

# Chapter 16

## Future of Bioengineering & World Health



As we conclude our study of Bioengineering and world health, we stop to examine some of the health challenges that developing countries face and consider how efforts to develop new, appropriate technologies may help address these challenges.

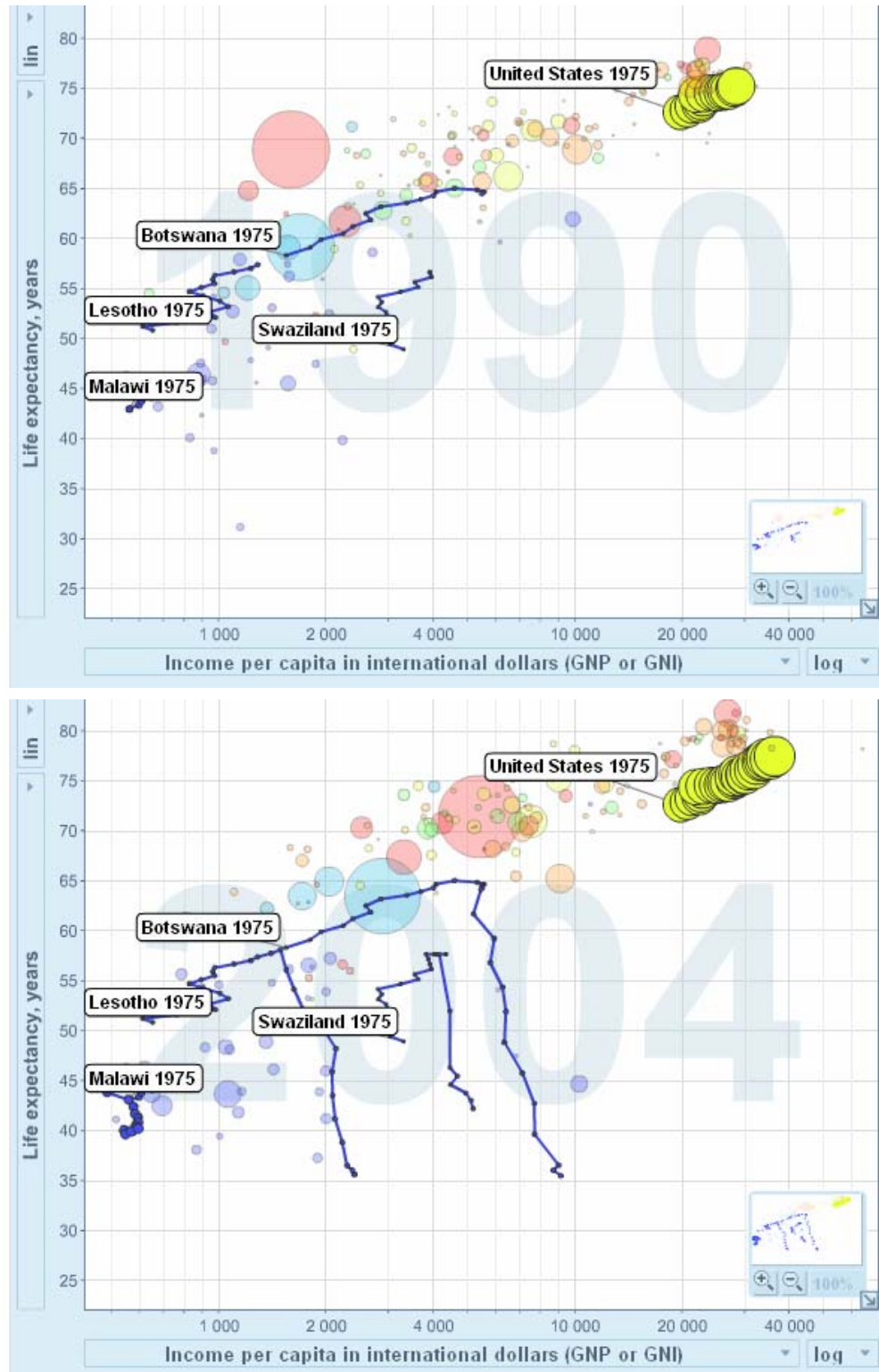
Ten million children under the age of 5 die every year throughout the world; 98% of these deaths occur in developing countries. This is more than twice the number of children born each year in the US and Canada combined. It has been estimated that 2/3 of childhood deaths could be prevented today with available technologies feasible for low income countries. Yet, current technologies do not reach millions of children in need – in many cases because these technologies are presently too expensive, require infrastructure that is unavailable (e.g. refrigeration for heat labile vaccines), or cannot be delivered because of a lack of effective health care systems.

Advances in the biosciences, bioengineering, and public health are responsible for the dramatic gains in life expectancy achieved over the last century. Throughout this book, we have seen that these advances are not equally available to people throughout the world (**Figure 16.1**). A recent global checkup of human health observes “In far too many countries health conditions remain unacceptably—and unnecessarily—poor.” Despite these inequities, 90% of the \$70 billion spent each year on health research and development is devoted to diseases that predominantly affect industrialized nations.

It is clear that many of the technologies we have examined in this book—for example, left ventricular assist devices—are simply not available in many developing countries. At the same time, developing countries are facing a growing



**Figure 16.1:** In the pediatric ward at Kamuzu Central Hospital in Lilongwe, Malawi, there is one nurse on staff for every 80 pediatric patients. Due to a shortage of staff, children cannot be admitted without a guardian to provide care for them. Because there are not enough beds, most patients must share beds, while their parents sleep on the floor beside them.



**Figure 16.2:** The top graph shows changes in life expectancy and per capita income for different countries throughout the world from 1975 to 1990. Progress in four sub-Saharan African countries is tracked over this period. Data from the US are shown for comparison. The bottom graph shows these changes from 1975 to 2004. Note the dramatic drop in life expectancy due to the AIDS pandemic beginning in 1990. The free software tool GapMinder provides an excellent way to explore global changes in income and health metrics over time. <http://tools.google.com/gapminder/>

burden of cardiovascular disease. Furthermore, the impact of **HIV/AIDS** has slowed, and even reversed much of the progress to improve health in many African countries (**Figure 16.2**).

What stops life-saving tools from reaching the world's poorest children? The Disease Control Priorities Project notes "... health inequities have arisen largely from uneven adoption and implementation of health interventions associated with technical progress" and cites as priorities developing effective low-cost interventions for neglected diseases as well as developing effective strategies to get interventions to neglected people.

In short, biotechnology and bioengineering research continues to transform the future of health care in developed countries, but ensuring that the benefits of research are available to all world citizens requires a new way of thinking, which must incorporate technology development as well as public policy and management of health care delivery. Often, due to limited infrastructure, it is not simply enough to provide existing technologies designed for use in developed nations; in many cases a new kind of technology—one which is robust and does not require disposable supplies—is needed to function effectively in the developing world (**Figure 16.3**).

The country of Swaziland, located in southern Africa, illustrates some of the challenges of **HIV/AIDS** in Sub-Saharan Africa. Swaziland has a population of about 1 million people. The HIV prevalence rate among adults is a staggering 42%, the highest in the world. Life expectancy at birth today is only 32.6 years. More than 70,000 Swazi children have been orphaned as a result of HIV/AIDS.



**Figure 16.3:** Another challenge of providing appropriate health technology in developing countries is the frequent lack of infrastructure, technical supplies and the difficulties associated with maintaining and repairing instrumentation. The photo at the left, taken at a government in Swaziland, illustrates that the availability of technology does not always translate into the ability to use that technology to address health needs. The photo shows a head CT imaging system in front of the hospital elevator. Both the elevator and the CT machine are broken, and parts to repair them could not be obtained. The CT machine is now used to block the entrance to the elevator.

**Departing Thoughts: August 3, 2007**

Yesterday, a young boy at the clinic lay paralyzed while several of the doctors struggled to keep him alive. His tiny body was on the examining table while beeping noises filled the room. The young boy could no longer breathe on his own. There are no child ventilators in this country. Why? None of the people we spoke to really knew for sure, but most speculated that this was due to a lack of organization of those who are in charge of inventory of medical supplies. The physicians decided to take the child to Bloemfontain, which is the town with the nearest South African hospital. I just thought about how this boy would have surely died if he was not in the care of the doctors at our clinic. The staff at the government hospital seems too over-stretched to have ever taken the care to send the child to Bloemfontain where a simple ventilator could be obtained to save this child's life.

There is such needless dying and suffering in this country. And when I hear that many are dying due to carelessness or disorganization - something inside me just burns with anger. The country always runs out of CD4 reagents...As a result, I have heard it announced repeatedly throughout my stay here that there are no CD4 counts for the week, which is crucial for monitoring HIV patients and starting them on antiretroviral treatment. In a country where 1/4 of the population has HIV, having CD4 counts available is a necessity. Again, there are speculations that the CD4 reagents run out not because of a lack of funding, but instead because of people who are disorganized.

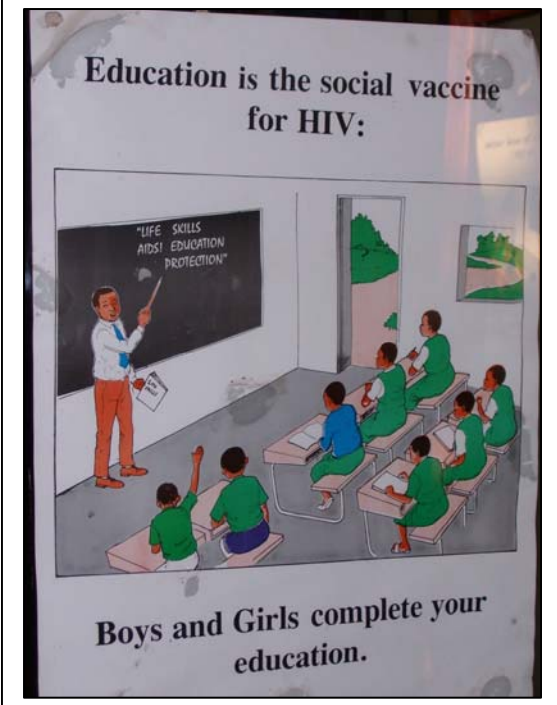
Another thing that deeply angered and frustrated me today was seeing about 20 spotless Mercedes Benzs lined up at the airport along with several beautiful black Audis and about 20 shiny Toyota Camrys... The government here pays for these cars for their highest government officials, while the lower down government officials all get Camrys (but not to worry, starting next year all the Camrys get upgraded to Lexus cars). It is all so wasteful... Especially now, after the government has declared a state of emergency. This country suffered from its worst drought in 30 years – many were expected to starve to death or die from malnutrition this year. Why is the government paying for these fancy cars and not spending it on their people who are suffering and dying from a mere lack of food?

The 500,000 rand or so spent on each of these cars could also easily be invested to send more kids to school. There is a lack of access to higher education for too many children of this country because they cannot afford to pay for high school tuition.

Furthermore, while the local government hospital is in shambles, a beautiful new ministry building is being built right next to it. The conditions at the hospital are terrible – it is overcrowded, the staff is too few, the building is too old - there are even cockroaches crawling out of the children's beds during the summer. There is absolutely no excuse for not making the rebuilding of the hospital a priority. People are dying needlessly due to the dreadful conditions of the place. But yet, a beautiful new ministry building is being built ...and the rebuilding of the hospital will continue to be put off while the government officials keep driving their sparkling cars....



Lack of educational opportunity also contributes to poor health in the developing world. Young people with little or no schooling are up to twice as likely to contract HIV as those who have completed primary education. Comprehensive solutions to global health challenges must include strategies to expand access both to appropriate technologies and to education.



The growing importance of global health problems has received substantial attention lately. Concerns about worldwide spread of emerging infectious diseases, humanitarian desires for equity in access to healthcare, and the fragile balance of sustaining past advances in world health in the face of increasing conflict and natural disasters all highlight the importance of increased efforts to address global health disparities. Thanks in large part to the substantial investments and efforts of the Gates Foundation, a number of high-profile scientific planning activities have delineated the research challenges most likely to lead to long term, substantial benefits in global health. These include the need for improved, cost-effective point of care diagnostic devices, the need for improved vaccines to prevent infectious disease, and the need for novel delivery methods for vaccines and medications.

Technologies for the developing world must adapt not only to inadequate resources, but also to unique economic, cultural, social, and environmental realities. Designing technologies like this is an exercise in extreme engineering, which can be approached through both novel high-tech and low-tech solutions (**Figure 16.4**). Efforts to design appropriate health technologies can improve care both in developing countries and in wealthy countries as well. New, simple health tools that work in hospitals in developing countries will also perform in rural, remote, and underprivileged healthcare settings in the industrialized world. We have seen that in many developed countries, healthcare costs continue to escalate, partly due to progressively more complex and expensive technologies that offer only incremental health benefit. New, cost-effective technologies have the potential to not only reduce inequities in health care, but also to reduce the costs of care for all.

**Figure 16.4:** Low Tech Solutions to Health Challenges in Developing Countries



Queen Elizabeth Central Hospital is the main government hospital in Blantyre, Malawi. The neonatal intensive care unit at the hospital has only one commercially made neonatal incubator (see photo, left). Unfortunately, when the thermostat in the incubator broke, no spare parts were available to repair the incubator.

Instead, Dr. Liz Molyneaux, chair of the Department of Pediatrics, invented her own incubator, which can be made for less than \$100 using locally available materials. The Blantyre Hot Cot (photos below) consists of a wooden crib, with a hinged plexiglass cover. Four 60W light bulbs which can be turned on independently are installed beneath the crib. The bulbs warm the air beneath the baby. Warm air rises up into the crib, and the temperature is controlled by adjusting the number of bulbs which are turned on.

The neonatal intensive care unit contains 12 Hot Cot incubators; an excellent example of a low tech solution which addresses the health challenge in a way that is affordable and can be operated in the current infrastructure.



### Things I Have Seen: August 7, 2007

It has been difficult accepting the fact that my time is over here because there are few times when I have left a foreign place feeling at home. It is true that I have missed my family and close friends, but I am leaving feeling as if I have become acquainted with an incredible family at Baylor. The physicians, the staff, the patients, and the people I have come in contact with have been some of the most amazing individuals I have known, and I will never forget their hospitality and their welcoming spirits. I am forever grateful to the Beyond Traditional Borders program, BIPAI, our program directors and mentors who have created such an incredible opportunity and have allowed me to be part of such a wonderful mission.

I have been told by many who have worked in developing settings or in some sort of volunteer work that those who attempt to teach others or contribute to a problem in some way end up leaving having learned much more than they could have ever taught others or end up gaining much more than they could have been left behind as some sort of contribution. I have found this to be true, and I have learned so much about the people, culture, health, education, challenges, and opportunities of this country in such a short period of time. I have felt such a unique combination of emotions all packed into a series of encounters and experiences that seem to blend into one another like one of the beautiful tapestries woven in rural villages here. It is as if all of life's emotions can be packed into a single day's work — happiness, frustration, empathy, anger, desperation, fulfillment....I could go on and on.

I am leaving with a refreshed and renewed perspective on global health and the complexities that exist when working on problems of such magnitude. I will miss the daily challenge of working on any aspect of HIV/AIDS and the tough questions I asked that ended up consuming my thoughts and conversations late into the nights. I have seen for myself the tragic truth that many speak of... of the needless deaths that occur daily and the completely preventable illnesses that young and innocent children die from. I have seen the "accidents of latitude" that Bono and Sachs speak of when they talk about the unthinkable disparities that exist among those who have been born in the developed world and those who have been born in areas such as sub-Saharan Africa. I have seen the struggling face of a baby who died of a simple case of diarrheal infection, and the face of her mother who thought her child was on her way to improvement. I have seen the determined faces of a medical team that went to great lengths to take a child to a South African hospital just to put a baby on a life-saving ventilator, a simple tool they lacked in this country. I have felt the pang of injustice, not injustice I have personally faced, but injustice that I have felt through my close encounters with children, mothers, grandmothers, health professionals, and people from all over the world working in this country. I have seen things and felt emotions that have left a lasting impression, and I only hope that I have been able to contribute a fraction of the impact I have felt myself and that I have been able to leave just one child with a fraction of the knowledge I have collected during my time here.



**Chapter 16 Homework**

1. The table to the right shows the global disease burden and the R&D funding for several diseases.

- a. Define DALY. Why is the DALY a better measure of disease burden than mortality rate?
- b. Based on this chart, what recommendations would you make for future funding of R&D funding?

**Disease Burden and Funding Comparison**

CONDITION	GLOBAL DISEASE BURDEN (million) DALYs*	R&D FUNDING (\$ Millions)	R&D FUNDING per DALY*
Cardiovascular	148.190	9402	\$63.45
HIV/AIDS	84.458	2049	\$24.26
Malaria	46.486	288	\$6.20
Tuberculosis	34.736	378	\$10.88
Diabetes	16.194	1653	\$102.07
Dengue	0.616	58	\$94.16

2. Over the last decade, describe the epidemiologic shift in burden of disease that has occurred in developing countries. Given this epidemiologic shift, recommend two specific changes that should be made to R&D funding priorities for chronic diseases. Discuss one challenge associated with each recommendation.

3. You are working for a non-profit organization dedicated to implement new health technologies in the world's least developed countries. The board of directors wants to allocate their 2006 budget to the development of biotechnologies that will most improve health in developing countries. To encourage the successful application of these technologies to global health, they have requested that you conduct a study to determine which biotechnologies could have the largest positive impact on health in developing countries. Your final report must address the following questions:

- a. Mention at least three technologies that you would recommend for implementation.
- b. Explain the potential positive impact that each technology could have on health.
- c. Describe the criteria you used to select these technologies.

4. You are provided with \$100 million dollars to make an investment in one of the three following areas:

- Launch of a public health program to educate people regarding the risks of lung cancer and the benefits of smoking cessation and offers free smoking cessation programs.
- Development of a new screening test for early lung cancer which costs \$100 and has a specificity of 95% and a sensitivity of 98%.
- Development of a novel pharmaceutical compound to treat lung cancer. The new treatment reduces side effects by improving the specificity of targeting and improves 5 year survival for lung cancer patients by 30%.

Choose one of options and explain your rationale for selecting this option. Be sure to justify why you feel the option that you selected is a better investment than the other two options. Please be as quantitative as possible in your justification.

5. Reflect on what we have learned about world health in relation to your own personal and career goals. How can YOU work to improve world health? Write down one personal goal illustrating how you will try to improve world health as a result of something you learned in this text.