Biotechnology

By

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Study and Review to determine best ways to launch a life science initiative in North Texas, USA.

This talk is based on two works:

1. Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming and Biofarming*, (World Scientific Publishing Company, New Jersey, London, Singapore, Hong Kong, Bangalore, Taipei, 2002).
   www.worldscientific.com
2. Hwa A. Lim, *Change: The operative word in high-tech, low-tech and no-tech*, forthcoming, (Fall 2002).

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Thank you Professor Da Hsuan Feng[1] for the kind introduction.

Old Biotechnology

It is a misconception that biotechnology is something very recent, something of the past two decades or so.

In certain sense, biotechnology has been contributing to human well-being for thousands of years. It began with the use of microorganisms to ferment foods during the dawn of civilization. In the present era, biotechnology is being used to produce wonder drugs such as antibiotics, anthelmintics, and cholesterol-lowering agents.

This is what I would call the "old biotechnology".

Since World War II, the old biotechnology has been instrumental in the development and implementation of processes for the manufacture of antibiotics and other pharmaceuticals, industrial sugars, alcohols, amino acids and other organic acids, foods, and specialty products through the application of microbiology, fermentation, enzymes, and separation technology.

In Dr. Walshok's lecture,[2] she mentioned how fifteen years ago, in the formative stages of the CONNECT Program, she went to Silicon Valley to interview and learn. She found that there was a lot of permeability among disciplines: engineers, scientists, attorneys, venture capitalists, real estate agents… all worked closely together.

To scale up biotechnology, this type of permeability is mandatory. Cash is required for mission-critical equipment; attorneys are necessary to protect intellectual property position; engineers, working with life scientists, often can achieve scale-up to industrial production in remarkably short periods. A relatively small number of biotech companies help to catalyze, over a period of fifty years since World War II, the growth of the pharmaceutical, food, agricultural processing, and specialty-product sectors of the U.S. economy to the point where annual sales exceeded $100 billion in the early 1990s.[3]

New Biotechnology

The "new biotechnology" started in the early 1970s, enabled by direct manipulation of the cell's genetic machinery through recombinant DNA technique and cell fusion. Its application on an industrial scale since 1976 has fundamentally expanded the utility of biological systems. This has also positioned a number of industries for explosive global growth. The principal impact of the new biotechnology has been in the pharmaceuticals arena.

Again, working with venture capitalists, attorneys and others, scientists and engineers can now change the genetic make-up of microbial, plant, and animal cells to confer new characteristics. Biological molecules, for which there is no other means of industrial production, can now be biologically manufactured or biofactured. Existing industrial organisms can be systematically altered or genetically engineered to enhance their function and to produce useful products in new ways.

On August 9, 2001, President Bush of the United States walked a political tight rope of allowing stem cell research, but with restriction to only existing cell lines. [*movements in the audience*]

In stem cell research for therapeutics, an enucleated egg cell is fused with the genetic material from a donor cell to get a fertilized egg. The fertilized egg is totipotent in the sense that

[1] Vice President, Research and Graduate Education, The University of Texas at Dallas.
[2] Dr. Mary Walshok, "How San Diego became a competitor in the life sciences", North Texas BioBoot Camp, The University of Texas at Dallas, February 7, 2002.
[3] *Putting Biotechnology to Work*, National research Council, (National Academy of Sciences, Washington, DC, 1992).

its potential is total, it can develop into a fetus. Approximately four days after fertilization during which several cycles of cell divisions have taken place, the totipotent cells begin to specialize, forming a hollow sphere of about one hundred cells called the blastocyst. The blastocyst consists of an outer layer of cells and a cluster of inner cell mass.[4]

The outer layer of cells will develop into placenta and other supporting tissues needed for fetal development. The inner cell mass will develop into virtually all of the tissues of the human body. These inner cell mass are pluripotent rather than totipotent. They cannot form an organism because they cannot develop into the placenta and supporting tissues necessary for the development in the human uterus.

The pluripotent stem cells undergo further specialization into stem cells that are capable of developing into cells of particular functions. For example, blood stem cells, skin stem cells, and other human body's 200 different cell types.

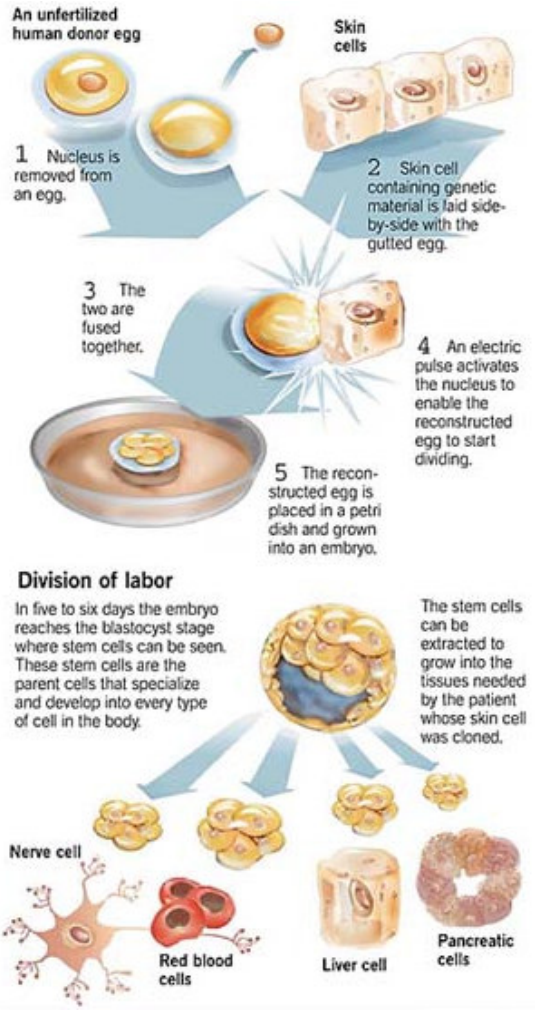


Figure 1. Using cloning techniques, scientists believe it is possible to grow in laboratory human tissues and cells for xenotransplantation. (Source: Advanced Cell Technology. Figure adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

In reproductive cloning, Texas has made its share of contributions. The cloning effort is closer to home than you know. It is in Texas A&M, and the press release from Texas A&M was dated September 2, 1999. [*some applause in the audience*]

[4] *Stem Cells: A primer*, National Institute of Health, May 2000.



Figure 2. Left: Second Chance, clone of the oldest bull, and Jonathan Hill (left) and Mark Westhusin (right). Right: This 1998 photo shows the late bull Chance, whose tissue was used to clone Second Chance. Chance, a Brahman who died at about 21 years of age, is believed to be the oldest animal ever cloned. (Source: Courtesy of Texas A&M. Photo adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Pharming, p-h-a-r-m, and not f-a-r-m, like in using animals as four-legged bioreactors, has come quite a long way. I am providing a few examples. These examples show how pharming may be used in therapeutics, in advanced materials and in farming. [*nods in the audience*]

Table 1. Biofactory barnyard. Genetic engineers are creating pharm animals or animals with given ability to produce valuable substances. (Adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Animal	Developer	Purpose
Chicken	University of Guelph	To produce antibiotic, lysozyme in its eggs, for keeping infection rates down in chicken eggs.
Cow	Pharming Inc.	To produce lactoferrin, a human protein, in its milk, for treating infection in humans.
Goat	Genzyme Corp.	To produce antithrombin III, a human blood protein, in its milk, to prevent blood clotting in humans.
Goat	Nexia Biotechnologies	To produce spider silk in its milk, for use in for example, light-weight bullet proof vests.
Sheep	PPL Therapeutics	To produce alpha antitrypsin for treating cystic fibrosis.
Pig	University of Guelph	To produce phylase, a bacterial protein for helping pigs digest the pollutant phosphorus better, resulting in manure containing less of it.

The new biotechnology, combine with the existing industrial, government, and university infrastructure in biotechnology and the pervasive influence of biological substances in everyday life, has set the stage for unprecedented growth in products, markets, and expectations.

The Other Half of The Story

This is only half of the story.

On June 26, 2000, at a photo-opportunity ceremony at the White House attended by Craig Venter, President of Maryland-based Celera Genomics,[5] Francis Collins, director of the National Human Genome Research Institute, and the U.S. President William Jefferson Clinton, a historical moment was defined. As the doors to the ornate East Room of the White House slid open, President Clinton strode in flanked by Collins and Venter. "Today the world is joining us here in the East Room to behold a map of even greater importance," Clinton said, "Without a doubt, this is the most important, most wondrous map ever produced by humankind."

[5] http://www.celera.com



Figure 3. President Bill Clinton, flanked by Celera Genomics head Craig Venter (to his right) and Francis Collins, head of the Human Genome Project of the National Institutes of Health, meets reporters in the East Room of the White House. (Photo: Courtesy of Associated Press. Adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Beside Celera from the private sector, the genome project involves sixteen institutions from six countries that form the Human Genome Sequencing Consortium (HGSC):

1. Baylor College of Medicine, Houston, Texas, USA
2. Beijing Human Genome Center, Institute of Genetics, Chinese Academy of Sciences, Beijing, China
3. Gesellschaft fur Biotechnologische Forschung mbH, Braunschweig, Germany
4. Genoscope, Evry, France
5. Genome Therapeutics Corporation, Waltham, MA, USA
6. Institute for Molecular Biotechnology, Jena, Germany
7. Joint Genome Institute, U.S. Department of Energy, Walnut Creek, CA, USA
8. Keio University, Tokyo, Japan
9. Max Planck Institute for Molecular Genetics, Berlin, Germany
10. RIKEN Genomic Sciences Center, Saitama, Japan
11. The Sanger Centre, Hinxton, U.K.
12. Stanford DNA Sequencing and Technology Development Center, Palo Alto, CA, USA
13. University of Washington Genome Center, Seattle, WA, USA
14. University of Washington Multimegabase Sequencing Center, Seattle, WA, USA
15. Whitehead Institute for Biomedical Research, MIT, Cambridge, MA, USA
16. Washington University Genome Sequencing Center, St. Louis, MO, USA

Together, the five highlighted labs – the G5 Alliance - produced 85% of the public program genome sequence. The remainder was handled by international collaborators over time.

Texas has made a significant contribution through Baylor College of Medicine. [*applause*]

With all the genetic data, it is conceivable that in the not too distant future, we can just walk up to our pharmacists, instead of giving them a prescription from a doctor, we give them a copy of our genetic sequence so that they can provide us more personalized medications:



Figure 4. Customer to pharmacist, "Here is my sequence…" (Reproduced with permission from Don Halbert of Abbott Laboratories, and adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

[*laughter and applause* at the sight of the figure]

This is further down the road. We have some other more immediate issues to address. For example, drug discovery.

Drug Discovery

Drug discovery can be both risky and expensive. It costs about $400 million - $700 million to roll a drug onto a pharmacy shelf. And only about a third of those drugs that make to the market actually make money.

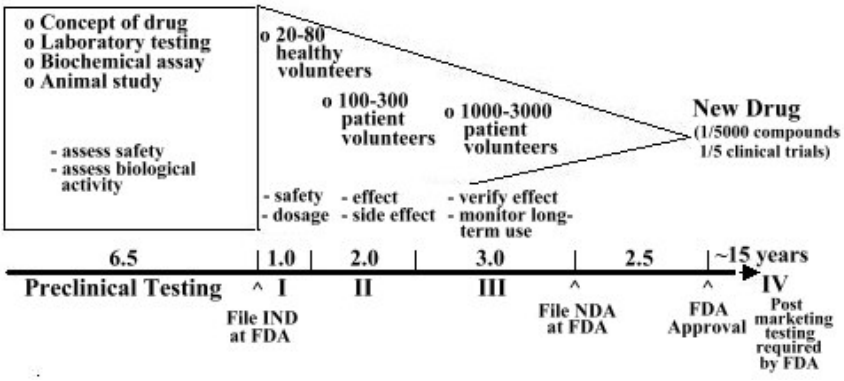


Figure 5. The long and expensive procedure for gaining FDA approval of a pharmaceutical product. (Figure adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming).*

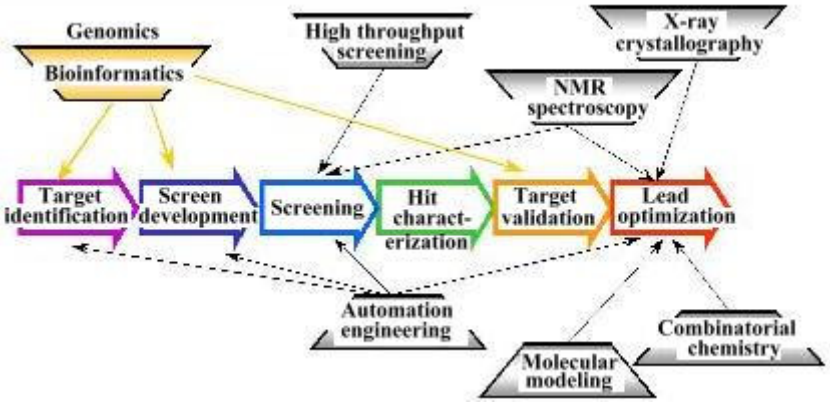


Figure 6. The drug discovery process involves six major steps: target identification, screen development, screening, hit characterization, target validation, and lead optimization. Other supporting technologies can help in accelerating each of the processes. (Figure adapted from Dr. Don Halbert, Abbot Laboratories, and from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

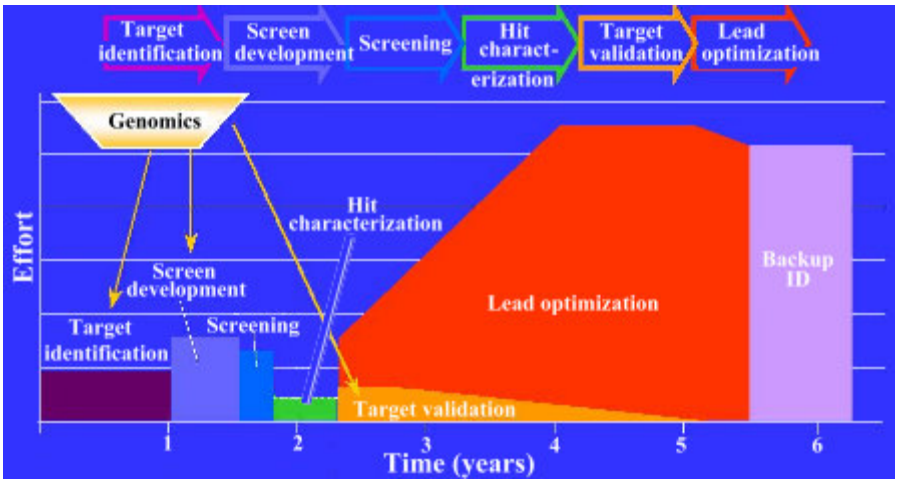


Figure 7. The time involved in each step of the drug discovery process is a very instructive piece of information. From a financial perspective, it is the effort that is involved is more indicative of the risk and cost involved. For example, lead optimization is a big bottleneck in drug discovery. (Figure adapted from Dr. Don Halbert, Abbot Laboratories, and from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Genomics leads to a new paradigm of healthcare system.

Table 2. Healthcare in pre-genomic and post-genomic eras. (HAL thanks Dr. David Wang, Motorola BioChip Systems [present: SNP Consortium Ltd.] for sharing the table. Table adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Pre-Genomic Era	Post-Genomic Era
❑ Disease description	❑ Disease mechanism
❑ Uniform disease	❑ Disease heterogeneity
❑ Patient homogeneity	❑ Individual variability – SNP
❑ Universal Rx strategy	❑ Patient risk profiling - pharmacogenomics and targeted care

Pharma Versus Farmer

A very seldom cited, yet very important, advantage of using genomics and informatics is that information is disciplinary-blind, that is, information can link disciplines that are seemingly unrelated to researchers. For example, it may seem that the pharmaceutical sector and the agriscience sector are not related. But if we compare and contrast drugs and seeds, certain similarities between the two sectors begin to reveal themselves.

Knowing the similarities and differences in, for example drug discovery and new seed development, shows that what one learns in one sector may be transferred to another sector, and vice versa. This in many cases, eliminates duplication of efforts, thus cutting down risks and cost.

Table 3. A comparison and contrast of the pharmaceutical and agriscience sectors. (Table adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Pharma	Farmer
Drugs are:	Seeds are:
❑ Chemicals	❑ Organisms
❑ Raw materials for screening	❑ Raw materials for breeding
❑ Sorted by chemistry	❑ Sorted by testing
New drug are:	New seeds:
❑ High margin	❑ Low margin
❑ Low volume	❑ High volume
Genes are	Genes
❑ Linked to diseases	❑ Increase yield

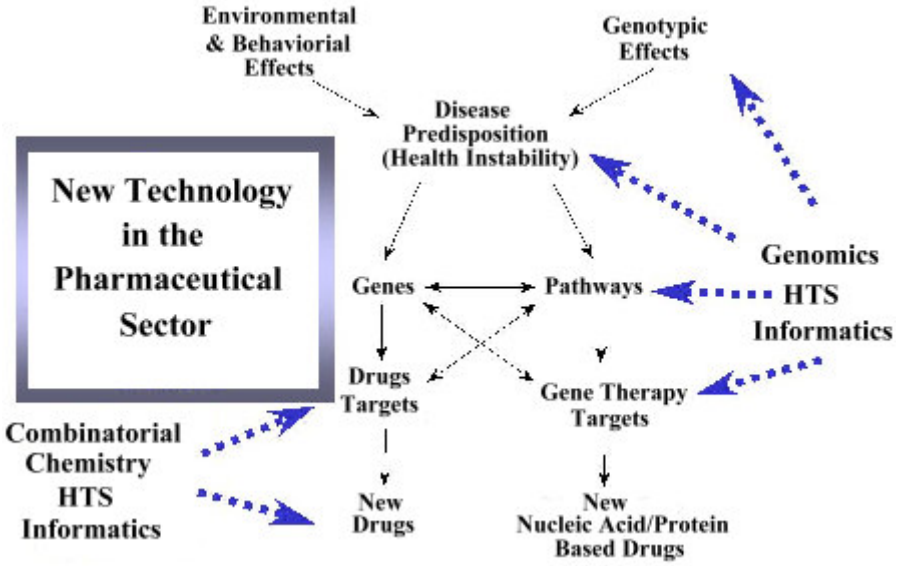


Figure 8. How combinatorial chemistry informatics and genomics high throughput sequencing informatics have shifted the discovery paradigm in the pharmaceutical industry. (Figure adapted from Benjamin Bowen, Pioneer Hi-Bred International, and from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

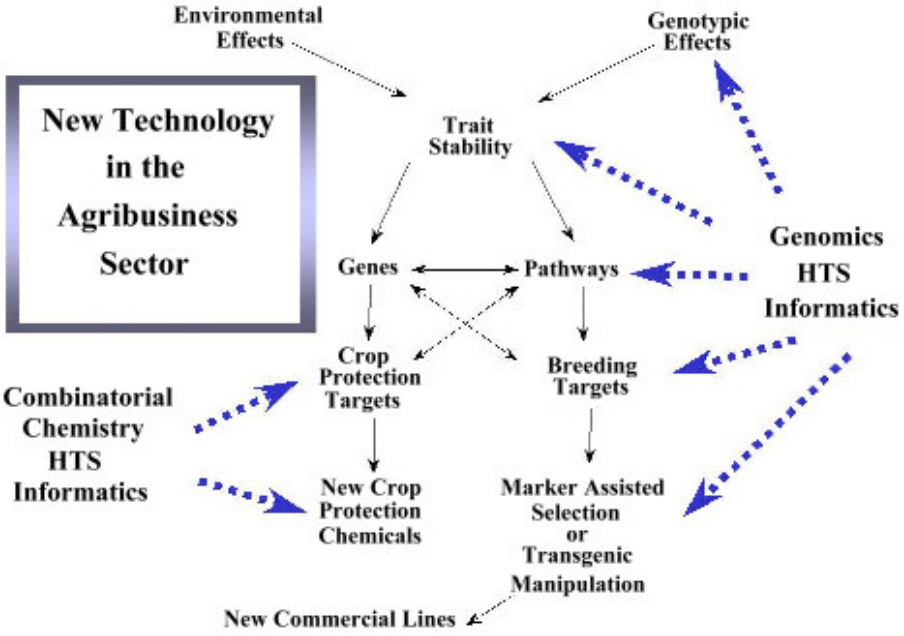


Figure 9. How combinatorial chemistry informatics and genomics high throughput sequencing informatics have shifted the discovery paradigm in the agribusiness industry. Note the similarity between this and the corresponding one for the pharmaceutical sector. (Figure adapted from Benjamin Bowen, Pioneer Hi-Bred International, and from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Array Technologies

An area in biotechnology that has recently garnered a lot of attention is the array technologies. [*nods in the audience*]

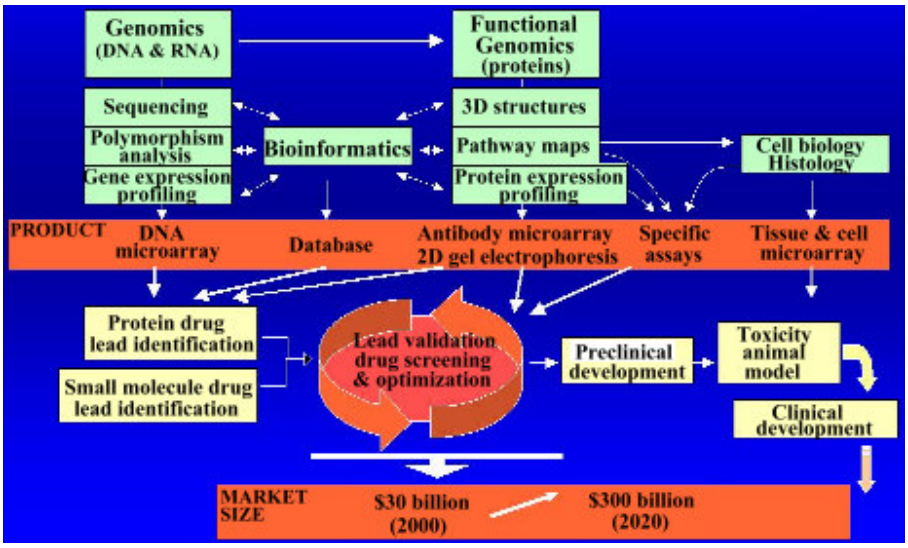


Figure 10. Genomics, functional genomics and bioinformatics in drug discovery cycle. (Figure adapted from various sources, including Dr. Jeff Wang, AbMetrix, Inc., and from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

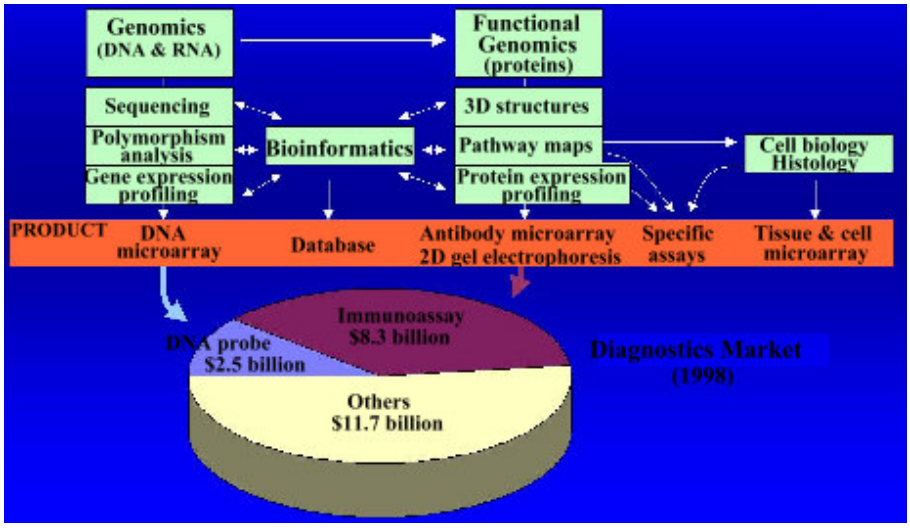


Figure 11. Diagnostics market for DNA microarray, antibody microarray, gel electrophoresis/mass spectroscopy and other technologies in 1998. (Figure adapted from various sources, including Dr. Jeff Wang, AbMetrix, Inc. and Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Market Summary

The microarray market in 1998 was $104 million.the microarray market is expected to be $777 million. Segmented into DNA chips and associated equipment, the segmental markets in 2003 are expected to be:

- DNA chips ($420 million/year)
- Arrayers ($64 million/year)
- Fluid stations ($96 million/year)
- Scanners ($190 million/year).

By 2006, the total market size is expected to be $3.6 billion. This shows that there is an organic growth in the market size of array technologies.

Challenges remain. Current challenges include cost: for example, a single-use high density DNA chip GeneChip™ costs ~$500 - $1,000, a GEM Microarray costs ~$2,000 - $4,000.[β] Scanners can cost ten times as much, for example, Axon's GenePix4000 costs ~$55,000.
There are additional challenges such as high setup cost, low-density chip, inflexibility, and low throughput. The density issue is particularly hairy since Affymetrix has a huge portfolio of patents covering high-density chips, something like any thing denser than 400 dots per square centimeter.

Different Level To Look At Biotech

I just described DNA microarray technologies. We can go one step further and talk about protein arrays, tissue arrays and cell arrays. I shall not delve into these areas. Instead, this brings us to another question – different levels of looking at biological systems. An organism may also be looked at at different scales, may be studied at different levels, and may be viewed from different perspectives. Genes, RNA, proteins, metabolism and methylation are five equally important levels of information in a cell. Thus we see that these different ways of studying an organism have also assumed more whimsical names like phenomics, ontogenomics.

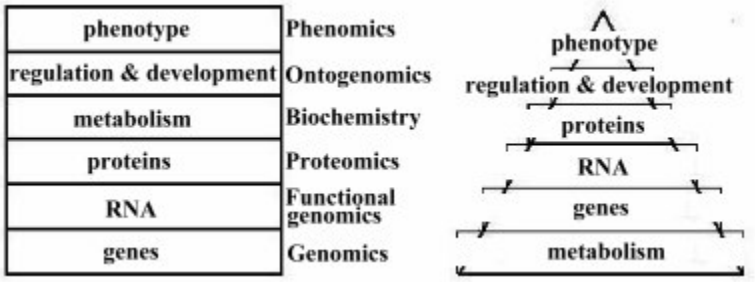
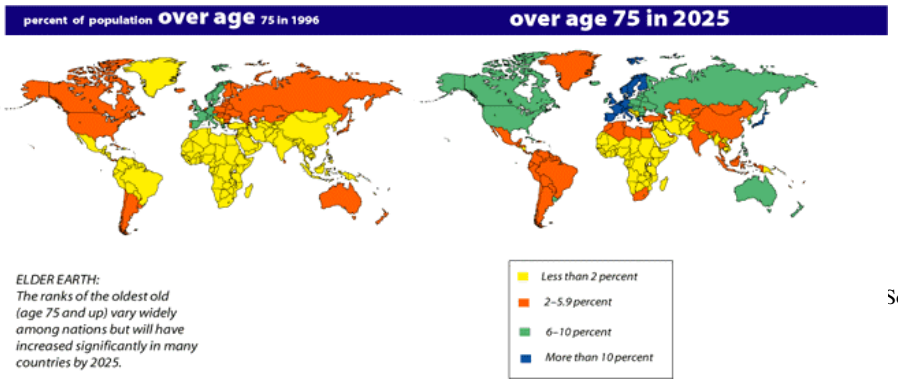


Figure 12. There are different ways of looking at an organism. But because some subject areas have been pursued more extensively than others, how much we know and how much we actually understand are not necessarily the same. We know phenotype, but we understand very little about it. Metabolism has been extensively studied in biochemistry, but we only know moderately about it. (Figure adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Traditionally, these areas have been pursued independently, with certain areas making more progress than the others. For example, biochemistry is a very well established field. It leads to understandings of metabolism. However, we only understand metabolism moderately. On the other hand, after the genome project, we know a lot about genes, but that does not translate to we understand genes.

Whether we are talking about transportation, navigation, space travel, electricity, telecommunication, advances in technology have improved life expectancies, quality of life and prosperity. We are fortunate beneficiaries of advances and wonders of modern biotechnology and healthcare system.



[β] On October 30, [illegible] So GEM is no longer in production].

Figure 13. The world growing older. Source: Nature Online, Feb 12, 2001. (Figure adapted from Hwa A. Lim, *Genetically Yours: Bioinforming, Biopharming, and Biofarming*).

Critical Success Factors

I shall end by discussing some of the critical success factors of a biotech community.

As average people have become more conversant with the latest biotechnology efforts, more and more cities and regions are injecting more energy, if not more monies, into biotechnology.[7] Thus Richard Seline of New Economy Strategies will discuss 35 regions in the U.S. competing in the bioeconomy.[8]

Because private returns are apt to be much more certain if one is looking for an extension of existing knowledge (cf. drilling a developmental well) than if one is looking for a major breakthrough (cf. drilling a wildcat well to find a new big oil field), private firms tend to concentrate their money on the developmental end of R&D process. Time lags are also shorter, and in the business sector, speed is everything.

For the risk, investors as well as the region profits. The biotechnology industry offers host cities more high-skill, high-wage jobs, increased diversification of the local economy into an industry set for long-term growth, and a higher tax base from a relatively clean industry. Leading biotechnology regions include Silicon Valley (Biotech Bay), San Diego (Biotech Beach), Boston Area or Route 128, North Carolina's Research Triangle, Seattle, and Washington DC area.

And soon North Texas! [*applause*]

Critical Mass

Those thinking about investing in research and development have an incentive to wait to see what they can get for free and skip the risky phases of investment. Because of this proclivity, they prefer to dive straight into the clear path of development. Capturing this free knowledge is one of the reasons that concentrations of high-tech companies exist in places like Silicon Valley and Route 128.[9] One learns sooner if one is in fact a neighbor. Knowledge, like fluids, finds its own level and eventually equalizes geographically. But eventually is not instantly. In fast-moving fields, the advantages of being inside the relevant learning communities are enormous. Companies establish windows, offices and subsidiaries in Silicon Valley to have listening posts. Other locations have much lower operating costs, but the same information is not as readily accessible.

Social Animals

We are also social animals. We love to gather information in unlikely places. For example, social engineering is a form of high tech reconnaissance. See what companies love to send their technical directors to meeting, workshops. These directors partake in *a pre* workshop beer hours. After a few beers, for example, researchers and post-docs tend to talk very freely and disclose more than they should. [*laughter*]

[7] "Biotechnology Dallas needs to inject more energy into effort", Dallas Morning Post, September 2, 2001.

[8] Richard Seline, "Global and national trends for the life sciences", North Texas BioBoot Camp, The University of Texas at Dallas, February 7, 2002.

[9] Adam B. Jaffe, Patent citations and the dynamic of technological change", *Reporter*, Summer 1998, National Bureau of Economic Research.

It Was Once Said

A mayor from a foreign country who led a trade delegate at a meeting for which I was keynote speaker said, "Silicon Valley is the holy ground for high tech. People come here to pay homage. But high-tech is very different from religion. In religion, you know who to pray to. In high-tech, you don't. So our delegate comes here to make a few friends and to look for opportunities to work together." [*laughter*]

I have been following the progress in Greater Dallas Cosmopolitan Region. In the past year, delegates make stopovers. News reports and press releases have been reporting great leaps forward. I also read Dallas Morning Post whenever I can to keep myself abreast with the excitements here. The region also has excellent learning institutions:

- University of Texas Southwestern Medical Center
- University of Texas at Dallas
- University of Texas at Arlington
- Other major learning centers.[*applause*]Many individuals, trade associations and organizations have made all the progress in the past year possible. These entities and Da Hsuan Feng have played a catalytic role. [*applause*]

Dallas is two hours ahead of Silicon Valley. When I awake each morning, your guys have done more than two hours of work. [*laughter*]

Today I came here for the third time in the past six months. Each time I turn around, something great has taken place in Greater Dallas Cosmopolitan Region. [*applause*]

Biotech And Telecommunications Century

The Time Magazine predicted two years ago that the 21st Century was going to be the telecommunications and biotech century. Currently, in telecommunications, supply exceeds demands. The telecommunications industry is faced with a glut of long-haul fiber optic lines installed by companies eager to cash in on the Internet Boom, which started around the time when Netscape went IPO in August 1995. Something like 100 million miles of these lines were laid in the two years of 2000-2001. The great bulk of this capacity is untapped. It is not surprising that Global Crossing filed for bankruptcy protection on Jan 28, 2002. ~~Global Crossing~~, kaput [*laughter*]; 360Networks did the same on June 28, 2001. ~~360Networks~~, kaput [*laughter*]; Winstar Communications – a competitive local exchange carrier – filed for bankruptcy protection on April 18, 2001; PSINet – a ISP – did the same on June 1, 2001. ~~PSINet~~, kaput [*laughter*]; and Exodus Communications – once the world's largest web hosting company – sought bankruptcy protection on September 26, 2001. ~~Exodus Communications~~, kaput [*laughter*] [*sigh and uneasiness*]

Enron, twice the size of Global Crossing, failed to broker capacity. Global Crossing failed to sell capacity. The end results are the same. Kaput, kaput. [*sigh*]

I do not foresee the telecommunications industry bouncing back in the next 4-5 years. So we are left with once clear winner.

The 21st Century is the ~~telecommunications and~~ biotechnology century. [*laughter*]

This is NOT the same as saying telecommunications is dead. It is just that at this juncture, supply exceeds demand in the telecommunications sector.

History is on the side of telecommunications.[10] Almost all of the big-mileage railroads west of the Missouri were built in advance of demand. Despite serious investor losses, a staggering

[10] Daniel Akst, "In technology, supply precedes demand", *New York Times*, September 2, 2001.

increase in national wealth would eventually result. The rail network completely transformed the West. It created cities where none existed, and businesses where none existed.

The story is typical of a growing industry in its pioneering stage. Competition then and now works itself out in a similar fashion. Some businessmen gain, some lose – but the public benefits. This is high-tech Darwinism.

Successful economic systems build social tools or infrastructures. In social tool building, there are three critical questions:[11,12]

1. What is the right amount to invest? Or equivalently, how much of today's resources should be devoted to the future?
2. What is the right mix of investment between private tools and social tools?
3. Are investment being made and used in the most efficient manner? Or could new technologies or new modes of social organization allow us to get more output from our existing tools?

In these intervening years of telecommunications downturn, North Texas should get into biotech. North Texas has been a Telecommunications Corridor. North Texas can be a Biotech Corridor. [*applause*]

Mayor Gary Slagel out it very nicely, "We may be able to have ehealth people to fill up the bandwidth." And Commissioner Jerry Hoagland, as a strong proponent of biotech effort in North Texas, is leading the noble effort to see that the mission is accomplished. When it comes to health, prevention is always better than cure; improving quality of life is always better than prolonging life with life-support machines.

Thank you.

[*applause…*]

Questions And Answers

Remarks by a member of the audience…

Question:

Should a program to promote biotech be in a university?

Answer:

The CONNECT program in San Diego region is within University of California San Diego. Participants of the program voted for the program to stay within UCSD. As an individual who has been both at the academia and in the private sector, I can tell you it is cheaper to keep the program in a university environment.

It is also not surprising to see that many big pharmaceutical companies have joint projects with universities. Universities are the nidus of creativity.

A few universities have very well established technology transfer departments to make sure that they are not taken for a ride. For example, University of Pennsylvania. University of Wisconsin is an excellent example when it comes to stem cell research. The Wisconsin

[11] Lester C. Thurow, *Building Wealth*, (HarperCollins Publishers, New York, 1999).
[12] Hwa A. Lim, *Change – the operative word in high-tech, low-tech, and no-tech*, forthcoming, 2002.

Alumni Research Foundation, WARF, holds patents. WiCell Research Institute, a nonprofit subsidiary of the WARF.

Question:

Besides Affymetrix, who are key players in the biochip business?

Answer:

Affymetrix, Apogent, and GeneMachines currently control three quarters of the arrayer market, with Affymetrix way in the lead. They are other smaller players.

Affymetrix is so comfortable in the DNA microarray that they decide not to enter the protein chip market.

A newcomer is GenoSpectra, first funded by a half a million dollars budget from no one other than Alejandro Zaffaroni, who founded Affymax, Alza, Maxygen and is a guru of biotech in the Bay Area. I happen to graduate from the same university, though many years afterwards.

Then GenoSpectra got funds from Affymetrix. This is probably their strategy to overcome intellectual property issue, feared by investors because Affymetrix has a broad portfolio of patents covering high-density arrays. The company just completed a second round financing of $20 million dollars.

They combine fiber optics with chip technology to produce low cost chips.

Question:

As an investor, if telecommunications is not an area to invest, which biotech areas are best to invest in?

Answer:

I am not saying that one should not invest in telecommunications. Telecommunications is still a very good area. But for now, supply exceeds demand and in my opinion, it will be a few years before it bounces back. Investing in cable laying is not a good idea. But if a company has a breakthrough technology such as to overcome last-mile problem, then investing in such companies is a good move.

In biotech, a lot of people talk about chip technologies. DNA chip is a mature technology. And the game is in applications. In my opinion, if you want to invest in DNA array companies, you have to make sure the companies are disease-specific companies, with potential of coming up with drugs, or drugs in the pipeline. Of course, if a company can come up with a way to produce DNA chips at a low cost, $10-$50, say, a level comfortable for most people, then this is also a good company to consider. At that price, chips may become a consumer product.

Otherwise, proteomics companies are good companies to consider. Antibodies, epitopes etc. Now with bioterrorism, this area has become even more pertinent.

Peripheral equipment market of chip technology is also a viable area. For example, Axon has a huge chunk of the DNA array scanner market. They are now in the proteomics market as well.

Diagnostics is probably better. Drug discovery take a long time, 10-15 years, and is very costly, order of $500 million.

The university here has a nanotechnology center, and the city has one of the nanotechnology companies, Zyvex. Investing in the convergence area of biotech and nanotech is an excellent idea.

Question:

You mention cell arrays. Do you know the market size?

Answer:

I do not have the number off hand. The fields of cell arrays, tissue arrays are still in R&D, as far as I can tell.

One can always jump ahead of everyone else. But investors prefer to invest in companies in late developmental stages.

I am sorry. I wish I could be more specific than this.

Question:

I am a software engineer, in artificial intelligence. How do I get into biotech? Can you also discuss patent issue?

Answer:

First the patent issue. In software, it is very difficult to patent your programs. As a programmer, you know that if inputs are different, this could mean technically the program is different. Thus you do not patent your programs. You copyright your program. You patent the procedure in solving the problem, essentially the flow-chart. But these days people do not draw flow-charts anymore. It is the procedure you patent.

Now how you can contribute in biotechnology. In my talk, I showed a figure of the six steps in drug discovery, from target identification through lead optimization. In that figure, I showed how supporting technologies have helped accelerate the discovery process. Two or three areas of interest to you, for example, are molecular modeling, automation engineering, and bioinformatics.

Question:

I am a telecommunications engineer. I am particularly interested in what you said about telecommunications. What do you see the future of telecommunications? If I want to move into biotech, how do I do it?

Answer:

There are actually three questions. I will answer each in turn.

First, about the telecommunications industry. Currently, in telecommunications, supply exceeds demands. The telecommunications industry is faced with a glut of long-haul fiber optic lines installed by companies eager to cash in on the Internet Boom. Supply exceeds demand is not a good thing in business. Thus many telecommunications companies have filed for bankruptcy protection.

But, let us remember, the parkways of the New York area were built to provide city dwellers easy access to outlying beaches and state parks. But these roads also led to the suburban development boom and soon were filled to capacity with commuters and all the traffic jams headaches that come with the heavy use.

When telephone numbers were first allocated, who would imagine that we would ever run out? Now we have more area codes than we care to remember. And once upon a time, a million shares was considered an enormous volume on the New York Stock Exchange. Now billions of shares are traded each day.

There are many reasons to believe that the vast new fiber optic network will similarly call forth unforeseen new applications. Some spectators predict an inferno of bit-burning applications once high-capacity networks overcome the last-mile bottleneck – the delay in

hooking up a high-speed Internet network to homes or businesses. If that happens, it may well be the time that communications overcapacity turns into a shortage.

Sure there are also failures in the biotech sector in the economic downturn of 2000 to the present. The most notable is Corning. Just over a year after formally announcing intentions to develop microarray applications, Corning, a fiber optic giant, closed their microarray initiative, Corning Microarray Technologies.

Many believe Corning could not compete. I am of the opinion that it is part of a cost-containing restructuring effort. Corning's retreat from the microarray sector appears to be mainly a casualty of the drastic downturn in telecommunications business. The company's net income in the third quarter of 2001 was $85 million, down from $317 million in the third quarter of 2000. The retreat from microarrays and closure of other manufacturing facilities is expected to save $400 million during the following year.

Soon after Corning, Incyte Genomics announced closing its microarray facilities, laying off about 450 employees in the Bay Area and St Louis. Incyte has contracts tied to Corning Microarray Technologies.

Now the question of getting into biotech. The best way to do so is not to switch to biotech, but to work with biotech people. Biotech people need expertise from engineers, from telecommunications people.

Da Hsuan Feng:

Due to time constraint, we have to stop here with one last very important question.

Question:

Can North Texas do biotech?

Answer:

North Texas has been a very successful Telecommunications Corridor. I have no doubt it has all the infrastructure. It can also be a very good Biotech Corridor. As far as I know, so far there is a lack of big pharma companies in the region. The immediate challenge may be to attract these people here.

Also, Richard Seline will talk more in depth of his findings and recommendations.

Da Hsuan Feng:

We have to stop here.

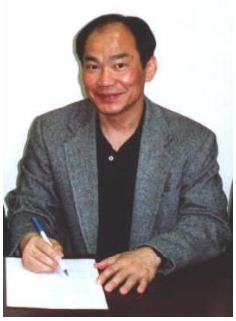
Speaker:

Today I come to Dallas – the Corridor for Telecommunications – for the third time in half a year to make a few friends and to look for opportunities to work together. This afternoon, I learned more than I gave away. This is what I call good business. [*laughter*]

I apologize for not being able to be more energetic during my talk. I have been talking to you in my sleep. 3:00pm in Dallas is 1:00pm in the West Coast. I miss my power lunch nap. [*laughter*]

[*applause*]

About The Author



Dr. Hwa A. Lim has a Ph.D. (Science) and an M.A. (Science), and an MBA (strategy and business laws) from the United States, a B.Sc. (Honours) and ARCS from the United Kingdom. In 1997, he founded D'Trends, Inc., a professional consulting company serving the biotech, pharmaceutical and healthcare sectors. Prior to this new venture, he was Vice President of Sc. & Tech., DoubleTwist (1996-1997), Director of Bioinformatics, Hyseq, Inc. (1995-1996), a tenured faculty member and Program Director, Supercomputer Computations Research Institute, Florida State University (1987-1995). He has authored/edited eleven books, and is a well sought after keynote speaker at international meetings. He is credited with coining the word "bioinformatics", pivotal in establishing and shaping the area, and for initiating the very first bioinformatics conference series (Bioinformatics & Genome Research), which is still ongoing. In addition to his scientific background, he has extensive experience in market research and developing strategic alliances internationally. Currently he also serves as a bioinformatics expert for the United Nations, a review panelist for the US National Science Foundation and the US National Cancer Institute. He has been a consultant for McKinsey, Prudential, VAXA, Eli Lilly and Company, Monsanto and Company, Taipei government, institutions in China, institutions in India and other organizations. Besides traveling for business, he also travels extensively to mingle with locals to experience and learn firsthand.

Dr Hwa A. Lim is on board of two Silicon Valley-based companies - AbMetrix, Inc. (www.abmetrix.com) and D'Trends, Inc. (www.dtrends.com) – and a Michigan-based company GeneGo, LLC. (www.geengo.com).