8th SGH Lecture: Genomics, Talent and the Development of the Life Sciences Industry in Singapore†

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In a few months' time, one of the most significant advances, possibly the most significant advance ever in the history of biology and medicine, will be achieved with the rolling out of the first draft of the map detailing the entire Human Genome.

The Human Genome Project started modestly and at a leisurely pace in 1988 when the US Congress approved funds to identify and sort out the approximately three billion basic chemical units making up the 100,000 genes in the DNA of the human cell. This public effort eventually grew to involve five laboratories in three countries—USA, Japan and France.

Progress was steady if unspectacular, and in 1998, 10 years after the project was approved by the Congress, about 3% of the units making up the Human Genome had been decoded. In that year, J. Craig Venter through his newly formed company, Celera Genomics, announced a bold and audacious plan to sequence the entire Human Genome alone and without assistance, in just three years using a riskier approach than that adopted by the public Human Genome Project.

As of today, the public sector effort, spearheaded by the US Human Gnome Research Institute, and the private sector effort led by Celera Genomics, are racing to be the first to announce the road map describing the entire Human Genome sequence.

The race is a deadly serious matter. It is not just about intellectual credit or which approach is superior.

If the private sector project succeeds ahead of the public sector project, this could result in many complicated patent and licensing disputes as rival companies seek protection for pharmaceutical agents and drugs which they hope to develop from the Human Genome blueprint.

Commercial Applications of the Human Genome Project

Regardless of how the public sector and private efforts pan out, the knowledge that the entire Human Genome sequence will become available within a couple of months has re-ignited the biotechnology industry and galvanised a host of companies, both big and small, to step up their R&D efforts in this area, hoping to roll out commercially valuable products and services.

Three areas appear to be of particular interest:
a) Drug Discovery, b) Genetic Screening and c) Gene Therapy.

The traditional method of discovering drugs is to test thousand of chemicals in the hope of finding one which will be effective in treating a particular illness or disease.

This approach is equivalent to shooting a shotgun at a haystack and hoping that one of the shotgun bullets will hit a needle buried in the haystack. It is expensive, laborious and can only be undertaken by large pharmaceutical companies, which have the financial resources to finance such research lasting over many years.

With the Human Genome roadmap, scientists now believe that it is possible to zero in on the genes, which play a fundamental role in causing particular diseases or illnesses, and then design drugs, which target these genes.

Using this smart rifle approach, where a bullet is aimed at a particular target, the focus of drug discovery has broadened from the large pharmaceutical companies to include small groups of clever doctors and scientists who can work out drug treatments for particular diseases or malfunctioning genes and then capitalise on the intellectual property generated to realise market value either through an IPO or through selling the process and knowledge to a giant pharmaceutical company.

In a way, this is similar to the process whereby small groups of information communication technologists create new business applications or services using the Internet and then get rich by capitalising on their knowledge to set up dot.com companies.

The exciting thing about this new method of drug discovery is that the drugs discovered need not be delivered broad-band but can be customised for an individual or for groups of individuals. It is known, for example, that many present day drugs do not have the same efficacy when applied to all individuals. Asians react differently to certain drugs than Caucasians.

Using a genetic-based drug discovery approach, it would theoretically be possible to devise drugs which would be effective for specific populations or even be suited to the genetic structure of individual human beings, thus minimising toxic side-effects.

Genetic screening of individuals to identify diseased genes or predisposition to particular illnesses or diseases is another active and exciting field of activity, which can be built on the knowledge of the Human Genome blueprint.

Using new diagnostic techniques such as microarrays or

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genebeads, it is possible to test and analyse tens of thousands or genes at the same time for research or for curative purposes.

This speed of analysis is several orders of magnitude more rapid than using traditional test tubes and opens up new fields of research in biology and medicine which were previously unassailable simply because the time it took to complete a particular analysis using a traditional method may stretch into thousands of years.

While genetic screening holds great promise as a curative technique to identify diseased genes so that they can be treated, it holds even greater promise as a means to identify individuals who have a predisposition to particular illnesses, e.g., heart failure.

Knowing that an individual has a predisposition to a particular disease or illness enables an appropriate course of treatment to be prescribed in order to lower the chances of that individual developing the disease or illness. Prevention of disease developing in an individual then becomes just as important, if not more important, than curing the disease after the individual has fallen ill.

The third area of application of the Human Genome knowledge, which is exciting doctors and scientists, is gene therapy.

Since many illnesses can be traced to an individual having defective genes, it would be possible in theory to cure the illness by altering or manipulating the genes of the patient, e.g. by replacing diseased genes with healthy genes. Unlike drug discovery and genetic screening, work on gene therapy is still at a very preliminary stage. Some successes have been reported in laboratory animals but extension of the techniques to human beings raises scientific, legal and ethical questions which have yet to be resolved.

Development of the Life Sciences Industry in Singapore

Against this exciting backdrop, Singapore is well placed to be a key player in the Life Sciences industry given our strong base of scientific talent, excellent medical institutes, pharmaceutical companies and active research centres.

With its high value-added and knowledge-intensive nature, Life Sciences can become the fourth pillar of Singapore's manufacturing sector, complementing electronics, chemical and engineering and adding diversity and robustness to the Singapore economy.

The key requirement to building an active Life Sciences industry in Singapore is developing talent and building up an active research programme in the biological, medical and pharmaceutical fields.

Three initiatives need to be implemented:

a) Increasing the number of scientists, technicians and medically trained personnel in the Life Sciences field;

b) Encouraging the growth of more research centres or schools in the Life Sciences; and

c) Fostering an active research programme in Life Sciences to create economic opportunities and enhance the career prospects for scientists working in this field.

As with all other knowledge-based industries, talented people are the key to success in the Life Sciences industry. For the Life Sciences area, we not only need biologists but also chemists, mathematicians, engineers and information technologists.

However, a key requirement will be medically trained personnel since the Life Sciences industry is about, at its heart, finding ways to cure people, helping people live better and preventing people from falling ill.

We therefore need to increase the number of medically trained personnel, particularly doctors, in Singapore not only to service our health system but also to create wealth for the Singapore economy.

Since educating doctors is very expensive and channelling too many of our brightest students to study medicine means fewer bright students for other critical sectors of our economy, we should increase our output of doctors gradually and carefully and re-design the training of our doctors to include more emphasis on subjects appropriate to the Life Sciences industry.

We should also supplement our need for doctors by bringing in more foreign-trained doctors to come and work in R&D and in our companies in Singapore. These foreign-trained doctors will have to be given conditional and medical registration so that they can practice in selected institutions but not in private medical practice.

Because the Life Sciences requires a plethora of expertise, EDB is launching a 4-pronged initiative to develop talent:

i) The Life Sciences Postgraduate Scholarship Programme will support postgraduate training in Life Sciences disciplines at both local and overseas universities;

ii) MBBS-PhD Scholarships will be available for up to ten candidates a year to train a new breed of doctors called "clinician-scientists" at NUS who combine both clinical skills and basic science knowledge;

iii) Life Sciences Fellowships will be offered to a dozen bright talents now pursuing postdoctoral training in overseas institutions; and

iv) Exchange programmes with renowned institutions overseas will be designed for up to ten research scientists and doctors in our universities, research institutes/centres and hospitals to gain exposure to the latest technologies and remain connected to nodes of excellence on their return to Singapore.

Next, we should encourage the development of more centres or schools of Life Sciences in Singapore. We already have a strong focus of Life Sciences R&D in the NUS Faculty of Medicine – National University Hospital – Institute of Molecular and Cell Biology combination. We should encourage the strong pool of expertise and knowledge residing in the NUS-NUH-IMCB group to grow and become internationally renowned.

At the same time, we should encourage the growth of other centres of Research and Development in Life Sciences, possibly through the combination of NTU and Singapore General Hospital (SGH) which already have an ongoing co-operative programme in biomedical engineering. NTU and SGH can build on their present co-operation in biomedical engineering to broaden this field into a comprehensive School of Life Sciences.

Having more active research centres in Singapore in the Life Sciences will generate competition, encourage development of different areas of expertise and enable us to draw in foreign talent from overseas as well as develop our own people.

The third initiative which we need to support is to have an expanded and focussed programme of biomedical research to create economic opportunities and enhance the career prospects for scientists working in this field.

Since Life Sciences is a research-driven industry, we need to put in substantial investment over many years before we can expect returns. Adequate funding for biomedical research is critical to implementing this initiative. At present, funding for Life Sciences research projects is spread among many agencies—EDB, NSTB, MOH, MOE.

There is merit in having some diversity of views and sources of funding so that we do not end up with only one view or direction of research to the exclusion of other promising areas.

The United States does this very successfully with their multiple funding agencies and research institutes, all competing against one another.

As a small country, Singapore does not have the resources, both financial and human, to take the same approach as the United States. Some co-ordination of research, particularly for long-term projects such as Asian Genomics, is necessary, but this should not lead to the stifling of initiatives by our present funding agencies or research institutes.

To achieve this purpose, it would be timely to consider setting up a co-ordinating Council or Board to tie together our present efforts in the direction and funding of biomedical research from the basic level to applied and clinical work so that our hospitals, Institutes of Higher Learning and Research Centres can better contribute to the growth of the Life Sciences industry in Singapore.

Role of the Singapore General Hospital

The SGH has an illustrious tradition in medical service, teaching and research. SGH doctors, nurses, engineers, administrators and other staff have always risen to the challenge of the times. SGH's humble beginnings can be traced to a wooden shed by the Singapore River in 1821. SGH has come along way since then.

SGH has scored numerous firsts—first heart transplant and first open-heart surgery using heart-lung machine in Singapore and first computer-aided neurosurgery and virtual reality surgery in Asia. The number of departments in SGH has grown from three in 1882, when SGH first opened in Sepoy Lines, to 26 specialty departments today.

SGH has played an important role in medical education in Singapore ever since the first medical school was established on SGH's premises in 1905. As part of the national health care, SGH plays a vital role in the training of our doctors. SGH took another significant step forward in 1994 with the formal establishment of the SGH Postgraduate Medical Institute. In the area of teaching, SGH plays a key role in helping the medical community in Singapore to continually update their professional knowledge.

As a better understanding of genes and disease emerges from knowledge of the human genome, doctors must constantly bring themselves up to speed with the latest developments. SGH can help to ensure that the next generation of doctors can quickly adapt themselves to new medical technologies and their implications on healthcare policy and practice.

As the largest tertiary level hospital in Singapore, with a total of 1600 beds, SGH will and must continue to be the key service provider to service the needs of our health system.

But SGH can do more. In the next phase of SGH's development, given SGH's wealth of expertise, talent and experience, SGH should expand its teaching, research and industrial expertise to become a significant participant in the Life Sciences industry in Singapore.

Conclusion

To sum up, with the completion of the Human Genome Project, Life Sciences are set to take off to become a major industry of the 21st Century. The Life Sciences field is different from Info-communications in that a strong research and institutional base is necessary if a country wants to develop its Life Science industry.

Singapore has all the ingredients to be a key player in Life Sciences. With energy, resources and direction, we may see, in 5 to 10 years' time, Life Sciences dot.gene companies creating as much excitement and generating as many headlines as the Internet dot.com companies do today.