleeding and potentially shock. Once shock occurs, dengue patients have a 50 percent chance of survival if left untreated. Another 250 million people are newly afflicted with malaria annually.

Besides having no effective treatments or vaccines, these diseases are also difficult to diagnose. With dengue fever, for instance, physicians are often unable to verify the presence of the disease until severe DHF symptoms emerge.

These issues with diagnosis and treatment are what prompted the Mahidol University's Medical Biotechnology Unit (MBU), in collaboration with BIOTEC, to launch the Dengue Clinical Data-





Loi Krathong festival in
Chiang Mai, Thailand

OVERVIEW

base (DCD) project with Imperial College and Oxford University 8 years ago. The MBU is the project leader, and receives laboratory support from the London partners.

“This project is the most powerful weapon to affect real change in the way we address the disease’s diagnosis and treatment,” says Prida Malasit, who leads the DCD project. As part of the project, Juthatip probes the virus’s cellular immunology, while colleagues at Siriraj Hospital collaborate with Chiang Mai University to look at how the complement system interacts with the virus, and use locally produced monoclonal antibodies to develop diagnostic tests. Other researchers are looking into the genetics behind various clinical phenotypes and the protein structure of the dengue virus.

So far, these efforts have helped elucidate the complement system’s role in the pathogenesis of internal bleeding and shock, as well as the molecular mechanisms behind the interactions of the dengue virus and host protein. Now, the researchers have established a method for determining the risk of developing hemorrhagic fever and shock syndrome, by comparing the levels of the dengue virus protein NS1 and the levels, or absence, of the terminal complement complex (SC5b-9).

“This discovery will enable doctors to differentiate between those dengue-infected patients who require hospital care from those who are unlikely to develop complications,” says Prida. All that’s needed now is for the private sector to step in and develop a rapid test kit, he adds.

While Prida’s team has been tackling the detection of dengue, a group of malaria researchers are focusing on treatment. For decades, science has waged a back-and-forth battle with the malaria parasite. All successful treatments eventually wane in effectiveness due to eventual resistance.

In 2002, with financial support from Medicines for Malaria Venture, Wellcome Trust, the European Union, and the World Health Organization, Yongyuth and his team were able to determine the structure of an antimalarial drug target, the enzyme dihydrofolate reductase (DHFR). A number of antimalarials act by inhibiting this enzyme, but eventually mutations caused the parasite to resist the drugs. Knowing the structure of the enzyme—including how it changed through mutations—enabled his group, together with international collaborators, to design and make drug candidates that are effective against the resistant parasites. Yongyuth is now embarking on a new effort to limit the parasite’s ability to mutate and develop further resistance.

VYING FOR VACCINES

Thailand’s efforts in the battle against dengue fever go even further—to stop the disease altogether. Vaccine research on the disease is yielding promising results, reinforcing Thailand’s growing role in the global vaccine hunt to fight infectious diseases.

Not far from where Prida spends his time searching for dengue diagnostic clues, Sutee Yoksan, director of Mahidol University’s Center for Vaccine Development, is tackling the dengue

problem from another angle. By attenuating dengue virus through serial passage in certified primary cell cultures, Sutee’s team has developed live attenuated dengue vaccine that potentially can be manufactured. “Right now we have a candidate vaccine in pre-clinical trials, and we hope to move to clinical trials within one year,” he says.

Promising dengue vaccine research is also taking place at Chiang Mai University’s Faculty of Medicine, where a team led by Nopporn Sittisombut is developing a vaccine in which he inserts pieces of the dengue virus envelope protein into a flavivirus.

With financial support from the National Science and Technology Development Agency (NSTDA), Nopporn has been able to develop almost 100 vaccine candidates. About 15 have passed early in vitro testing, and are now in animal testing.

Prasit Palittapongarnpim, NSTDA’s vice president, hopes to see at least 200 potential candidates, of which at least one will be a viable candidate to prevent transmission of the dengue virus.

But Nopporn and Sutee have competition. Sanofi-Pasteur, in cooperation with the Thai Public Health Ministry, has recruited 4,000 Thais to participate in clinical trials of a recombinant live attenuated dengue vaccine. Establishing the capacity to host such clinical trials has been one of the building blocks of Thailand’s overall vaccine development program. In September 2009, Thailand made international headlines for hosting the world’s largest HIV/AIDS vaccine trial. Some 16,000 Thais participated in what many feel is among the most promising steps to date in developing a defense against HIV. The trial of RV144 HIV vaccine, which was developed based on HIV strains that commonly circulate in Thailand, demonstrated that it was modestly effective in preventing HIV infection, lowering the rate of HIV infection by 31.2 percent.

Last year, Thailand’s vaccine production achieved another milestone when the Government Pharmaceutical Organization (GPO), a state enterprise under the Ministry of Public Health, in collaboration with NSTDA, produced a local version of the H1N1 vaccine, now undergoing trials.

MINDING THE GENE GAPS

The achievement of the Human Genome Project accelerated Thai scientists to step up work in genomic medicine. In 2002, they launched the Thai Single Nucleotide Polymorphism (SNP) Project to isolate and map 30,000 polymorphisms in Thais. The project has helped Thai scientists identify disease-associated genes and work on pharmacogenomics. New research on thalassemia, tuberculosis (TB), acute leukemia, cancer, HIV, and post-traumatic stress disorder have all benefited from the Thai SNP project.

Thalassemia has become a particular concern to Thai health officials, because an estimated one-third of the Thai population carry thalassemia genes. While only three percent of Thai carriers have contracted this inherited blood disease in its severe form, public health experts fear that, with such prevalence in the country’s DNA, the percentage of severely afflicted carriers could skyrocket.

Genomics has been a welcome tool in Suthat Fucharoen's 20-year effort to diagnose and treat the disease. From his lab at Mahidol University's Institute of Science and Technology for Research, he has been developing a diagnostic method for detecting fetal abnormality. A novel approach to managing and treating newborn thalassemia patients using anticoagulation drugs, including aspirin, is also being tested and shows promising results.

Given the rate of blood transfusions required for thalassemia patients, the burden on the public health budget is tremendous. As a result, authorities estimate that Suthat's efforts will help contribute to nearly \$1 billion in savings over 5 years under a government program to better diagnose and treat thalassemia patients.

In 2003, Surakameth Mahasirimongkol, medical researcher with Thailand's Public Health Ministry's Medical Sciences Department, assembled a team to study Thai genetic susceptibility to TB. The project became the first in Asia to study genome-wide, SNP-based linkage analysis of TB patients.

Only 10 percent of all TB carriers become symptomatic. Researchers have speculated that immune system differences play a crucial role in TB susceptibility. Surakameth's research confirms this suspicion—genotyping of 195 TB patients from 93 families revealed that a region on chromosome 5q is associated with developing symptoms of TB.

However, it is too early to identify specific genes associated with protective immunity, he cautions. "We're still working toward that goal so we can provide a method to differentiate individuals who are genetically predisposed to succumbing to TB to aid in the disease's prevention and treatment," he says.

GOING GENERIC

In 2002, Thailand made a major contribution to HIV patients in the developing world when the GPO released GPO-Vir, a single tablet that contained the three antiretroviral (ARV) drugs—nevirapine, lamivudine, and stavudine. Costing 10 percent of ▶

LIFE SCIENCES MEETS UNIVERSAL HEALTH CARE

by Pennapa Hongthong

After more than two decades of public organizing, in 2001 Thailand joined an elite group of developing countries to extend public health care to all of its 64 million citizens. At the same time, Thai researchers were gearing up to enter the era of genomics, with the hope that soon next-generation information technology products developed and built by Thais would be commonplace in public health services.

"We were looking for future technology that could create a more cost-effective healthcare system, with greater treatment efficiency and fewer side effects," says Wittaya Tonsuwonont, director of the Bureau of Human Resources and Change Management for the National Health Security Office (NHSO).

In 2003, the Thailand Center of Excellence in Life Sciences (TCELS) launched the Single Nucleotide Polymorphism project to aid Thai scientists in their pharmaceutical research. So far, they have identified genetic traits associated with susceptibility to thalassemia, tuberculosis, acute leukemia, cancer, HIV, and post-traumatic stress disorder. Researchers have also success-

fully identified genetic traits responsible for adverse reactions to five drugs used to treat HIV, epilepsy, and gout.

Presently, genomic tests for allergic reactions to the HIV drug nevirapine, which induces skin rashes, and the epilepsy drug carbamazepine, which can cause Steven Johnson Syndrome, are available for public use. Unfortunately, they are not yet covered by the government health plan.

"We were ready to include genetic tests for adverse reactions to carbamazepine, but the benefit package committee was not convinced," says Wittaya. The committee was concerned that should they allow such tests now, it could open the door for a vast array of similar requests, for which they are not yet prepared to handle, he notes.

The NHSO's reluctance to pay for these genetic tests does not surprise Prasit Palitapongarnpim, vice president of the National Scientist and Technology Development Agency. The public health system is seldom the first to adapt interventions related to biomedical research, he says, noting it took the World Health Organization more than 25

years before it finally recommended the BCG tuberculosis vaccine for children.

Wasan Chantratita, head of Mahidol University's Ramathibodi Hospital pharmacogenomics project, says he is certain that genomic medicine such as allergy tests will one day prove itself to save costs over the long term.

Of course, the cheaper personalized diagnostic aids become, the more likely the universal coverage (UC) system will accept them. The price of sequencing equipment is dropping rapidly, and the ability to afford such equipment is a major barrier for Thailand. When such equipment becomes commonplace within the diagnostics industry, that too is going to drive costs down and accelerate the use of genomics by the public health system, says Prasit.

While it remains unclear when the UC system will be able to take full advantage of genomics, Thai people are already benefiting from the country's biotechnology pipeline, says Wasan—HIV genotyping is commonly used to test resistance to antiretrovirals and viral loads.



the market price of the three drugs individually, GPO-Vir was a major breakthrough in generic drug manufacturing, causing new facilities to emerge in Africa and Asia.

“While our capacity to develop new drugs may be limited, we take pride in our ability to push the boundaries of generics and giving the world its first generic AIDS cocktail,” says Achara Eksaengsri, director of GPO’s Research and Development Institute.

GPO-Vir has given hundreds of thousands of AIDS patients in developing countries access to treatment that they otherwise would have gone without, says Achara. It’s a critical first-line defense; but unfortunately, GPO-Vir is not effective for all patients, she says, and the longer patients stay on it, the greater the likelihood that resistance will develop.

In response to this resistance, the GPO is manufacturing the generic version of two second-tier HIV treatments—efavirenz, and lopinavir combined with ritonavir. But the GPO’s decision has sparked intense international controversy, as both these drugs are under patent. The Thai government asserts that it is within its right to grant what’s known as Compulsory Licensing (CL) for generic manufacturing of these drugs, since HIV has been defined as a “health emergency” in Thailand, in accordance with policies from the World Trade Organization.

Pharmaceutical companies and many Western countries disagree with Thailand’s claim, however, and argue that as a lower-middle-income country, Thailand should be able to afford to pay a “reasonable price” for these drugs, and not exercise the emergency condition to produce them generically.

However, Somsak Chunharas, secretary of NSTDA’s Medical and Public Health Cluster, looks at CL as an appropriate tool for countries like Thailand to exercise.

“It would be regrettable if business models impede scientists’ discoveries from benefiting the public,” says Somsak. Intellectual property protection is a cornerstone of the drug industry, he concedes, but not when it makes valuable drugs inaccessible because of their high prices.

Somsak’s views are not universal within Thailand’s scientific community, but as CL is established government policy, local scientists are reluctant to express their sentiments publicly. “There’s a balance somewhere that can ensure appropriate profits are made, and equitable treatments are delivered; we just need to find it,” expresses one senior researcher, who asked not to be named.

THE MISSING LINK

While there may be disagreements on the CL, there is one area where Thai scientists see eye to eye: the need to address the lack of public and private investment funds to support products generated by local researchers.

The efforts of Mahidol University’s Medical Biotechnology Unit to detect the severity of dengue infections is a case in point. “We may have the patent, but as a state institution we have no capital to invest. And so far, no one from the private sector is stepping forward since there is no guaranteed market,” says Prida.

Arpornpun Pochanukul, Managing Director of Bio-Genomed Co Ltd, adds that she would like to expand her laboratory equipment company to include such test kits, but the lack of any signal from the government that the kits would be utilized in the public health systems gives her pause.

If the government took steps to guarantee investors that there would be a market for such devices, it would send a strong signal to investors that there is money to be made in Thailand. “Attaining worldwide recognition in emerging disease research is not yet enough to stimulate the level of investment that is clearly warranted if Thailand is serious about integrating medical science into economic development,” says Arpornpun.

As tough as it may be, the government needs to assert greater leadership in the development of biomedical products, and the “Made in Thailand” brand. Until such time as Thailand has established credibility in this marketplace, Arpornpun argues, customers in developed countries in particular will remain off limits.

There are several different investment methods governments are using, says Somsak, including serving as a guaranteed customer, or “picking the winner” of research breakthroughs.

“I don’t know which model is the most suitable for our country, but all sectors have to talk and get something underway. The only thing of which I am quite certain is we urgently need stronger partnerships between research and development and manufacturing if we’re going to fully realize the benefits of our home-grown medical science,” he says. ■

A Shot in the Arm

Government incentives and other factors are helping make Thailand attractive to vaccine developers.

by Vitoon Vonghangool
and Dr. Pham Hong Thai



The world vaccine market is growing at the very fast pace of 15 percent annually, with the key drivers being increased demand, the accelerated introduction of new vaccines, mergers and acquisitions, the emergence of new vaccine players, and the growth of the biotech sector through new technologies.

The vaccine market in Thailand has also grown fast, reaching around THB 4.0 billion (\$US120 million), with the Ministry of Public Health (MOH) being the major customer. The MOH purchases for its National Immunization Program mainly pediatric vaccines but also vaccines for women and travelers and for post-exposure rabies treatment. Vaccines are also available on the private market and mainly imported as finished products, though some are imported in bulk form or in naked vials to be filled and packed by GPO-MBP, a local joint venture between the GPO (Government Pharmaceutical Organization) and a multinational. A few traditional vaccines are also produced by two local organizations: the Queen Saovabha Memorial Institute (QSMI), which is part of the Thai Red Cross Society, and the GPO.

Thus Thailand is one of only three out of the 10 members of the Association of South East Asian Nations (ASEAN) that produces vaccines.

Thailand is also known for its academic research on vaccines against diseases prevalent in the country and as a top location for conducting clinical trials of vaccines against diseases such as Japanese encephalitis and dengue.

Thailand's government has recently made some efforts to strengthen the pharmaceutical biotech industry with tax and

nontax incentives such as an 8-year income tax exemption, a 200 percent tax credit on R&D activities, and permission to bring in foreign workers. Only time will tell whether these measures have created a favorable enough environment or whether more incentives are needed to attract pharma and biotech companies to the country.

Considerations for biotech start-ups developing vaccines include product technology, location of development operations, skills of the development and operation team, and opportunities for local public-private partnerships. The production of vaccines requires very large investments, therefore new companies should thoroughly assess their manufacturing and business strategies, including production capacity, competency of the local workforce, product needs for both domestic and export markets, and options for funding.

While progress in attracting foreign bioindustries in Thailand has been remarkable, so far not many biotech companies have set up their development or manufacturing facilities in the country apart from Thai-owned pharmaceutical companies upgrading their plants or investing in new projects.

BioNet has started a research program on an acellular pertussis vaccine in collaboration with Mahidol University and is exploring various public-private partnerships with other institutions and organizations in the field of vaccine R&D. ■

Vitoon Vonghangool is the Managing Director, and Dr. Pham Hong Thai is the Joint-Managing Director, BioNet-Asia Co., Ltd.

The Bioindustry in Thailand

Opportunities for Green and Sustainable Investment

The global market for green and clean industry has expanded rapidly as society in general is becoming increasingly concerned about issues such as climate change and the impact of rising energy prices. Thailand is no exception. In fact, the Thai government has already put into place a 15-year plan for exploring and developing sources of alternative energy to cope with higher oil prices in the future, with a special focus on biofuels.

Thailand is constantly improving and building upon its capabilities. To sustain and augment biofuel production, the country is investigating and supporting biotechnology opportunities in order to increase the yield of raw materials such as sugarcane, cassava and palm oil. Thailand will leverage its abundant natural advantages to develop the country's clean energy sector and, thus, is in an excellent position to become the regional hub for biofuel and bioplastic production and export.

Furthermore, there is growing interest from local industries in adopting wastewater treatment technologies that are coupled with biogas production. More than 2,300 bioreactor systems have been deployed since 2007 in agro-industry, at bio-refineries and at various municipal level facilities.

The clean energy sector is an important pillar of Thailand's bio-industry and is a target sector for investment promotion in Thailand.

NATURAL ADVANTAGES

Biofuel: Ethanol & Biodiesel. The major crops used for ethanol production in Thailand are sugarcane and cassava. Currently, Thailand is the largest producer of sugarcane in Southeast Asia, with annual production of about 73 million tons. Cassava is considered one of the best raw materials for ethanol production. Thailand is the number one cassava exporter and the number two sugar exporter in the world.

Biomass. Thanks to its strong agricultural base and ranking among the world's top exporters of several key agricultural commodities, biomass has traditionally been one of the more pervasive sources of alternative energy in Thailand, accounting for approximately 80% of Thailand's alternative energy. The Thai government has been promoting the supporting infrastructure for this energy source for years.

Biogas. Thailand has approximately 10,000 food factories and 20 million head of livestock generating waste and wastewater that can be utilized for biogas production. The top sources of feedstock for biogas production are cow manure, cassava pulp, wastewater from cassava-starch, palm oil, and tapioca production facilities. Biogas produced from various agricultural and indus-

trial manufacturing processes and from organic municipal solid waste offers incredible opportunities to small-scale producers.

Bioplastics. In addition to its abundance of raw materials that can be used for bioplastics production, Thailand has a well-established plastics industry—with 4,500 factories producing a wide range of products for overseas customers. It is the number one plastics exporter in ASEAN and the eighth largest plastics exporter worldwide. The bioplastics sector can capitalize on the existing capabilities, network, and resources of this industry to hasten its own development and growth.

There are tremendous opportunities for Thailand to tackle the country's growing waste management and disposal problem through the production of bioplastics. Greater adoption of bioplastics will result in cost saving as well as better waste disposal practices.

Microbial Utilization. Thailand is also carving a niche as a bio-resource for new bioactive compounds discovery. Thailand is home to various distinct species of fungi, microorganisms, insects, and plants, and Thai researchers from the National Center for Genetic Engineering and Biotechnology (BIOTEC) have discovered bioactive compounds that can fight diseases such as cancer, malaria, and tuberculosis.

BIOTEC is running a Bioresources Utilization Program to preserve, utilize, and manage the country's rich microbial diversity. Its mission is to exploit and transform the unique microbial resources available in Thailand into value-added ingredients that can be used in the pharmaceutical, food and feed, and enzyme industries. It is also tasked with developing platform and innovative technologies, as well as building up the national R&D infrastructure for bioresources utilization.

LEADING MEDICAL SERVICES

Thailand is the world's leader in medical tourism, offering world-class technology infrastructure and quality of care at a fraction of the cost of similar procedures in developed countries. Nearly 2 million foreign patients visit Thailand each year for the range of health care services, including sophisticated procedures like stem cell treatment. As a result, the domestic drugs and medical market has grown to over US\$1 billion.

In addition to being the premium health care service provider, Thailand is also known as a leader in biotechnology research programs, especially in emerging diseases (e.g., avian flu), re-emerging diseases (e.g., HIV and tuberculosis) and tropical diseases (e.g., malaria and dengue).

Pharmaceutical Products. BIOTECH-Novartis International Pharmaceutical Drug Discovery Partnership: A three-year



partnership was initiated in 2005 with the goal of identifying potential uses of micro-organisms and natural compounds as sources for innovative medicine. The research partnership has recently been extended for another three years to May 2011.

Diagnostic Kits/Service. Thailand has been successful in the development of the world's first commercial biosensors for avian influenza H5. Biosensor products include Avian Influenza, the Alpha Thalassemia immunochromatographic strip test and simple CD4+ lymphocytes test kits used to count CD4 lymphocytes or T-cells for HIV patients.

In the service industry, there are now at least three companies providing genetic testing services. These services are beneficial in the prediction of diseases and prevention of the side effects from taking medicine.

Stem Cell Technology. In July of 2008, the transplant of bone marrow blood stem cells for leukemia became the only authorized use of stem cells in Thailand.

SUPPORTIVE INFRASTRUCTURE

An extensive public infrastructure is already in place to support biotechnology and science research. With more than 15 research centers involved in conducting research into alternative energy and biotechnology, Thailand is looking to be a leading force in this movement. Of particular note is the work being done by:

National Science and Technology Development Agency (NSTDA). The NSTDA is an independent government organization providing technical assistance, research, and development services to Thai industry. It provides R&D grants in the public and private sector and implements in-house research at four national research centers (BIOTEC, NECTEC, MTEC, NANOTEC). The Technology Management Center (TMC) and Thailand Science Park (TSP) under NSTDA provide a range of services, e.g. intellectual property management, incubation facilities, industrial consulting and technological upgrading in the private sector. Currently there are seven legal acts protecting IP rights in Thailand.

Thailand Science Park (TSP). TSP was established in 2002 as a one-stop service center to assist foreign and local companies

engaged in scientific and technological research. It serves as a hub for R&D and facilitates collaboration among academia, industry researchers, and the NSTDA. About a third of the companies within the park are biotechnology based. The TSP facility works with many world-leading biotechnological companies such as Ecolab, Air Products, Alltech Biotechnology, Shiseido, and Maine Biotechnology.

Thailand Center of Excellence for Life Sciences (TCELS). In 2003, TCELS was established as a center of knowledge management to add value in health biosciences. Its primary functions are to support the establishment of bioscience companies in Thailand; develop the basic infrastructure to increase product value, service and investment; set up funding for business; and bridge the public and private sectors in the development of products, business, and investment.

ENHANCING HUMAN CAPITAL

To ensure the future development of the biotechnology industry in Thailand, the National Biotechnology Policy Framework (NBPF) estimates future demand for an additional 500 biotech managers and 10,000 biotech university students. Twenty four of Thailand's universities have the combined annual capacity to supply 800-900 individuals with undergraduate biotechnology degrees, 300-400 MScs and 50 PhDs. BIOTEC is also conducting a regional capacity building program to enhance the skill and availability of human resources for Thailand's biotechnology industry. ■



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Diagnostic Tools for the Masses

After developing rapid tests for H5N1 and HIV, can Thai researchers compete with the multinationals?

by Apiradee Treerutkuarkual

“Anxiety”—that’s how Jitra Cheng describes genetic testing in advance of having a child. “If the results indicated that either my husband or I were thalassemia carriers, it might dash our plans to have a baby forever,” she says.

While it’s unlikely that the worry factor can ever be removed, Thai researchers have been able to simplify and increase access to this important diagnostic test. Instead of waiting weeks, couples receive results on their genetic markers for this debilitating blood disease in minutes. Moreover, these rapid tests are more affordable—about \$3 compared to \$30–40 for laboratory blood work.

Thalassemia is common not only in Thailand but also in Southeast Asia, China, India, the Middle East, and in the Mediterranean region. In Thailand, around one percent of the estimated 65 million Thais suffer from the blood disorder, while around 40 percent are carriers of the thalassemia trait.

Thalassemia test strips are just one of the point-of-care diagnostic tools Thai researchers have developed recently for commercial use. Others include the world’s first antibody strip test for HIV/AIDS and a rapid test for H5N1 influenza in humans.

Prasit Palittapongarnpim, Vice President of the National Science and Technology Development Agency (NSTDA), believes the further development of Thailand’s diagnostics industry can revolutionize disease control among developing countries like Thailand.

First and foremost, he points out, the kits save money. Similar to the thalassemia test, those developed for counting CD4 protein for HIV/AIDS patients cut costs by a third, down to \$10, because they do not require the use of cytometers. Both cytometers and the reagents used with them are expensive, so only about 30 major hospitals in Thailand are able to have them. Those without have to send blood specimens to hospitals that have cytometers, and wait days for the results.

The so-called “CD4 select” was developed by Watchara Kasinrerk, professor of microbiology and immunology at Chiang Mai University, and his team. It can be used with a hematoanalyzer, a common laboratory device found in general hospitals. “Any medical laboratory technician can deal with it,” says Watchara.

Diabetes test kits allow patients to monitor blood sugar levels at home, reducing the burden on hospitals and improving patients’ quality of life, particularly those in remote areas. More frequent and effective testing on the front end could also reduce or eliminate treatments downstream.

Right now, Thailand spends roughly \$100 million on diagnostic supplies, a small fraction of the ballooning budget for pharmaceuticals, says Sirirurg Songsivilai, director of the National Nanotechnology Center. He would like to see this trend reversed.

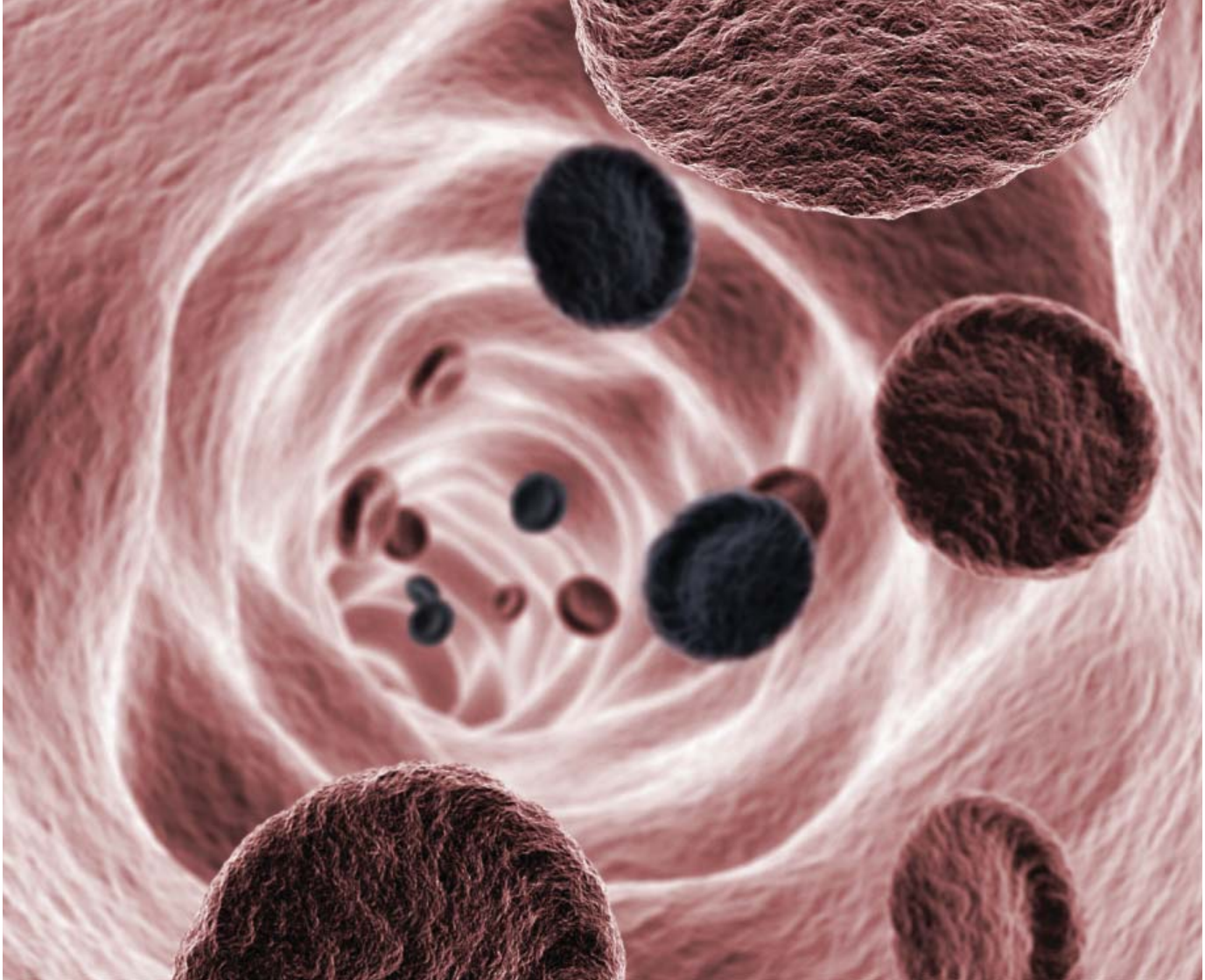
Even greater savings can occur by manufacturing more of these diagnostic devices in Thailand. “Local versions of these test kits could enable us to reduce costs from imported products and develop national sustainability in terms of medical and scientific R&D,” says Sirirurg, who is also cofounder of the diagnostic manufacturer Innova Biotechnology, a joint venture with NSTDA and The National Center for Genetic Engineering and Biotechnology (BIOTEC) and the private sector.

But he and many others concede that while the world knows Thailand has the capacity to develop these products, it has not yet developed the capacity to sustain an industry around them.

“It makes more sense for Thailand to further develop its point-of-care diagnostics industry because it requires much less investment than the billions of dollars necessary for pharmaceutical research,” says Sirirurg. Moreover, he advises, with additional government leadership, local manufacturers could begin to take a slice of the growing global diagnostics market.

The problem, says clinical immunologist Watchara, is that most local companies wait to receive technological transfers in the form of “ready products” from government researchers.

Prasit wants to see the government do more to stimulate investment. The \$5 million annual fund for diagnostics research at universities and medical institutions is clearly insufficient, he argues. Furthermore, Thailand’s healthcare system lacks policies to promote or prioritize the use of locally made diagnostic tools at public hospitals. Without these ingredients, it’s difficult to get the private sector to improve the quality and effectiveness of test kits.



To compete internationally, Sirirurg, adds, Thai companies face even greater challenges. A whole range of additional regulations and standards need to be met, as well as potentially more advanced manufacturing facilities. Domestic companies developing both lab-based and point-of-care diagnostic equipment lack the resources of their international counterparts in the United States and Europe.

“The competition gap between multinational and local diagnostic manufacturers is getting bigger. They have much more money and introduce new products more quickly. The government needs to support academic institutions, but also private sector R&D so it can develop and improve product quality,” says Sirirurg. “Otherwise researchers don’t know how long their innovations will last in the market.”

Prasit also believes there’s more the private sector could do on its own after receiving technological transfer from R&D agencies, such as develop ways to improve packaging design, and make products more user friendly and attractive to the market.

But not all Thai manufacturers are complacent. Komkrit Sajjanantakul, managing director of I+MED Laboratories, plans to

list his diagnostic test company with the Stock Exchange of Thailand. With the new capital, I+MED will establish its own R&D facilities to supplement the technological transfers it receives from governmental agencies.

I+MED is currently fulfilling an order for up to 300,000 thalassemia test strips to be used by public hospitals. Iran, which like Thailand also has a high incidence of the blood disease, has expressed interest in purchasing the product as well.

Carving out Thailand’s own market segment is essential, stresses Komkrit. He wants to see the necessary government investment to ensure Thai companies can capitalize on the country’s leadership in tropical disease research, especially malaria and dengue fever.

“Surely, Thailand cannot compete with Western drug makers or mass producers like China. We have to be more unique and niche oriented. I still believe in this business model. As long as we’re eager to differentiate ourselves, we’ll find opportunities and a solid position for us to stand in the global market,” concludes Komkrit. ■

A Policy Pioneer

Yongyuth Yuthavong is not your ordinary biochemist.

by Klomjit Chandrapanya



Holding 7,000 Thai baht (about \$300) in his hands, Yongyuth Yuthavong had an epiphany. It was the late 1960s and he was a fresh-faced researcher, back in Thailand with a doctorate degree from Oxford, and about to embark on his own research project studying enzymes from papaya. The research grant from the National Research Council of Thailand was small, but the council had little to give. The process of obtaining even this tiny amount involved using connections and powers-that-be to push the proposal through. Eventually, a government employee counted out and handed Yongyuth 70 one-hundred baht bills.

“I was a bit bewildered. There really was no system to govern any of it. I knew then that if I were to just keep to my lab I would be of little help to Thailand,” says the vibrant 66-year-old Yongyuth.

Thus, the biochemist decided to use his energy and talent to assist his country so that other scientists could more easily follow in his footsteps. He pursued a dual-track career in scientific research and policy making, and was a part of the team that established the Ministry of Science and Technology in 1979. He wrote a three-page proposal that set up the National Center for Genetic Engineering and Biotechnology (BIOTEC) in 1983, and drafted the legislation that would create the Thailand Research Fund in 1992. When he became Minister of Science and Technology in 2006, he tried unsuccessfully to raise the level of R&D funding to one percent of GDP. He did, however, help set up the National Science, Technology and Innovation Policy Office dedicated to science policy development.

One of the reasons why Yongyuth has remained vigilant in establishing efficient, clear, and transparent systems for researchers may have to do with his prolific career in the lab, especially his work on malaria parasites. Malaria is one of the world’s most common and serious tropical diseases, causing nearly one million deaths each year, mostly among young children under 5 years of age. According to the Global Fund to Fight AIDS, Tuberculo-

sis and Malaria, almost half the world’s population is at risk for malaria, and the situation is getting worse because of poor health systems as well as growing drug and insecticide resistance, among other reasons.

In 2003, Yongyuth and his team discovered the structure of the malaria parasite enzyme DHFR, which enables it to become drug resistant—a finding that was met with much excitement. This breakthrough has led to new directions in designing effective antimalarial drugs that directly target the enzyme. Today, Yongyuth, officially BIOTEC’s senior research fellow and advisor, leaves most of the lab work to his colleagues and focuses on planning and providing guidance. One of the drugs developed by his Thai team is at the advanced preclinical trial phase.

“We should be so proud. It’s the first time Thais have developed a drug that has reached this level. We used to only conduct clinical trials using other people’s products.”

Yongyuth is also one of a handful of members of the scientific board of the Grand Challenges in Global Health (GCGH) who is from a developing country. GCGH, supported by the Bill and Melinda Gates Foundation, is focused on discovering and developing new ideas to fight major global health problems that may be neglected by large pharmaceutical companies. Ever the cheerleader for new scientists and small science, Yongyuth is even more excited about GCGH’s new initiative called the Grand Challenges Explorations, which awards smaller grants and is more accessible to smaller-scale scientists, inventors, and entrepreneurs. Two BIOTEC researchers have already received grants from this program.

“Things are gradually getting better for scientists in Thailand,” says Yongyuth, comparing current conditions to what he faced when he first started working as a researcher, standing at the beginning of his career holding 7,000 baht in his hands. “There’s a system, good governance, better infrastructures and opportunities. I’m hopeful. Always have been.” ■





Watchara Kasinrerak

The head of Chiang Mai University's Biomedical Technology Research Center has broken down the walls between the university's scientists, producing impressive and marketable results.

by Klomjit Chandrapanya

Watchara Kasinrerak almost cancelled his interview. He wasn't sure he wanted to talk about himself so much. It was not until he was assured that the focus would be on his work that the award-winning immunologist relaxed and displayed the enthusiasm that fuels him as he lectures to undergraduates three times a week while also maintaining an active research career.

Watchara uncovered a new leukocyte surface molecule, CD298, in 2004. He has already applied results from his basic research to develop diagnostic tools that have the potential to save significant time and money for healthcare systems in developing countries like Thailand. Yet asked if he would rather spend more time conducting research, he shakes his head emphatically. "I wouldn't do this if I couldn't both teach and do research," he says.

As the director of the Biomedical Technology Research Center at Chiang Mai University (CMU), Watchara is known for research on the use of monoclonal antibodies. His team at the university is focusing on technologies for the production of protein antigens and antibodies, as well as basic research on gene therapy and biochemical characterizations, and functional studies of leukocyte surface molecules. They are also developing high-performance immunodiagnostic kits.

Watchara founded the center in 2006 to encourage collaboration between scientists. "People from different parts of the university were separately working on their projects, and I broke down the walls," he recounts. "I said, 'Let's work together as a team. I have space. I have the equipment. Come use it anytime.'"

Watchara received his BS in medical technology from CMU, but after spending a year as a medical technologist in a hospital, he knew "daily routine work was not me." Having long been fascinated by immunology, he returned to his alma mater's medical school and immersed himself in the subject, acquiring an MS in

microbiology. He began his academic career in CMU's Department of Medical Technology, Faculty of Associated Medical Sciences, where he remains today. He received a PhD in immunology from Universitat fur Bodenkultur Wien in Vienna in 1992.

In the past 3 years, two of Watchara's discoveries have been adapted into products and licensed to a local company. The first is a simple method for screening for carriers of the genetic blood disorder α -thalassemia-1. Watchara's team developed the immunochromatographic strip, which takes 3 minutes and costs less than a tenth of a DNA assay, using a generated monoclonal antibody.

Watchara's team also produced a unique monoclonal antibody against CD4 protein, which was then applied as a new method and reagent for enumeration of CD4 lymphocytes. The method requires only an automatic hematoanalyzer, as opposed to conventional methods, which require an expensive flow cytometer that must be run by a specialist. The new method can be conducted locally at small facilities and yields results in less than an hour. It is a boon for a country like Thailand, which has a generalized HIV epidemic. Plans are already underway to market a commercial form to other high-burden countries.

Watchara's current pipeline includes immunodiagnostics for α -thalassemia-1 Southeast Asian type, which is the most common genetic disorder in the Asian population. He is confident that he will have a final product within the year.

He is also pleased with his team's progress on an antibody being developed into a TB diagnostic, which he believes will improve on current methods that are cumbersome, time consuming, and frequently yield false negatives. He is less gung-ho at the moment about his research into a protein believed to be a tumor marker—but ever the striver and optimist, he believes that the work will eventually yield a product that will be used as part of patients' routine annual medical checkups. ■

MTEC

Materials Research, Development, and Engineering for Better Living

Founded in 1986, the National Metal and Materials Technology Center (MTEC) is operating as one of the four technology centers under National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology (MOST).

MTEC supports and carries out research, development, and engineering (RD&E) in metal and materials to support industries, together with the development of technological infrastructure and human resources for RD&E by working with the international organization network such as the World Materials Research Institute Forum (WMRIF) and International Energy Agency (IEA).

MTEC drives RD&E in materials technology through nine research units and two platform technology programs.

Research Units

1. Computer-aided Technology Research Unit
2. Design and Engineering Research Unit
3. Ceramics Technology Research Unit
4. Polymer Research Unit
5. Biomedical Engineering Research Unit
6. Materials for Energy Research Unit
7. Materials Reliability Research Unit
8. Environmental Research Unit
9. Analytical and Testing Research Unit

Platform Technology Program

1. Design and Simulation for Materials and Manufacturing
2. Materials Design and Production

Flagship Products

Bioenergy Laboratory: Biodiesel Testkits. Thailand's biodiesel specification announced by the Department of Energy Business, Ministry of Energy includes specifications for community and industrial scale production. Both specifications identify testing and analytical methods, which require expensive analytical instruments and experienced technicians to perform the tests.



Unfortunately, fully equipped biodiesel testing facilities are not available to all producers, especially community-level ones, due to the fact that the facilities are only located in major cities.

MTEC through Bioenergy Group has developed biodiesel test kits for community level biodiesel quality control. The biodiesel test kits are developed to measure fundamental properties such as density, viscosity, acid value, and iodine value. The biodiesel test kits are handy, easy to use and relatively inexpensive, which makes it a practical tool for probing preliminary biodiesel properties. All biodiesel test kits have been filed for patents and currently tested in the field. Feedbacks and comments from users have been collected and assessed in order to improve the test kits quality and design to accommodate users' demand. Technology transfer and production of the biodiesel test kits will help upgrading and strengthening biodiesel production capability in Thailand. For further information, please contact nuwongc@mtec.or.th.

Biomedical Engineering Research Unit. The focal point of our research at the National Metal and Materials Technology Center (MTEC) is to develop effective, customized implants and medical devices using one of our core technologies—medical rapid prototyping (MRP). Here at MTEC, the applications of medical image-based RP models and customized implants have been introduced for over 10 years in the fields of neurosurgery, plastic and reconstructive surgery, oral and maxillo-facial surgery, orthopaedic surgery, etc. The use of these medical models and implants not only enhances the quality of surgery in terms of accuracy and precision, but also operation duration and minimization of operational risk.

The fabricated RP implants and devices have dimensions that perfectly fit the patients' anatomy. We are currently branching out the applications of MRP technology into a tissue engineering field, developing well-defined 3-D porous scaffolds for culturing of stem cells and other cells, e.g., osteoblasts and chondrocytes for bone and cartilage engineering applications. We are now pursuing international collaborations in research on biomedical engineering, especially, but not limited to, MRP and tissue engineering areas. For further information, please send inquiries to wanidaj@mtec.or.th or kriskrs@mtec.or.th. ■



NANOTEC

A Hub of Nanotechnology Development and Nanobiotechnology in South East Asia

The National Nanotechnology Center (NANOTEC) was founded in 2003 as one of the four national research centers under the umbrella of the National Science and Technology Development Agency (NSTDA). NANOTEC aims to be an internationally recognized nanotechnology institute conducting R&D, which has a major impact on the development of the Thai economy and society. Initially, the fundamentals of nanoscience were emphasized and strengthened, along with the capacity to build high-precision equipment, the essential tools for nanotechnology research. NANOTEC has a dual role as a national R&D center and as a granting agency that provides support to universities and other research institutes. It has established strong links with other institutes in Thailand, covering more than 400 nanotechnologists, as well as with other leading nanotechnology centers around the world.

Currently, NANOTEC has 11 central laboratories established at the Thailand Science Park:

- Hybrid Nanostructure and Nanocomposites (NanoHybrid)
- Nanomaterials for Energy and Catalysis (NanoEnergy & Cat.)
- Nano Delivery System (NanoDelivery)
- Nano-molecular Target Discovery (Target Discovery)
- Nano-Cosmeceuticals (NanoCosme)
- Nano Safety and Risk Assessment (NanoSafety)
- Nano-molecular Sensor (NanoSens)
- Nanoscale Simulation (NanoSim)
- Organic Nanodevice (NanoOrg)
- Testing and Service Laboratory (TSL)
- Bi-component Spinning Fiber Pilot Plant

Eight leading universities in Thailand are partnering with NANOTEC and have formed the Center of Excellence in Nanotechnology (COE). Currently there are approximately 400 nanotechnologists in Thailand working full time on research. One

goal of NANOTEC is to be a “*Solution Provider in Nanotechnology*”; and therefore numbers of nanotechnology research were applied to industry, for example, textiles (antimicrobial fabric, self-cleaning and water repellent fabric), cosmeceuticals (nano-emulsions, controlled release nano-capsule), and food (e-nose sensor for quality control process). Approximately 14,000 testing services were provided for industries and researchers each year. Nanosafety initiatives were also developed with the compliance of international standard and global network via SAICM, OECD, and UNITAR.

On nano-biotechnology and life science aspects, NANOTEC is conducting research on nano-delivery systems, nano-molecular sensors, and nano-cosmeceuticals. For delivery Systems, NANOTEC aims to develop the platform for drug delivery by using nano-encapsulation and molecular complexation techniques for the controlled release and targeted delivery of bioactive compounds. With this approach, various types of nano-carriers were investigated—e.g., core-shell nanoparticles, self-assembly nanoparticles, polymer conjugates, nanoemulsion, and molecular inclusion complexes. Also, various types of targeting moieties are explored—e.g., peptide, magnetic, and antibody.

For nano-molecular target discovery, the design and development of antibody fragments for targeting of infectious diseases and cancer are being investigated. Focus is on therapeutic antibody-based nanomolecules and molecular diagnostic tests. For nano-cosmeceuticals, novel nano-cosmeceutical products encapsulated with Thai medicinal herbs are the focus. Core strengths are on formulation, especially encapsulation in nanoparticle, nanoliposome, and nanoemulsion. Capabilities also include testing of activity, efficacy for moisturization, anti-aging, whitening, anti-acne, anti-septic, and anti-inflammatory applications. ■

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NANOTEC
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4. ENERGY AND THE ENVIRONMENT

Biotechnology in the Era of Climate Change

Climate change threatens Thailand's farmlands and the country's valuable biodiversity. Scientists are working to predict future changes and minimize their impact.

by Nantiya Tangwisutijit

A month before world leaders gathered in Copenhagen last December to haggle over CO₂ emissions, another greenhouse gas made headlines briefly. The NASA Goddard Institute for Space Studies released findings that methane (CH₄) was potentially a more serious contributor to climate change than previously thought. Though less abundant than CO₂, CH₄'s impacts on atmospheric warming are 21 times greater, and so it has been gaining traction as the next greenhouse gas targeted for global regulation. This worries Thailand. Rice paddies, which are integral to Thailand's society and economy, generate 20 percent of the world's methane.

"Our scientists are aware of this issue and are exploring more integrated approaches to rice paddy irrigation and fertilizer application, and the need for new rice varieties that might bring substantial reductions in methane emissions, but it's not our highest priority right now," says Chitnucha Buddabun, senior researcher of the National Rice Department.

Like many Thai researchers, Chitnucha's hands are full determining how best to respond to the impacts climate change has already sent their way, including warmer temperatures, more erratic rainfall, and droughts. Thailand and much of Southeast Asia face a disproportionate share of global impacts as atmospheric temperatures rise. From the lack of glacial melt feeding the Mekong headwaters to seawater encroachment into Thailand's vast coastal zones, the country will not escape the impacts of climate change.

"We've got to prepare for changes in storm patterns and rainfall that could have far-reaching impacts throughout the country," says Chitnucha. "More frequent natural disasters, disruption of historical farming patterns, and water shortages are a few of the impacts that we will likely experience in many parts of the country. Coastal communities, especially Bangkok's metropolitan area, will face additional challenges due to storm surges and sea level rise."

Thailand leads regional climate modeling efforts. Thai scientists are also trying to understand how the country should evolve its agricultural sector, land-use planning, and energy strategy to

adapt to these changes as well as contribute to global CO₂ emissions reduction efforts.

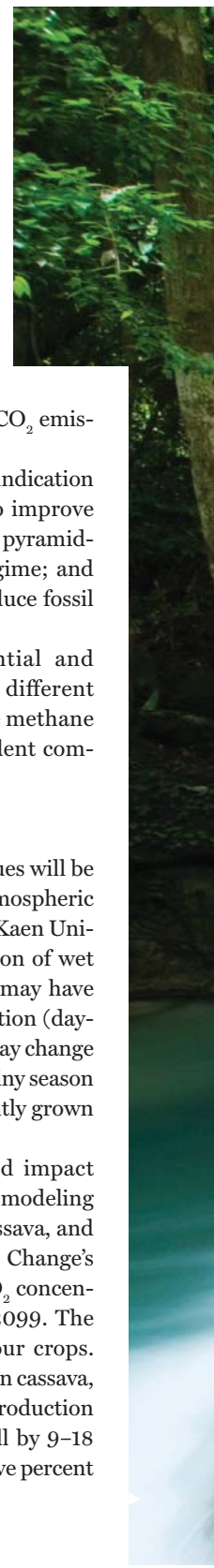
Biotechnology is an integral tool in this process. Bioindication from changing plants and wildlife behaviors helps to improve understanding of the changes already occurring; gene pyramiding is helping to devise crops for the new climate regime; and advances in biofuels and bioplastics are helping to reduce fossil fuel consumption and CO₂ emissions.

"We're even capturing methane from residential and livestock waste, as part of our biofuels effort, but a different approach will certainly be needed if we have to reduce methane from our rice fields," says Saijit Jawana, an independent community biogas consultant.

MAPPING A FARMING LANDSCAPE

Crop production as a food source and for export revenues will be strongly affected by hydrological change caused by atmospheric CO₂ concentrations, says Krirk Pannengpetch of Khon Kaen University's Faculty of Agriculture. Changes in the duration of wet and dry seasons, as well as in precipitation patterns, may have strong impacts on crop yields and crop cycles as radiation (daylight), moisture, and distribution of rainfall over time may change in the future. The generally shorter and more intense rainy season implies that the varieties of rice and other crops currently grown may not be as productive in the future.

To better understand how climate change would impact Thailand's agriculture, Krirk applied regional climate modeling to simulations for major crops including rice, corn, cassava, and sugar cane. The Intergovernmental Panel on Climate Change's A2 scenario was used, which assumes atmospheric CO₂ concentrations of 330 ppm in 1980, rising to 833 ppm in 2099. The findings revealed different trends for each of the four crops. Increases in CO₂ and temperature had a severe impact on cassava, showing a 43 percent reduction in productivity. Corn production decreased by 15 percent. Irrigated rice production fell by 9–18 percent, while rain-fed rice and sugar cane both saw a five percent increase in productivity.





Erawan Falls near
Kanchanaburi, Thailand
© SANDER KAMP

OVERVIEW

However, the results for all crops were highly variable, both geographically and temporally. One northern region, for example, saw the percentage of low productivity cassava plantations increasing from 0.7 percent in 1989 to 79 percent by the 2090s. Low-productivity rice fields increased from 4.9 percent in 1989 to 6.5 percent in the 2090s.

“There’s little doubt that climate change is going to keep our agricultural researchers busy,” says Sahaschai Kongthon, senior advisor in the Agricultural Soil Management Department. “Moreover, we have to communicate these risks to farmers, who are experiencing and bewildered by today’s climate variability anyway.”

While concerned, Sahaschai believes that Thailand can be as prepared as any nation to adapt its crops to rising temperatures. “I’m not saying it’s going to be easy, but we’ve had a fairly solid research infrastructure in place to support the development of more advanced varieties of nearly all our major crops.”

Theerayut Toojinda, a leading plant breeder at the National Center for Genetic Engineering and Biotechnology (BIOTEC), is currently working at the Rice Gene Discovery Unit, using gene pyramiding to develop what he calls Super Jasmine Rice, a variety that is highly disease- and pest-resistant, as well as more resilient to floods and drought. He sees climate change as merely an extension of what he’s already been doing.

There is one caveat, however. Thailand’s Agricultural Ministry has been slow to accept Kirk’s findings, and has yet to incorporate climate-change modeling and adaptation planning into its operations.

“It’s not that we doubt climate change is coming, it’s just that nobody wants to endeavor into something new unless policy makers give the nod, accompanied by budgets,” Sahaschai says. “Most government agencies’ responses to climate change now are merely to add the terminology into their vocabulary.”

Agency foot dragging on climate change may come to an end soon. Thailand is in the process of preparing a 10-year National Science, Technology and Innovation Policy Framework that is heavily influenced by the need for the government to develop a coordinated response to climate change. High on the agenda will be innovations to enhance climate-modeling capacity, agriculture for food and energy security, and emerging diseases, says Sura-chai Sathitkunarak, Policy Researcher at the National Science Technology and Innovation Policy Office.

TANGIBLE EVIDENCE

Computer modeling and simulations are unnecessary for biologist Visut Baimai to know that climate change has a real impact. He sees it in the responses of plants and animals to the higher ambient temperatures of their habitats. Visut coordi-

CLEARING THE AIR

Biotechnology may help turn Thailand’s spring fires from a hazard to a resource.

by Nantiya Tangwisutijit

When April arrives in Thailand, so do the fires. Individually, the blazes aren’t large, just a farmer burning off a previous crop’s worth of corn or rice stalks before planting again. Added together, they send a biomass into the atmosphere that can close local airports and fill doctors’ offices with patients suffering from respiratory difficulties.

“It’s too bad that despite the growing number of community-level, small-scale power projects and the technological solution going into larger-scale biogas projects, there’s not some solution to merge the two,” says Winai Somsap, a community leader in Chiang Mai province. “We really need help putting this waste to good use, too, instead

of creating health problems and contributing to global warming.”

That help may be on the way. EcoWaste, an agricultural waste-management technology research center at the King Mongkut’s University of Technology Thonburi, is experimenting with turning cellulose into biogas.

“Currently, the cost is still too high because we need to digest the cellulose in a large reactor, and it takes more time than when digesting starch,” says Suvit Tia, Senior Advisor at the National Center for Genetic Engineering and Biotechnology (BIOTEC). “But we’re working on a shortcut by identifying an effective enzyme to hasten the process.”

Ideally, Suvit would like to discover an enzyme that is easily obtainable by the com-

munities themselves, so he is experimenting with a host of microorganisms that are readily available, as opposed to commercial products.

Meanwhile, community biogas technology using livestock and household organic waste is becoming popular. Anaerobic fixed domes are used to concentrate methane that is then used to fuel community members’ kitchen stoves. The technology has been in high demand by communities surrounding small pig farms to address a less harmful respiratory annoyance.

“It’s a win-win situation to help pig farms coexist nicely with the community,” says Saijit Jawana, an independent, community-based, renewable energy expert.

nates a growing network of field biologists who operate long-term research stations and share their data with his Biodiversity Research and Training Program (BRT), established jointly between BIOTEC and Thailand Research Fund (TRF).

Phillip Round, one of Thailand's most prominent ornithologists, says he started to sense something was amiss nearly 25 years ago when he began monitoring Siamese firebacks (*Lophura diardi*), a type of pheasant, at Thailand's oldest national park, Khao Yai. Historically, the birds were never found above 700 meters, but gradually they began living at higher altitudes, and now they are seldom seen below 800 meters, says Round, who is with Mahidol University's Department of Biology.

Temperature gauges surrounding the park have recorded a 2°C increase in the minimum mean temperature over that same period, Round adds. He has observed no other changes in the species' habitat that might account for their move upward.

Chutiorn Savinee, another ornithologist with Mahidol University, has been studying the rare great hornbill (*Buceros bicornis*) and suspects that warming temperatures at Khao Yai are responsible for lengthening the incubation and rearing periods for fledgling birds. "It's grown from 120 to about 140 days now, largely, we believe, because their food supply has diminished due to the warmer and drier climate here," she states in a recent report.

Another species in the park that may be affected by changing food supplies is the white-handed gibbon (*Hylobates lar*). In a recent report to the BRT, researchers noted that distribution of wild rambutan (*Nephelium maingayi*) has moved to higher latitudes. "This fruit plant is usually found in shady areas with cool climates, so they might be escaping the increasing heat and stronger sunlight exposure in the lower altitude," Visut says.

Round suspects that solar heat may also affect regeneration of plant species in Khao Yai. At the same research field where the pheasants were observed, the research team found reduced numbers of wild plant saplings. Within a 10-hectare observation area, of the 143 gambir trees, only seven had new saplings nearby. The coral trees of the *Erythrina* genus and *Sapium baccatum* Roxb. demonstrate similar patterns of sapling reduction.

Closer to the equator, changes are also being observed in one of Thailand's rare cloud forests. Visut says the forest's moisture content is declining, so he is now funding researchers to establish monitoring stations to better document the changes. Researchers in Malaysia and Indonesia have been reporting declining moisture content in their cloud forests for more than a decade. Globally, cloud forests are seen as important bioindicators, and many are targets of international conservation efforts.

"All the evidence coming in seems to point to rising temperatures," says Visut. "Individually, we might be able to argue away the relationships, but in the aggregate, the cause and effect appears rather stark."

He believes that further documentation of such trends will help accelerate public support for more aggressive climate-change policies. "Thai people are more concerned with animals

than they are [with] graphs and charts. For better or worse, they need to see these kinds of impacts before they will feel compelled to act," he says.

BIOMASS BREAKS

By 2022, Thailand plans to meet 14 percent of its total energy demand with renewable energy. Much of this transition is anticipated to come through converting the country's extensive amounts of fibrous biomass materials from its agriculture sector into electricity and liquid biofuels.

More than 60 million tons of biomass is generated annually from Thailand's agriculture sector, especially sugarcane bagasse, rice straw, corn stover, and cassava pulp. While about one-third is used for fertilizers, animal feed, and construction material, the remainder offers the theoretical equivalent of 70 million barrels of crude oil. While Thai scientists do not expect ever to reach that level of efficiency, they are nonetheless working to squeeze as much energy as possible from this valuable resource, especially as its natural decomposition adds to atmospheric CO₂ concentration.

In conjunction with Thailand's efforts to support self-sufficient economies at the community level, ethanol production from local agricultural byproducts has been promoted. The concept for community ethanol is based on small-scale production of ethanol from local lignocellulosic feedstock with onsite-produced enzymes for reducing the cost of transporting bulky biomass. The ethanol will then be partially concentrated and transported to ethanol plants for upgrading to high-grade biofuel. Researchers at BIOTEC have developed an enhanced method for ethanol production from bagasse—the leftover cane stalk after the sucrose is pressed out—that is as efficient as conventional processes, but simpler and more environmentally friendly.

First, simple ball milling is used in a pretreatment process to increase the efficiency of the enzymes used when converting the bagasse cellulose and hemicelluloses into sugars. Second, the biomass hydrolysis—the conversion of cellulose and hemicelluloses into sugar—is performed with enzymes produced from selected microbial strains from BIOTEC's culture collection with a simple fermentation process, reinforcing local biodiversity protection for biotechnology purposes.

"Conventional fermentation process only converts glucose to ethanol, but ours results in more ethanol obtained, because we use Thai-isolated yeast strains that can utilize both glucose and xylose," says Lily Eurwilaichitr, Director of Bioresources Technology Unit at BIOTEC.

The most interesting and challenging aspect is the screening and production of active lignocellulolytic enzymes from microbial strains for efficient hydrolysis of local biomass. Although the locally made enzyme is not much better than the commercially available enzyme, a concept of onsite enzyme production that uses local fungal isolates and inexpensive agroindustrial wastes as substrates for enzyme production makes this new process economically attractive, says Lily. The on-site enzyme production ▶

OVERVIEW

also results in minimal carbon footprint compared to commercial enzymes, which are imported from overseas as Thailand has no enzyme production industry.

Although Lily's integrated process is not so much of a breakthrough discovery, she offers an improvement to the conventional process by using mechanical pretreatment rather than chemical to minimize environmental impact, as well as the utilization of local microorganisms for the fermentation process and enzyme production. Current research activity is focusing on further improvement of a more economically feasible process in bioreactor scale based on this concept. The study is still at a lab scale and will need pilot demonstration. However, it is a promising alternative for bioethanol production that will save cost and minimize carbon footprint in the long run.

GREENER CONTAINERS

Thai researchers are also utilizing surplus biomass to mine raw materials for organic plastics or bioplastics. Pursuing bioplastics offers multiple benefits, including reducing the petroleum typically used for plastics manufacturing, generating products that degrade more efficiently, and creating opportunities to supply both raw material and finished products to the export market.

"We may be just coming out of our infancy with this technology, but we've got the complete manufacturing process operating in Thailand now," says Wantanee Chongkum, director of the Innovation Management Department at the National Innovation Agency. "All that's needed to scale up production and bring costs down is sufficient government support and more private investors."

Wantanee emphasizes that this is big business for Thailand. Coming in behind only China and Japan in Asia, Thailand is the world's eighth leading exporter of plastic, and is now utilizing its agricultural muscle and biotech expertise to play a leading role in bioplastics research, development, and manufacturing. Global demand for bioplastics is forecasted to nearly triple over the next 4 years to 1.5 million tons, worth \$2.5 billion. By 2020, the United States market alone is expected to be worth \$10 billion.

Renewable sources, such as starch from cassava or sugarcane, are particularly desirable to manufacturers, and Thailand grows both. Many of the country's top producers of conventional petroleum-based plastics have already diversified their operations to include bioplastics manufacturing. In 2007, the Cabinet approved and funded the 2008–2010 bioplastics road map to prioritize the industry's further development.

Wantanee explains that Thai manufacturers keep scientists busy in their constant search for feedstock with higher starch contents and for more efficient fermentation processes to lower manufacturing costs. In 2001, scientists at the Suranaree University of Technology identified and developed two starch-fermenting bacterium isolates, SUT1 and SUT5, which convert glucose to lactic acid, a principle biodegradable polymer for bioplastics, at a rate of 90 percent.

Driving the increased demand is the fact that nonbiodegradable plastic waste is littering the planet and affecting the potential survival of many species, Wantanee stresses. "We're trying to engineer materials that are strong when needed, but break down quickly when their useful life is over," she says.

FUNGUS FUTURES

Plastic in the waste stream is something Jariya Sakayaroj, microbiologist with BIOTEC's Bioresources Technology Unit (BTU), knows all too well. She sees it nearly every time she wades into Thailand's coastal areas in search of fungi that may harbor bioactive compounds to help battle heart disease, cancer, or osteoporosis. Penicillin introduced the world to fungi's value to medicine more than 60 years ago, but only in the past 15 years have pharmaceutical companies been more aggressive in combing the planet for new fungi and bacteria.

The Swiss pharmaceutical company Novartis came to Thailand in 2005 to partner with BIOTEC in the quest for new microorganisms in which valuable natural compounds might be found. It is estimated that ten percent of the world's microorganisms and fungi can be found in Thailand, which is why Novartis and other pharmaceutical companies are interested in conducting research in the country.

"The unique ecology of mangroves, with their brackish water rising and falling twice daily, represents a particularly hostile environment for fungi, making their resilience particularly attractive to pharmaceutical companies," says Jariya. Of the 549 high-marine fungi species known to exist in the world, 180 are found in Thailand. Forty of these are new species her marine fungi unit has discovered over the past decade.

In total, 15 BIOTEC researchers probing marine, freshwater, and forest ecosystems have studied 2,500 microbial isolates and investigated 70 pure compounds. Some of these are now in collaborative research between BIOTEC and Novartis, to screen for substances that may be effective in treating disease.

Novartis has also provided capacity-building for BTU scientists to improve systems for chemical extraction and screening of compounds, as well as to identify and isolate different strains of microorganisms. This has benefited BTU's overall effort to more efficiently catalog Thailand's microorganisms and identify ways to utilize them in the country's agriculture, energy, and medical sectors.

With climate change advancing, BTU's work is becoming more urgent, says Jariya. Only about 10 percent of the world's estimated 1.5 million microorganisms have been identified, and she fears that many may be disappearing.

"We will never know which ones we might be losing, and the benefits along with them," she says. "Yes, there are big changes taking place out there that we need to address, but the microscopic ones need attention, too." ■

NECTEC

The National Electronics and Computer Technology Center (NECTEC) is a statutory government organization under the National Science and Technology Development Agency (NSTDA), Ministry of Science and Technology. NECTEC was established on 16 September 1986, then organized into a national center under the National Science and Technology Development Agency (NSTDA) in 1991. Its main responsibilities are to undertake, support, and promote the development of electronics and computer technologies through research and development activities. NECTEC also provides linkage between research communities and industries through the established industrial clusters.

NECTEC contributes to the development of Thailand's capability in electronics and computer technologies through:

- Research, development, design, and engineering
- Technology transfer to industries and communities
- Human resource development
- Policy research and industrial intelligence and knowledge infrastructure

NECTEC has organized the research and development function units into nine groups:

Research Unit

- Digital Media and Human Interface
- IT Cryptography & Security
- Advanced Industrial Electronics & Automation
- Informatics & Communication
- Intelligent Devices
- Policy Research

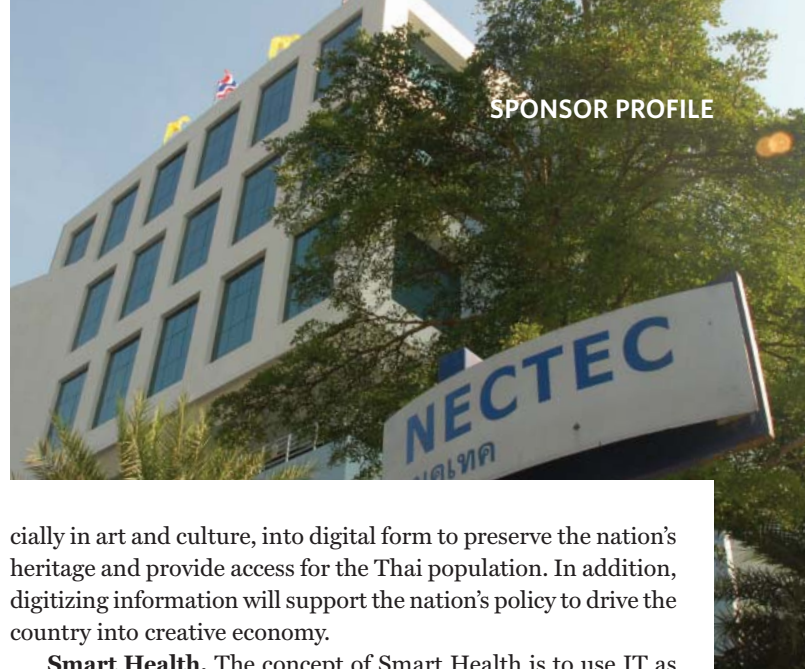
Development, Engineering & Services Unit

- Microelectronics Fabrication Engineering
- Assistive Technology Development
- Product Development, Engineering & Testing

FLAGSHIP PROJECTS

NECTEC has initiated program-based researches in three flagships which are "Digitized Thailand," "Smart Health," and "Smart Farm." The main objective of the flagship programs is to drive NECTEC's research works into applications relevant to the nation's problems. The flagship strategy will ensure our direction to apply E-C-T-I technology into nation's problems.

Digitized Thailand. The concept of Digitized Thailand is to create and organize the national information and archives, espe-



cially in art and culture, into digital form to preserve the nation's heritage and provide access for the Thai population. In addition, digitizing information will support the nation's policy to drive the country into creative economy.

Smart Health. The concept of Smart Health is to use IT as an important tool to facilitate the implementation of National Health Policy of Thailand more efficiently and effectively. The early stage of implementation is to develop the standardization of the national health information systems, which will be utilized by all concerned health organizations in the country.

Smart Farm. The concept of Smart Farm is to apply IT and electronics technologies in the agricultural sector, in order to amplify the productivity and quality of agricultural products. It is hoped that ultimately this will raise the quality of living of farmers and maintain the ranking of being the main food exporter of the world.

To pursue the NSTDA's vision of being a key partner in developing a knowledge-based society through the application of science and technology, creating global and local partnerships is a key strategy. Not only public and private sectors, but also academics and societies will be considered as NECTEC's partners for researching and developing technological capability aimed at national economic and social development. The mode of cooperation may include joint research projects, exchange of researchers and experts, and other collaborations.

NECTEC has promoted and supported both bilateral and multilateral cooperations with strategic partners through various forms such as the memorandum of understanding (MoU), memorandum of cooperation (MoC), agreement, and contracts.

MULTILATERAL COOPERATION

NECTEC has actively participated in many international forums such as the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), and European Union (EU). In addition, NECTEC's efficient performance has been recognized by UNESCO and the Economic and Social Commission for Asia and the Pacific (ESCAP), both of which have cooperated with NECTEC in many ICT research projects aimed at creating a knowledge-based society. ■

The Biogas Boom

Technology developed by Thai scientists to process wastewater into biogas is rapidly becoming the industry standard.

by Janjira Pongrai and Urisara Kowitdamrong



Narin Kajohnchalearmsak couldn't be happier with the \$1.3 million investment he made to his tapioca starch factory 9 years ago. He installed what's called an anaerobic fixed film reactor (AFFR) to process wastewater into biogas. Within 3 years of completion, the reactor had saved his Chol Chareon Company \$2 million in fuel oil costs.

Chol Chareon is one of Thailand's largest tapioca starch factories, exporting about 500,000 tons of tapioca starch annually, generating \$6 million in revenue. It is one of four such facilities the National Center for Genetic Engineering and Biotechnology (BIOTEC) and King Mongkut's University of Technology Thonburi (KMUTT) worked with to deploy the novel wastewater treatment process in 2001.

The AFFR technology is the result of research undertaken in 1984 by two scientists, Morakot Tanticharoen and Sakarindr Bhumiratana, who were then working at KMUTT.

Back then, biogas, and renewable energy generally, did not receive the attention they are getting now, nor did they offer the CO₂ savings currently possible, adds Morakot. But increasingly such technologies are being seen as the industry standard for factories like Chol Chareon in Thailand.

The AFFR method utilizes a net-like device fabricated with local materials that is layered inside an anaerobic reactor to trap and concentrate the microorganisms so that they can consume the wastewater's organic compounds.

Bacteria inside the reactor break down the wastewater's carbohydrates, proteins and fats into smaller organic compounds, releasing acetic acid and hydrogen as byproducts. Methanogenic bacteria then generate methane and CO₂, which are captured and used as biogas.

The process takes much less time and requires far less space than an open-pond system. Moreover, the treated water is of sufficient quality to be safely used for irrigation. AFFR reduces the chemical oxygen demand (COD) level in Chol Chareon's wastewater by more than 90 percent, from 24,000 mg/L to just 2,000 mg/L.

"The economics were far too enticing to pass up," says Narin. When he first considered AFFR, he had \$700,000 in annual fuel oil expenses. Had he delayed, these costs likely would have doubled or tripled as global oil prices increased.

"Environmentally speaking, AFFR efficiently treats the wastewater to a point that odors are nearly gone and the water is much cleaner than what we produced before," says Anuwat Ruethaiya-

non, managing director of Northeast Starch Company, another early AFFR adapter.

The AFFR process allows Northeast Starch to generate 17,000 cm² of biogas daily, replacing about 6,900 kilos of liquefied petroleum gas, realizing an annual savings of about \$460,000.

Eleven AFFRs are now in operation in food processing factories, says Morakot, and the process has spawned a sister technology. EcoWaste, an agricultural waste management center operated jointly by KMUTT and BIOTEC, has developed what's called an Anaerobic Hybrid Reactor (AHR), which combines AFFR with a granular sludge system.

A new AHR installation at the Tha Chana Palm Oil Company is slated to treat 230 m³ of wastewater with a COD of 90,000 daily and to generate 1.31 m³ of biogas annually.

The success of these technologies has motivated the Thai government to offer additional incentive programs, including subsidies and soft loans to encourage more widespread adoption of the equipment. The government intends to introduce AFFR, AHR, and other biogas technologies to all 60 tapioca starch factories and all 40 of the country's palm oil factories. Additionally, many preserved-fruit factories are now shifting their open ponds to biogas technologies.

Pawinee Chairasert, a researcher with EcoWaste, says one of the main reasons for the increased interest in the technology is the potential for capturing marketable carbon credits. The CO₂ savings from replacing fossil fuel inputs with biogas may render factories eligible for carbon credits offered through the United Nations' Clean Development Mechanism. Companies in developed countries can purchase these credits to offset their CO₂ emissions.

In 2009, the average price per ton of carbon on the European Climate Exchange was €12.25. Once certified, a facility like Chol Chareon might be able to claim up to 24,000 tons in credit annually, Narin estimates. Presently, more than half of 94 CDM projects at different stages of approval by Thailand's Greenhouse Gas Management Organization are tapioca and palm oil factories.

Thailand's wastewater treatment methods are also finding their way overseas. In 2005, Nigeria's "Cows to Kilowatts" program received a United Nations Development Program SEED award for eliminating environmentally hazardous effluent from slaughterhouses using AHR technology designed by EcoWaste. "One never knows where one's research might lead," says Marakot with a smile. ■

Dr. Anond Snidvongs

On the Front Lines of Climate Change

by Nantiya Tangwisutijit



Dr. Anond Snidvongs is Thailand's Al Gore. The hard-charging, 50-year-old director of Southeast Asia's START program has arguably done more to advance regional climate science over the past decade than anyone else in Southeast Asia.

An oceanographer by training, Dr. Anond recognized in the 1980s that changes in the ocean environment could only be understood with a solid grounding in climate science. As he began to familiarize himself with the discipline and with the intricacies of atmosphere-ocean modeling for the region, he discovered it was lonely work.

"Back then, only a few scholars ever mentioned climate change here," he says. "The challenge was not only to get more scientists involved, but for policy makers, the media, and the public to recognize the gravity of the situation and to start formulating a response."

Dr. Anond's efforts finally gained significant traction in 2002, when his team undertook the first regional downscaling of a global climate model. "It's all well and good for global models to say it might get a bit warmer in Southeast Asia and rain patterns may change, but absent more localized forecasts, it's difficult to garner people's interest," he says.

With higher-resolution results identifying specific areas where droughts and floods could be expected, public concern grew. In 2007, Dr. Anond was charged with aiding in the creation of initial climate change action plans for Thailand and the Bangkok metropolitan area.

What's key, he stresses, is that both the public and private sectors engage fully to work toward mitigation and adaptation measures, including the application of biotechnology.

"You don't have to look far to see the biotech gears grinding away on climate change problems," he observes. "Climate-friendly bioenergy, increased food security, and public health advances are all accelerating here thanks to those in the biotech field."

He notes that research on salt tolerance in rice by BIOTEC has yielded varieties that can thrive in saline areas of the country, which are expected to expand as a result of climate change. More productive agricultural yields also mean less farming area, reducing the necessary scale of climate adaptation in the future.

None of this would have been possible without Dr. Anond's passion and influence, says Dr. Attachai Jintrawet, associate professor of Soil Science and Conservation at Chiang Mai University. "We can't come up with solutions until we have a solid understanding of the problem," he says. "Anond's work has kindled the fire that's got many of us bringing our resources to the table, and eventually, some products to market."

Dr. Anond's influence also spills beyond Thailand. He assists researchers in Vietnam, Lao PDR, Myanmar, the Philippines, and Cambodia in undertaking their own downscaling. He encourages the scientists to organize community consultations to create feedback loops that enhance the quality of both the forecasting and the response.

"This is not a linear equation working from the top down, but really two sides of a coin working together to improve our inputs and understanding of what's actually happening," Dr. Anond says. "Local communities can provide the indigenous data and knowledge to better constrain the regional models, and communities can utilize these results in their own scenario planning for development purposes."

Like Al Gore, Dr. Anond recognizes the importance of using the media to stress the urgency of combating climate change to the public. Channel 3 TV documentary producer Jittima Bansirang notes that Dr. Anond is known for his accessibility to reporters. "So many researchers have little time for journalists... to help us understand the modeling and science behind the warnings," says Jittima. "But for Anond, no question is too stupid and no request for an interview or public comment is denied, so his message gets out." ■

Prince of Songkla University

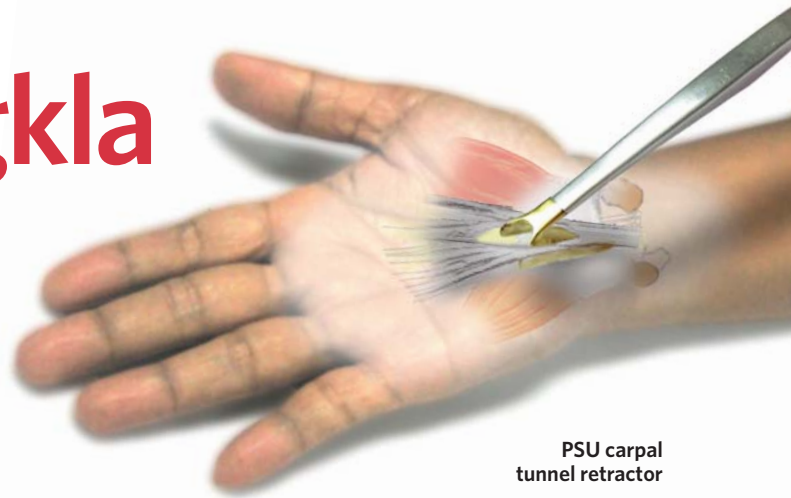
A National Research University

Prince of Songkla University (PSU) has been selected to be one of the nine Thailand National Research Universities in 2009. The ultimate goal of PSU is to nurture students to be good and well-educated citizens ready to serve society, to build wisdom and knowledge through research, and to transfer knowledge to students and society for the sake of mankind.

Prince of Songkla University was named after the father of current King, Bhumibol Adulyadej. The name was graciously granted on September 22, 1967, by King Bhumibol Adulyadej. PSU consists of five campuses all located in the south of Thailand. The main campus is based in Hat Yai, Songkhla province, a large trading city in the south. Others are located in the Pattani, Phuket, Surat Thani, and Trang provinces.

PSU is a comprehensive public university with areas of research focusing on all disciplines, including natural science and technology, medical science, and social sciences and humanities. The south of Thailand forms a long peninsular sandwiched by lengthy shores on both sides, all of which have abundant natural assets. These include natural rubber, oil palm, coastal and marine resources, and biological diversity. Inefficient exploitation of these resources will only accelerate their depletion. Man's invasion of nature creates multi-dimensional problems for society and the environment. The great challenge is for the university to apply the knowledge gained through research to maximize the value of these resources, as well as decelerate the deterioration of the environment.

To enhance research capacity, PSU has set up more than 25 Centers of Excellence and Research Centers in the university. These includes Centers of Excellence in Natural Rubber Technology, Genomics and Bioinformatics, Nutraceuticals and Functional Food, Nanotechnology, Drug Delivery, Biodiversity and Biotechnology in Agriculture, and Research Centers in Oil Palm and Palm Oil, Biodiesel, Energy Technology, Material Engineering, Membrane Technology, Biosensors, Rehabilitation Engineering, Phytomedicine and Oral Disease and Multicultural Management, to name but a few. Through the years, PSU researchers



PSU carpal tunnel retractor

have received continuous funding from leading grant agencies, international and domestic. These include the World Health Organization (WHO), National Institutes of Health (NIH), Japan Society for the Promotion of Science (JSPS), the Thailand Research Fund (TRF), National Science and Technology Development Agency (NSTDA), and Agricultural Research Development Agency (ARDA).

PSU research has consistently contributed to the wealth of the nation and local communities. The research successes that have been commercialized include: the Songkla Uterine Manipulator, and a later version named Tintara Uterine manipulator, which has been marketed and used in hospitals worldwide; the poor laryngeal elevation disorder treating apparatus; the PSU carpal tunnel retractor, which is designed to save time in surgery and to reduce the size of the surgical wound; scar TMTD and ZnO test kits for natural rubber concentrate analyses; HB brightening cream from natural rubber latex; a Braille computer keyboard and display units suitable for the visually impaired; and biodiesel production plants that use palm oil. In addition, many products of research are used in local communities to enhance peoples' living standards. Some of these are the portable biodiesel production unit, utilization of oil palm residue for cow and goat feeding, the development of medicinal plant conservation and rehabilitation centers in the local community and eco-tourism in local villages in southern Thailand.

Constant research funding and output make Prince of Songkla University one of the most prominent universities in Thailand. PSU is geared towards excellence in research for the sake of the wellbeing of people to go along with the determination in our motto – *Our Soul is for the Benefit of Mankind* – which has been instilled into all PSU hearts by the Prince of Songkla, the father of King Bhumibol Adulyadej. ■

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Thailand Science Park

Phase II

To strengthen the research and development infrastructure in the country, the National Science and Technology Development Agency (NSTDA) has set aside 2 billion baht for the expansion of Thailand Science Park (TSP). With the planned enlargement, the park will be the largest fully-integrated research and development hub in Thailand.

NSTDA established the first phase of Thailand Science Park (TSP), the country's first science and technology park, in 2002 with the aim of promoting innovation development and R&D activities in the private sector. TSP is a key infrastructure built to support technology-intensive businesses. In addition to advanced facilities and business space, TSP offers a full range of value-added services targeted at technology intensive companies.

The park is situated close to the Asian Institute of Technology, Thammasat University and the Sirindhorn International Institute of Technology as well as housing NSTDA's four national research centers, i.e. National Center for Genetic Engineering and Biotechnology (BIOTEC), National Metal and materials Technology Center (MTEC), National Electronics and Computer Technology Center (NECTEC) and National Nanotechnology Center (NANOTEC). This proximity provides the opportunity for corporate tenants to gain access to highly-skilled personnel including 1,600 full-time NSTDA researchers, of which around 400 are Ph.D. scientists.

Phase I of TSP, with 140,000 square meters of built-up space, is fully occupied by the four national research centers and over 60 corporate tenants. Around 30 percent of the corporate tenants are international companies, from Japan, the United States, Germany and France. The distribution of tenants fall into the electronics & computer technology cluster (30%), metal and material technology cluster (25%) and biotechnology cluster (20%). As a hub for science and technology research, TSP is the preferred location for many world-leading high-tech companies.

International biotechnology companies who have regional research centers located within the park include Ecolab, Air Products, Alltech Biotechnology, Shiseido and Maine Biotechnology. Western Digital, a global leader in the development and



manufacture of hard drives, uses TSP as a base to develop human resources for hard disk drive producers through Industry-Academic-Government linkage. PolyPlastics has set up an Asian Technical Solution Center for engineering plastics to support their customers in the region. TUV SUD PSB supports science and technology companies through product testing, inspection and certification services. These corporate tenants hire a combined workforce of over 500 skilled workers, of which 60% are involved directly in R&D. Together, these companies contribute an approximate US\$100 million to the economy.

To meet rapidly growing demands, the NSTDA has started the construction of new facilities for TSP Phase II since 2008. This Phase II complex is named Innovation Cluster 2 (INC 2), and is expected to be operational by 2011.

INC 2 will total 127,000 square meters with approximately 72,000 square meters for occupation. It comprises four interconnected towers built around the concept of "Work-Life Integration" to create a conducive environment where today's knowledge workers can live, work and play.

The four buildings are interconnected by walkways on every floor. Numerous green spaces have also been created throughout the buildings. These and other enhancements have been made to facilitate interactions and encourage networking among the occupants, so as to promote the exchange of ideas across various disciplines and collaborations among different groups.

The NSTDA believes that the expansion of the TSP will accelerate the pace of new innovation development and strengthen collaborations among the government sector, private sector and research institutions, hence stimulating and driving private sector research and development activities, which in turn will contribute towards Thailand's goal of becoming a knowledge-based economy. ■

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Thailand Center of Excellence for Life Sciences

The Thailand Center of Excellence for Life Sciences (TCELS) foresees Thailand to be a world leader in life sciences via three strategies:

1. Developing and adding value to health product and services with emphasis on improving infrastructures, sources of funding, human resource, technology, and new standards to meet international requirements.
2. Promoting the development of business and investment in the life sciences.
3. Developing and strengthening the cooperation among domestic and international organizations.

TCELS is a fully integrated bio and pharmaceutical services provider offering preclinical, clinical, commercial, consulting, and capital solutions. In just four years there has been widely recognized accomplishments supporting and driving research areas described below.

PHARMACOGENOMICS

Thailand has recently launched a genotyping initiative. TCELS' Pharmacogenomics project—in collaboration with Ramathibodi hospital, Mahidol University, Thai Ministry of Public Health, and RIKEN Center of Genomic Medicine in Japan—uses a Genome-Wide Association Study (GWAS). Here, two groups of participants are required: people with an adverse drug reaction (cases) and similar people without (controls). After genotyping each participant, the set of million markers such as SNPs is scanned into computers. Then bioinformatics is applied to survey participants' genomes for markers of genetic variation. For instance, different adverse reactions to the antiretroviral drugs nevirapine and stavudine were found to be associated with specific genetic variations (HLA-B*3505 and SNPs in the CCHCR1 gene for the former, and HLA-B*4001 for the latter). These associated variations then point to the region of the human genome where the cause of the adverse reaction is likely to reside. Since the entire genome is analyzed for genetic associations of particular adverse drug reactions, this technique allows a disease to be investigated in a non-hypothesis-driven manner. With the discovery described above, a low-price lab chip is being developed in collaboration

"TCELS' role is to position Thailand in the global life sciences industry and services."

Prof. Pornchai Matangkasombut,
The Board Advisor, TCELS



with Japanese biotech company, Riken Genesis. The prototype of the lab chip and machine are being validated with 2,200 HIV-1 patients who have taken the antiretroviral drug cocktail, GPOvir (3TC+d4T+Nevirapine). A major factor that makes it difficult for patients to take antiretroviral drugs on schedule as prescribed is adverse drug reactions. Missing just two drug doses can result in increased levels of virus in the body, or resistance to the drug, derailing their effectiveness and causing treatment failure and waste of financial resources. Patients then need to switch to costlier second-line drugs. Pharmacogenetic testing could minimize adverse drug reactions and thus increase compliance with drug treatment. This will directly increase durability of first-line antiretroviral drugs.

GENETIC SERVICE PROJECT

The Center for Medical Genetics Research at Rajanukul Institute, Bangkok, takes its pride as the sole genetic laboratory of the Department of Mental Health, the Ministry of Public Health of Thailand. The Center's main missions cover both facets of medical sciences: researching the cause of mental disorders and providing genetic diagnostic services to clinicians.

Currently, the Center is collaborating with the Riken Institute of Japan to conduct a genome-wide association study. The main objective is to discover genes responsible for major

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depressive disorder, especially in Thai and Asian populations. The Center also collaborates with leading medical universities in Thailand in a pharmacogenetic study. The expected result is to improve the efficacy of antidepressant treatment.

For genetic services, the Center provides comprehensive genetic testing, ranging from a chromosome study to DNA



“With my work in natural latex rubber, I am very pleased that TCELS has given the support so we can finally come up with the whitening product from natural latex.”

Prof. Dr. Rapepun Wititsuwannakul, Project Investigator, Prince of Songkla University

analysis. All tests provided are ISO15189: 2007 certified. This reflects our commitment to deliver the highest quality services to the users.

To achieve our vision in improving patient care, the Center is widely open to collaboration, either from private or public sectors. Our fields of interest include, but are not limited to, genetics and mental disorders, genetic and developmental disorders, and neurogenetic disorder.

PTSD

Posttraumatic stress disorder (PTSD) is a chronic mental disorder which is a state of anxiety that can develop after exposure to one or more traumatic events. PTSD mostly develops among survivors from great natural disasters. TCELS provided benefits for patients from the 2004 tsunami in the south of Thailand and extended its support to the work of Chulalongkorn University and Rajanukul Institute. This resulted in the collection of more than 3,000 genetic samples and in-depth information of the survivors from the tsunami and their relatives. This data has been analyzed and the researchers are on the verge of identifying the genetic marker that leads to PTSD. The hope is to ultimately reduce Thailand’s relatively high budget allocated for treating mental patients. Now the project is cooperating with an international organization to further study this area, and has also attracted the interest from the Department of Mental Health to extend the scope of the project to benefit a larger group of people.

THE *Hb* EXTRACT FOR IMPROVING SKIN HEALTH

Rubber trees are wounded almost everyday by tapping. This repetitive wounding stress assists in signaling the tree to produce special phytochemicals that facilitate rapid wound-healing and new tissue generation to replace the old tissue damaged by tapping. It is thus feasible that natural rubber latex will be very rich in various phytochemicals such as protease inhibitors; organic acids AHA, BHA and AA; the sugars sucrose, fructose, and quebrachitol; the super antioxidant ergothioneine; vitamins B₂ and B₅; the minerals Cr, Cu, Mn, Se, and Zn; and tannins—most of which have been included in expensive skin health care products from reputable “beauty care” companies. Accordingly, an *Hb* extract, with a characteristic 1H-NMR spectrum, was prepared from fresh latex serum. Following the OECD Test Guidelines, using animal models, upon applying this *Hb* extract onto skin, no adverse effects were observed in irritation and skin sensitization tests. The microbial load of the *Hb* extract was within the standard limits allowed by the FDA. Moreover, an *Hb* cream, containing 5 gram % of the *Hb* dried powder extract, was shown to improve the skin health of several volunteers. After nine weeks of topical application, the self-assessment data collected from those with facial melasma (n=64) indicated positive effects on skin whitening (98.4%), melasma fading (96.8%), skin smoothening (92.2%) and reduction of sebum level (53.1%). For those with facial acne (n=36), 100% of sufferers reported reduction of skin inflammation, 100% reduction of acne, 88.9% reduction of sebum level, and 86.1% reduction of the intensity of acne scarring.

PRE-CLINICAL, CLINICAL AND RESEARCH INFRASTRUCTURE

As a member, and a national focal point in life sciences, TCELS has been assigned by APEC Life Sciences Innovation Forum Strategic Plan to work on a technology platform for pre-clinical and clinical research. The following is the infrastructure established in Thailand:

- Laboratory Animals Breeding (AAALAC)
- Laboratory Animals Monitoring Center (Standard ISO/IEC 17025)
- Safety Testing and Toxicology laboratories service Unit (OECD GLP)
- OECD GLP Accreditation Body
- Clinical Research Collaboration Network (CRCN) facilitating multi-site studies
- Joint Research Ethical Committees (JREC) for multi-center studies
- CRO, Destination for medical outsourcing
- International standard clinical trial sites
- Standard Data Management Units (DMU)
- Tsunami PTSD Genomics Center
- The Alzheimer Foundation of Thailand
- Mental Health Genetic Development Foundation
- International Anti-Aging Institute



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