PHD CAREERS
MEET SEVEN
INDIVIDUALS PURSING DIFFERENT
PHD CAREERS IN SCIENCE

EDUCATION FOCUS
EXPLORE THE STUDY OPTIONS
OPEN TO BUDDING SCIENTISTS
Science and engineering graduates have more career options than before, thanks to rich and diverse Research and Development (R&D) initiatives from the public and private sectors. But what does it take to succeed as a PhD holder?

GO THE DISTANCE THROUGH R&D

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Use the QR code below to enter our competition for a chance to win an innovative new 3D smart phone film, developed by A*STAR IMRE and Temasek Polytechnic.

Visit www.a-star.edu.sg/aspire2013 for the full competition.

Cover model:
Dr Samantha Lee, A*STAR Scholar
Research Fellow at Institute of Molecular and Cell Biology and Lecturer at Singapore Polytechnic.

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Overview

... in its fastest-growing markets in Asia-Pacific, to focus on two innovation centres in Asia. The company plans to build a 500-strong R&D team here, the second of only two innovation centres in Asia. Procter & Gamble's Singapore operation represents more than 25 nationalities and connects with businesses around the world.

The number of research scientists and engineers in Singapore has grown almost seven times from 6,325 in 1990 to 23,483 in 2011 (National Survey R&D, 2011).

The whole idea of research, innovation and enterprise rests on risk taking. People need to try different routes and explore; that's how they learn and become better researchers.

--- Prof Alfred Huan

As more companies realise the value of technology and adopt innovation as a growth strategy, it will fuel the demand for R&D talent with different skill sets, from engineers, lab researchers to intellectual property experts.

--- Mr Tan Kai Hoe

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**UNLOCKING EVOLUTIONARY SECRETS**

Prehistoric fish linked to evolution of land animals

Researchers from A*STAR’s Institute of Molecular and Cell Biology (IMCB) have combined forces with researchers from around the world to crack a fish’s genomic code.

The once-thought-to-be- extinct African coelacanth resembles the fossilised skeletons of their ancestors from more than 300 million years ago. Findings from this study are providing new insights into what may have helped aquatic animals to transition from water to land.

By comparing a coelacanth’s genes with other vertebrate species, the researchers have uncovered valuable information on genetic changes that may unlock evolutionary secrets.

The coelacanth’s most prominent feature is its fleshy fins, which resemble the limbs of land animals. Within this fish, the team found several important regions of the genome used in the formation of limbs, which suggest that land animals adopted evolutionary sequences from coelacanths to help them form limbs.

Prof Byrappa Venkatesh, Research Director at IMCB, said: “By comparing the genomes of coelacanths, human and other vertebrates, our group has been able to discover gene regulatory elements that played a key role in the development of our limbs and fingers as well as our ability to detect air-borne odours.”

**IBN HAS RECEIVED A GRANT FROM A*STAR JOINT COUNCIL OFFICE TO FURTHER DEVELOP PREDICTIVE IN VITRO MODELS FOR LIVER- AND KIDNEY-SPECIFIC TOXICITY**

**IBN CREATES HUMAN KIDNEY CELLS**

New research has powerful implications for drug screening and toxicity models

Human kidney cells have been successfully generated from human embryonic stem cells in vitro by researchers at the Institute of Bioengineering and Nanotechnology (IBN) in Singapore.

Scientists produced the renal cells under artificial conditions in the lab without using animals or organs, something that has not been possible until now.

According to IBN Executive Director, Prof Jackie Y. Ying, this discovery could provide an alternative to animal testing. “This has wide-reaching implications for in vitro toxicology, drug screening, disease models and regenerative medicine,” she said. “In particular, we are interested in applying our technology to develop predictive in vitro drug testing and renal toxicity models as alternatives to animal testing.”

**TELECOMMUNICATIONS BREAKTHROUGH**

Researchers from Singapore’s A*STAR Institute of Microelectronics (IME) have pioneered technology for high speed long-haul data transmission. In collaboration with Fujikura Ltd, the team developed the world’s first 40 to 60Gbps silicon-based optical modulators with advanced multilevel modulation formats, which are significantly cheaper to fabricate.

**A GREENER SINGAPORE**

A*STAR and Fujitsu pool resources to enhance urban sustainability through high performance computing-enabled R&D technologies

A*STAR and Fujitsu have joined forces to address the challenges and demands on infrastructure and energy usage faced by both Singapore and Japan.

In early 2013, both parties signed a Memorandum of Understanding to explore the creation of the first Centre of Excellence (CoE) for Computational Social Science and Engineering in Singapore towards achieving this purpose.

The CoE will identify technology solutions and opportunities for sustainable urban development of Singapore in key areas such as transportation management and energy efficiency with High Performance Computing (HPC)-enabled technologies based on real-world data. Insights and outcomes from the research may likely be applied to other big cities in planning and implementing urban sustainability initiatives.

The collaborative effort is led by A*STAR’s Institute of High Performance Computing (IHPC), with its HPC capabilities in analysis of real-world data and knowledge of complex systems and social behaviour.

**NEW MEDICINES FOR EMERGING MARKETS**

**Globe pharmaceutical giant GlaxoSmithKline (GSK) and A*STAR’s Institute of Chemical and Engineering Sciences (ICES) have signed a five-year agreement to develop new medicines designed specifically for emerging markets.**

The new evidence-based formulations (EBFs) are medicines that are reformulated to provide additional patient benefit.

The collaboration leverages on ICES’s expertise in synthesis, formulation and process development, as well as GSK’s vast experience in drug candidates’ election, optimisation, and product development, to develop a pool of local expertise in specialised formulation for pharmaceutical development.

**SAY GOODBYE TO 3D GLASSES**

Mobile device users can now view 3D content with the naked eye thanks to a plastic film developed in Singapore.

The innovation from Temasek Polytechnic (TP) and A*STAR’s Institute of Materials Research and Engineering (IMRE) is the first ever glasses-free 3D accessory measuring less than 0.1 mm. It is made up of about half a million perfectly shaped nano-sized lenses engineered onto its surface.

Called EyeFly3D, the film, which can be applied onto smart phones, is being marketed by start-up, Nano- veu Pte Ltd. Applications for Apple iOS and Android have also been developed, to allow users to play the 3D content, and convert 2D pictures into 3D. A software development kit for 3D game developers is being researched. The same technology can also potentially be used as next generation security tokens employed by banks and corporations.

See page 2 for a chance to win the film.
A GLOBAL EDUCATION

A scientific education can take you around the world

AN INTERNATIONAL EDUCATION
Dr Huili Guo is an Independent Fellow at A*STAR’s Institute of Molecular and Cell Biology (IMCB). She undertook her undergraduate and post-graduate studies overseas – in the UK and the US respectively – on A*STAR’s National Science Scholarship (BS–PhD) before returning to Singapore in 2012.

I knew I wanted to study science and I wanted to do it in the best place in the world. That, to me, was Cambridge University in the UK where I did an undergraduate degree in Natural Sciences.

When I left Singapore I was painfully shy and really found it had to build up my confidence in order to thrive abroad. After three years, I came back home to spend a year working at IMCB as part of my bond with A*STAR. During this time, I also worked on my applications to PhD schools in the US.

One day in my current work, I was always interested in engineering at NTU. I worked at A*STAR’s Data Storage Institute (DSI). At that time, DSI was exploring some collaborative work with a professor in Cambridge University in the UK, so I jumped on the opportunity and pursued a PhD under that professor, specialising in Nano-technology and Nano-optics.

I was under a Research Institute Scholarship then, which was converted to a National Science Scholarship (PhD) in 2001. Apart from the opportunity of working with the professor in my area of interest, I also had a preference to pursue my PhD in the UK as I thought it was the minimum duration for a PhD in UK universities, just as for where I will eventually pursue my PhD, I am still deciding between Singapore, the UK, or Sweden. Right now, I’m leaning more towards pursuing it locally, mainly because Singapore’s position as a scientific leader is attractive. As we all know, Singapore doesn’t have many natural resources, and engineers are constantly forced to come up with innovative new solutions.

A PhD IN THE UK
Dr Leong Siang Huei is a senior scientist with the Data Storage Institute of Singapore. He studied engineering for both his undergraduate and masters degrees at the National University of Singapore (NUS) as one of the first A*STAR scholars. Following this, he undertook his PhD in the UK at the University of Cambridge.

After my Masters Degree in Engineering at NUS, I worked at A*STAR’s Data Storage Institute (DSI). At that time, DSI was exploring some collaborative work with a professor in Cambridge University in the UK, so I jumped on the opportunity and pursued a PhD under that professor, specialising in Nano-technology and Nano-optics.

I was under a Research Institute Scholarship then, which was converted to a National Science Scholarship (PhD) in 2001. Apart from the opportunity of working with the professor in my area of interest, I also had a preference to pursue my PhD in the UK as I thought it was the minimum duration for a PhD in UK universities, just as I was interested in design and technology and since I was a kid I’ve wanted to understand how things work. I eventually decided to pursue an undergraduate degree in mechanical engineering at MIT. While most of my education thus far has been overseas, after returning to Singapore, I did get the chance to study in Linköping, Sweden for five months on an exchange programme. Sweden is often ranked as one of the top few most innovative countries in the world, and I saw that they focused very much on academic research, while Singapore universities tended to have an equal focus on academic and applied research to support industry.

After returning to Singapore, I did a research attachment at the Singapore Institute of Manufacturing Technology (SIMTech) and spent five months in Sweden in his third year on an exchange programme.

A PhD BACK HOME
Xiong Jingwei Rachel is a second year NUS PhD student doing research at the Institute of Medical Biology (IMB). She’s studying in Singapore on an A*STAR Graduate Scholarship (AGS) following her undergraduate degree, where she studied Molecular and Cell Biology in the US under A*STAR’s National Science Scholarship (BS).

By the time I signed up to the A*STAR scholarship, I had my sights set on being a scientist. I did my undergraduate degree at the University of Illinois at Urbana-Champaign (UIUC), and conducted my undergraduate research at The Beckman Institute.

The mental and psychological freedom afforded from a liberal arts education in the US was a breath of fresh air. There, we were allowed to design our own course curricula, and I enjoyed a variety of other topics ranging from Astronomy to Literature to Music, on top of the bulk of biology courses.

Despite having the opportunity to continue with a PhD overseas, I am pleased with my decision to stay in Singapore for my PhD work. I currently work on rare genetic diseases with Dr Bruno Reversade at IMB. Science here is progressively evolving and improving, especially with the diverse mix of scientists from all over the world. Working with people from different cultures and backgrounds is great, as everyone takes different approaches when solving the same questions.

In the R&D landscape, Singapore maintains its competitive edge by rapidly renewing its focus. Being back home, I get to watch all the action happening live here, and not to mention enjoy the comforts of home at the same time.
In today's Singapore, where Research, Innovation, and Enterprise are cornerstones of the economy, a PhD opens doors to many different pathways. Seven talented PhD graduates, with very different jobs, open up about their career choices.

Dr Jonathan Loh Yuin-Han is a Principal Investigator at the Institute of Molecular and Cell Biology (IMCB). He is also an Assistant Professor with the Department of Biological Sciences at the National University of Singapore (NUS). Ever since he was a small boy, Dr Loh had a passion for science. “Even as far back as primary school I would focus all my energy on research. I really enjoyed working across disciplines,” he said. Eventually, he settled on biological research and pursued a diploma in Biotechnology at Singapore Polytechnic.

Driven by his passion for the life sciences sector, Jonathan moved on to carry out his PhD research at the Genome Institute of Singapore under the A*STAR Graduate Scholarship. He also carried out post-doctoral work at Harvard Medical School in the US, on the A*STAR Post-Doctoral Fellowship. There, he was first in the world to successfully reprogramme human blood cells to pluripotent stem cells.

“Doing my post-doc in the US was great both culturally and academically. It really expanded my network, which is vital in this field.” Against international competition, Jonathan won a prestigious A*STAR Investigatorship Award and returned to Singapore in 2011 to set up his lab. As a principal investigator at IMCB today, Jonathan specialises in stem cell research and his laboratory is interested in cell fate changes. “We help doctors solve real problems in real life situations using our knowledge,” he said. His research could potentially benefit patients who require replacement cells and tissues.

In recognition of his outstanding work, he won the Singapore Youth Award in 2010, and was featured on MIT's 2012 TR35@Singapore list, which recognizes the top 35 innovators under 35 from Southeast Asia to Australia. He credits A*STAR for allowing him to pursue his career in his home country. “Without a place like Biopolis I'd have to go overseas. Singapore isn't yet a world leader but we're doing everything right. We're grooming our own talent, there's plenty of funding and we're encouraging great research collaborations. The framework is right.”

Jonathan sits on the executive committee of the Stem Cell Society Singapore and is the first Singaporean elected Fellow of the World Technology Network.

**CHARTING DIFFERENT CAREERS IN SCIENCE**

In today’s Singapore, where Research, Innovation, and Enterprise are cornerstones of the economy, a PhD opens doors to many different pathways. Seven talented PhD graduates, with very different jobs, open up about their career choices.
Microfluidics research is making waves in the medical industry and Dr Gary Ng is one of the scientists behind the technologies in development.

Solving real world problems with science has kept Dr Gary Ng at SIMTech for the past 14 years. As a Mechanical Engineering graduate, he joined SIMTech in 1999 and spent two years learning the ropes before taking on a PhD on an A*STAR scholarship at the Georgia Institute of Technology in the US. Four years later, he returned to Singapore to continue his work at SIMTech and he remains there today.

Focusing on microfluidics and its manufacturing, Gary and his team of researchers are furthering technologies that could facilitate huge medical advancements in the not so distant future. Microfluidics research is the study of how fluids behave at the micro scale. It involves the manipulation and precise control of fluids, which is important in the development of lab-on-a-chip platforms to detect certain conditions with a tiny amount of fluid – as little as a pinprick. This could potentially eliminate the need to visit a doctor for some diagnostics, which may be able to detect various conditions, from tropical disease to cancer. While such diagnostics are still in the research stage, the ramifications for the medical industry could be huge, given the pressure of ageing populations and the rising costs of healthcare.

Gary explained that SIMTech works on industry requests to further R&D in areas of demand, to help develop and improve products for the market. “In 10 or 20 years time this could be the kind of diagnostic device you can use at home, it’s the next generation of healthcare,” said Gary.

Working with industry partners keeps Gary abreast of product innovation: “There’s a lot of collaboration with outside teams from manufacturers to medics to chemists. It helps us know what the industry needs and stops us developing something commercially useless,” he said.

In addition, he said the wider opportunities at SIMTech have kept him on board for so many years: “It’s not just the science and research, there are travel opportunities, and attachment students, from pre-university to graduate level, we get to train, who in turn contribute to our research.”

“IN TEN OR 20 YEARS TIME THIS COULD BE THE KIND OF DIAGNOSTIC DEVICE YOU CAN USE AT HOME, IT’S THE NEXT GENERATION OF HEALTHCARE”

Patent examination is challenging. Each patent application is an intellectual puzzle,” he said.

Although Kwang Hwee opted out of an academic career path, he likened the role of a patent examiner to that of a reviewer of academic literature. “With a literature review, you conduct an extensive literature search to identify potential knowledge gaps that can be exploited. Similarly, in patent examination, you perform an extensive search to assess the patentability of each application.”

Before joining IPOS, Dr Seah spent a year working as a Digital Integrated Circuit Designer at Infineon Technologies, assessing both hardware and software before a patent is granted. “Patent examination is an intellectual puzzle,” he said. “It’s amazing that I can simply walk over to the next cubicle and strike up a conversation with domain experts on areas including info-communication technology, nanotechnology, chemistry and materials engineering,” he added.

“I could be the kind of diagnostic device you can use at home, it’s the next generation of healthcare.”

Patent examiner

Singapore’s aspirations to be a leading IP hub makes it an exciting place to be a Patent Examiner. Dr Seah Kwang Hwee explains why he enjoys solving ‘intellectual puzzles’
Dr Yar Kar Peo now works at the forefront of the nation’s defence communications as a Principal Engineer with ST Electronics.

"I love that I can use everything I learnt throughout my education in real life situations,“ he said.

Karen Crasta leads a team in Singapore and has won accolades worldwide for her pioneering work. Today, she’s leading a team in Singapore.

Karen was awarded the two-year A*STAR International Fellowship (AIF) to carry out her post-doctoral training at Harvard Medical School, USA. Winning acclaim for her research, which has been cited widely, she said the AIF experience changed her life: “My overseas training was key to getting a lab here in Singapore.” Prior to her post-doctoral stint, Karen studied Microbiology as an undergraduate at NUS and did her PhD research at A*STAR’s Institute of Molecular and Cell Biology (IMCB) in Singapore.

Karen is busy recruiting PhD students and post-doctoral scientists for her new laboratory at the Lee Kong Chian School of Medicine in Nanyang Technological University (NTU).

Karen has always had a passion for research, specialising in genomic instability, mitosis and cancers, she enjoys lab work and couldn’t imagine another career. “It’s great to be able to dictate what you do, asking questions you want to answer, and working with people who share the same vision.

Few governments in the world invest so much into building state-of-the-art facilities and solid research infrastructure. I can’t do what I’m doing now as easily anywhere else.”

Karen’s research is funded by her prestigious National Research Foundation (NRF) Fellowship award. She and two other Singaporeans won the grant, which attracted strong international competition.

Karen would eventually like to focus on improving efficacy of treatment against breast and ovarian cancers. With continued collaboration with A*STAR, she hopes to be part of the future of R&D in Singapore.

Engineer

Moving out of a research institute and into industry may strike many as a risky move, but Dr Yar Kar Peo is happy he took the leap.

“I had been in academia and public sector research for almost a decade, so I felt like it was time to move on to something else and gain some real world experience while I was still young,” he said.

He studied Electrical Engineering at the National University of Singapore (NUS), before pursuing his PhD at the University of Michigan, Ann Arbor, in wireless communication, supported by A*STAR’s National Science Scholarship (PND).

“I feel that the older you get, the less inclined you are to take on new challenges.”

As a Principal Engineer at ST Electronics today, he is responsible for developing cutting-edge defence communication technology. He feels an tremendous sense of pride in developing technology that may be used to protect the country.

Kar Peo credits his prior work experience at A*STAR’s Institute for Infocomm Research (I2R), where he worked on the smart grids project, which involved heavy collaboration with industry. This had helped him prepare for his career at ST Electronics.

“At I2R, I had a chance to work as part of a team on many large scale projects, which involve many different departments. It helped to set the foundation for working in industry with many people and it developed my project management skills.”

He said the opportunity to study overseas has benefited him both personally and professionally.

“I love that I can use everything that I’ve learnt throughout my education in real life situations,” he said.
Dr Davy Cheong

"I'VE ALWAYS WANTED TO BRING SOMETHING TO MARKET. THIS REALLY IS A DREAM COME TRUE, TO BRING A PRODUCT TO LIFE"

Dr Davy Cheong, his Eureka moment came a few years ago while playing with a tub of cornflour.

"It all began in 2009, while I was working at A*STAR's Institute of Materials Research and Engineering (IMRE). We took a tub of corn flour to a three-day science carnival – a few days science carnival – and showed how it could be stirred easily, but somehow resisted impact force. Children started asking questions like 'can it stop a bullet?' he laughed.

"With an undergraduate degree in biology and a PhD in Pathobiology, Dr Cheryl Koh returned to Singapore in 2011 to join the Institute of Molecular and Cell Biology (IMCB), where she currently works in the division of cancer genetics and therapeutics.

The international exposure she gained from eight years in the USA on the A*STAR National Science Scholarship (NSS) helped her to mentor her own junior college and undergraduate students in the lab today. "My scientific mentors have been key in my training," she said. "I try to give back to my students in the same way."

Cheryl's interest in science research was sparked at junior college where she worked at a lab in the Botanic Gardens as part of the Science Research Program. There, she studied different culture conditions for germinating orchid seeds, and discovered that the seeds germinated much better and faster when grown in a symbiotic culture with a fungus. "It's fun to ask questions and then devise ways to answer them. And there are always unanswered questions in science."

Today, Cheryl works on identifying novel targets for cancer therapy, by investigating their involvement in cancer pathways. For one of her projects, she studies the function of MYC, one of the most commonly over-expressed oncogenes in human cancers. She is also exploring the potential clinical utility of a newly-described class of RNAs as diagnostic and prognostic markers of cancer.

Her research is supported by two grants she recently won: "With A*STAR there are various funding opportunities, even for young researchers. The grants give me more flexibility to explore my scientific interests at this early stage in my career."

While science can be an extremely competitive field, she said Singapore fosters collaboration. "The A*STAR institutes bring together researchers with diverse interests and expertise, and there are many opportunities for inter-disciplinary research. We're encouraged to maintain ties with our overseas network."

"MY SCIENTIFIC MENTORS HAVE BEEN KEY IN MY TRAINING. I TRY TO GIVE BACK TO MY STUDENTS IN THE SAME WAY"

"I try to give back to my students in the same way."

"Without A*STAR, this wouldn't have been possible. Before, it was just an idea, but they helped us to commercialise it," he said.

"The mechanical engineering undergraduate undertook a PhD in Sydney, followed by a post doctorate, before applying for a position at IMRE, where he spent seven years working as a materials scientist on the theoretical characterisation of materials behavior.

After two-and-a-half years testing his product – a process which involved firing ball bearings and dropping spikes onto it – Davy and Mr Yap licensed the technology they needed from A*STAR to launch Sofshell.

"There's lots of opportunities for inter-disciplinary research. We're encouraged to maintain ties with our overseas network."

"I try to give back to my students in the same way."

"Without A*STAR, this wouldn't have been possible. Before, it was just an idea, but they helped us to commercialise it," he said.

"It's win win for the individual and the country. Singapore needs entrepreneurs to support the economy."
SPECTRUM OF RESEARCH

A*STAR oversees 20 biomedical sciences, physical sciences and engineering research entities, located within the Biopolis and Fusionopolis research complexes and their vicinity. These two bustling R&D hubs house a diverse community of local and international research scientists and engineers from A*STAR’s research centres as well as a growing number of corporate laboratories.

1987 1990 2000 2005
Singapore Institute of Manufacturing Technology (SimTech) 1989
Data Storage Institute (DSI) 1992
Institute of High Performance Computing (IHP) 1998
Genome Institute of Singapore (GIS) 2000
Bioprocessing Technology Institute (BTI) 2003
Singapore Biomanufacturing Consortium (SBIO) 2005
Biopolis Phase I (2003)
Biopolis Phase II (2006)
Fusionopolis Phase I (2008)
Experimental Therapeutics Centre (ETC) 2008

What is a PhD?

A PhD is part of training you need in the Scientific Method. You learn to ask questions, to see problems and formulate them, and also learn many advanced skills in instruments, statistics. It’s very broad. It’s an apprenticeship, a form of self-education. It’s not a course and you can’t expect things to be handed out.

Why is there a need to pursue PhD studies?

We can give a very romantic view of what it is, world fame and Nobel prizes... But that’s for just a tiny group of people. Today, a PhD is an ‘entry fee’. It’s a necessary qualification to participate in modern Science and Technology. Whether you want a research job in academia to do research and teach, work in a research institute, in industry, or hospitals, you will need a PhD. And increasingly, people will hire at higher and higher levels.

What should you consider before you decide to pursue a PhD?

There are two things you should consider. First, are you interested in any aspect of Science and Technology? and second, what are the opportunities for a career after PhD?

What are some of the things to look out for when choosing a PhD lab/topic/supervisor?

Well, the very important thing is to make sure the PhD supervisor chooses you. He will be looking out for certain things, so it’s not a direct thing. You have to come to an agreement, first of all on the area of study. Sometimes that is constrained by what you’ve already studied.

You mentioned that the most important thing is to have the supervisor choose you. What do you look out for in a PhD student? What I’m interested in is found only in a very small number of people. They have to have certain characteristics which are hard to find because they are contradictory. They have to have an open mind, be very creative and think of new things. But when the time comes, they have to go straight through brick walls. I’ve seen many young people who are great at the first but useless at the second, and also people who have no ideas of their own but are very well organised. To get all these things into one person is very difficult. Most can follow and deliver, but they may not have too many original ideas.

Research is doing something new and originality in thought and practice is the source of good science.
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