Biotechnology:
A Changing Global Landscape

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Section 1 – Biotechnology: Past, Present and Future

The United Nations has broadly defined Biotechnology as “any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use” (“Convention on Biologic Diversity”). This definition would thus make the early agriculturalists of the Fertile Crescent the first to employ biotechnology approximately 10,000 to 11,000 thousand years ago (Bower). However, modern biotechnology has expanded far beyond the agricultural fields of the past to impact nearly every facet of life. Driven by the transportation and technological improvements brought by the modern age, the explosive growth of modern biotechnology has dramatically changed society, improving global agriculture, industry, health and economy, yet significant ethical issues linked with biotechnological advances have not yet been resolved.

Biotechnology has always had a significant influence on society. As early agricultural societies stabilized and increased their food supplies with primitive technologies, they were able to expand their populations, expand their territories, and affect changes in surrounding cultures by spreading their own languages and practices (Bellwood). However, the speed of these transitions was slow. As an example, the spread of agriculture from the Fertile Crescent to Western Europe took nearly 3,000 years, and 4,000 years for it to spread from China to the islands of South East Asia (Bellwood). The vastly improved transportation and communication technology of the modern globalized era has greatly reduced these spread times. The Green Revolution, which introduced high yielding varieties of food crops to developing nations, had its beginnings in the early 1940s with agricultural improvements in Mexico, but in 20 years

time the high yielding crops and other technological improvements brought by the Green Revolution were being employed in developing nations from India to Indonesia (Gaud).

Although communication and transportation improvements have had significant impacts on the spread of biotechnology, the modern biotechnology industry is defined by the advancements made in the area of genetics during the twentieth century. By the mid 1970s, these advancements spurred the creation of the world's first true biotech companies, such as Genentech and Cetus ("Biotechnology becomes a gold rush"). By the mid-1980s, nearly 200 other Biotech companies had been established across the globe ("Biotechnological firms eyeing competition…"). During this early period, over a billion dollars had been invested in biotech companies from the global stock market, venture capitalists, and older more entrenched companies in areas as diverse as the petroleum, chemical and pharmaceutical industries ("Biotechnology becomes a gold rush"). This early enthusiasm was created not by an outpouring of profits from these early biotech companies, but from the large amount of promise found within the industry. At the time, biotechnology derived products were predicted to create anywhere from a 15 to 40 Billion USD industry with applications in creating new pharmaceuticals and medical therapies; expanding agricultural productivity; and even enhancing mining techniques ("Biotechnology becomes a gold rush"). International competition ensued, as nations competed with each other to establish viable domestic biotech industries with government leaders believing biotechnology a key to future economic growth. Japan, France and Britain were among the first nations that began to both invest millions of

dollars and shift policy to develop domestic biotechnology in the early 1980s ("Challenging the US …"; Yanchinski).

Although the early biotechnology industry did yield some successes with the production of insulin, human growth hormone and a few other products, biotechnology did not quickly meet with the economic success predicted of it (Hilts). However, by the early 1990s, the biotechnology market finally begun to mature with the faster release of biotech derived therapies and products. Between 1990 and 1991, a number of biotechnology products were approved for sale in the United States that was equal to that of the previous 8 years, and biotech revenues in nations, such as Britain, were posting double digit growth rates ("Biotechnology market to grow to dollars 60 billion"). Although the intervening years between then and the present would still present the occasional difficulty for the industry, the biotech industry still posted consistent growth. In the 14 year period between 1991 and 2005, global biotech revenues increased from 6.5 to 63 Billion USD, and the 200 global biotech companies that existed in the early 1980s had ballooned to over 4,000 private and publicly traded firms by 2005 ("Biotechnology market to grow…" and "Beyond Borders…2006"). And more importantly, the biotech industry had finally begun to live up to its early expectations. The year 2005 saw the passage of a milestone for agricultural biotechnology as the billionth acre of genetically modified (GM) crops was planted, an amazing milestone as the first commercial GM crops were planted only a decade earlier ("Beyond Borders…2006"). Medical biotechnology has also seen increasing success. In 1991, only 11 biotech products were approved by US regulatory agencies ("Biotechnology market to grow…"). By 2005, United States and European regulatory agencies

combined approved over 60 biotech products (“Beyond Borders…2006). This explosive global growth is being fueled not just by revenues, but also by the influx of investment capital. Although the Asian biotech sector is still largely government funded, both the North American and European Biotech sectors have received over 40 Billion USD in venture capital and stock investment in the past 2 years (“Beyond Borders…2007”).

Although the explosive growth of biotechnology has been largely seen as a positive, controversy has ensued as to the ethical impact of biotechnology on society from its inception. Early arguments against the implementation of biotechnology in the 1970s were multifaceted, but most centered on either the value of life or the inherent dangers of biotech research. Some believed that in tampering with the process of evolution that a deadly pathogenic organism could be created (Cohn “Gene Study…”). Far from being a fringe belief, US scientists called for a moratorium on genetic biotech research in 1974 (Cohn “Genetic Patent…”). Although the National Institutes of Health instituted regulatory guidelines in 1977, the city of Cambridge, Massachusetts actually banned genetic biotech research both at Harvard and the Massachusetts Institute of Technology (“City Extends Ban…”). Other states and cities followed suit proposing similar restrictions (Cohn, “Gene Study…”). In Canada during this period, the Science Council of Canada noted that biotechnology may increase abortions due to improved prenatal screening technologies, may lead to genetic discrimination, and may cause environmental harm due to the placement of altered life forms in the environment with unknown consequences (Immen). Ownership of altered organisms and newly discovered genes/organisms were another issue of major concern during the early

development of the biotechnology industry leading to debate in the US Congress and multiple challenges in US courts (Cohn, “Genetic Patent…”; Scott).

Unfortunately, the early concerns of society were never fully resolved 30 years ago at the inception of the modern biotechnology era, and these important issues are persistently raised even today. Of all segments of biotechnology, perhaps Agricultural biotech reflects best the full spectrum of these continued concerns. Noted activist and popular author Dr. Michael Fox has argued in recent books that legitimate concerns remain as to the escape of genetically modified organisms (GMO) into the environment (49). He has also raised issue with biotech companies owning and controlling the rights to genetically modified seeds thus giving monopolistic control over crop production to a few companies (49). In Europe, fears over the safety and the environmental impact of GMOs led to a moratorium on the approval of new GMOs in 1999 (Varzakas et al). Legislation by the European Union has now instituted mandatory labeling of all GMO foods and animal feed (Varzakas et al). The European public appears to be equally skittish on GMOs with polling data in 2001 showing that approximately 71 percent of Europeans simply do not want GM foods (Varzakas et al). The current moratorium by the United Nations Convention on Biological Diversity on Genetic Use Restriction Technology or “Terminator” seed technology reflects a global concern over the ownership of GMOs (Osava). This technology implants genes into crops that renders them infertile, and would make farmers buy seeds from biotech companies year after year costing billions of dollars (Osava). Activists also fear if these modified plants were ever placed in nature that their infertility trait could be passed to other plants (Osava).

Globalization has made biotechnology a household term from India to Canada. Presently, modern biotechnology impacts almost every segment of life from the food we eat to the medicines and therapies we use to extend our lives. The future promises only more growth for this increasingly important industry. However, the fears as to the ethical use of relatively new biotechnologies have persisted in the public. The past and present demonstrates that these fears have the ability of slowing and stopping progress in the biotechnology industry. Thus the success of biotechnology relies on more than profit forecasts, venture capitalists, expanding research budgets, and new product rollouts. Biotechnology is unlike any industry that has come before, and thus requires the full and complete debate of the many ethical issues it touches upon. Without this debate, biotechnology will be locked into a pattern of stopping and starting with each novel development.

Section 2 – The Biotechnology Renaissance of South Korea

Although modern biotechnology had its beginnings with developments and scientific advances in the industrialized west, it has rapidly spread and ignited biotechnology industries in many other nations both industrialized and unindustrialized. Asia has recently undergone a transformation into a major biotechnology force with its biotechnology industry having an estimated value of over 39 Billion USD (“Research and Markets: The Expected Value…”). Currently, the Asian biotech sector is posting growth rates above 11 percent with Japan, China, and Taiwan representing 76 percent of the Asian biotech market share (The Expected Value…”). A nation often, yet wrongfully, ignored in the fast expanding and ever changing Asian biotech sector is

South Korea. The investment and policies of the South Korean government have quickly expanded its domestic biotechnology industry; however, its rapid growth has also left little time for the correct development of not only regulations but also a culture of ethical practices among scientists, which if not corrected threatens South Korea's position in the biotechnology arena.

The South Korean biotech sector had its true emergence with a series of government policies beginning in the early 1980s. At the time, South Korea's technology sector lagged far behind its more industrialized rivals. In a 2004 survey conducted by Kang Du-yong, of the Korean Institute for Industrial Economics and Trade, "Korea's technical expertise in some industries [in the early 1980s] had reached 80 percent of the world technological frontier" (Choi). This was a significant deficiency for a nation attempting to compete in the global market place. In response, the Korean Ministry of Science and Technology instituted a broad-based research program to catch up to its competitors. Included in this program was an initiative to increase research in South Korea's biotech sector (Rhee). In the same year, South Korea's private industrial sector founded the non-profit Korea Biotechnology Research Association. The government's biotech initiative was codified approximately a year later, in 1983, with the Biotechnology Promotion Law with the intent to improve South Korea's genetic engineering industry. Later, in 1985, the Korean Institute of Bioscience and Biotechnology was founded with the purpose of laying the foundation and promoting South Korea's biotech industry (Choi; Rhee). This met with some success as by the 1990s Korean Colleges and Universities began to start new biotechnology centered departments and research institutes (Rhee). Government action continued in the 1990s.

In response to a rapidly growing global biotechnology sector, the Bioindustry Association of Korea was founded in 1991 (“Current Status”). This was followed by another expansive project by the Ministry of Science and Technology, the Highly Advanced National Project (Rhee). Among the biotech sectors it focused on were biomaterials, pharmaceuticals and agrochemicals (Rhee). In 1994, the government began its next big biotechnology push called the 2000 Biotech Program and for publicity named the year 1994 “the Year of Biotechnology” (Rhee). It was an ambitious three-phase, 14 year program intended to have South Korea be competitive with the most advanced nations by 2007 and significantly increase South Korea’s biotech world market share (Rhee; Choi). The overall project involved universities, government-funded research facilities, private companies, and seven government agencies (Choi). The South Korean government investment of 14 Billion USD was given directly to universities and research facilities in the form of R&D grants and was given to private industry through R&D tax incentives and other financial incentives.

In 1999, the Korean government continued the advancement of its domestic biotech industry with the 21st Century Frontier Research Program (Si-young). This program has a somewhat different intent than the 2000 Biotech Program, as it focuses much more on practical application of biotechnology with the intent of improving Korea’s future competitiveness (Si-young). Beyond its different intent, the 21st Century Frontier Research Program is also structured for efficiency and faster results (Rhee). It consists of several 10 year projects with funding between 95 million and 160 million USD, and involves Seoul National University, Korea Institute of Science and Technology and the Korea Research Institute of Bioscience and Biotechnology (Choi). The funding is

divided among four major categories: New Technology, Fusion Technology, High Added Value technology and Unique Resources (Choi). Projects in development included everything from stem cell research to nanobiotechnology (Choi).

The final piece to the South Korean Government biotech development is increasing the number of homegrown researchers. To do this, the Ministry of Education of Human Resources began the High Quality Human Resources Development also known as Brain Korea 21 (Rhee). Its purpose was to upgrade Korea's graduate research infrastructure across several areas including biotechnology (Rhee). It has had a profound impact by increasing the number of Ph.D. graduates in biotechnology related fields from 1,719 in 1999 to 2,654 in 2005 (Choi). Now South Korea's universities play its most significant role in R&D. Between the years 1992 and 2001, South Korea's universities were responsible for 89 percent of all health biotechnology publications.

The impact of these various government initiatives on Korea's biotech sector has been significant. Economically, South Korea's biotech sector has multiplied over 14 fold since the inception of the 2000 Biotech Program ("S. Korea's biotech industry…"). In 1994, Korea's biotech industry was valued at 183 Million USD and by 2006 this value had increased to nearly 2.3 Billion USD ("S. Korea's biotech industry…"). The Bioindustry Association of Korea (BAK) notes that there were over 708 companies in the biotech sector as of 2005, an 8 percent increase over the previous year ("Current Status"; Beuzekom and Arundel 106). Of these companies, 390 are involved in the sale and development of domestic biotechnology. The prominence of Korean biotechnology is evident through its ever increasing presence on the Korean Stock exchange. In 2004, 23 biotech companies were listed compared to only 1 four years earlier (Wong et al).

The practical application of biotechnology has also seen growth in South Korea. South Korea has become an important global economic presence with the commercialization of biotech products as diverse as bacteria derived insecticides, anti-cancer drugs, and food-destined amino acids. South Korea's biopharmaceutical and biofood industries have been the biggest beneficiaries of this success and combined they represent 83 percent of all Korean biotech firms (Beuzekom and Arundel). The Biopharmaceutical industry alone possesses approximately 59 percent of South Korea's biotech market share ("Current State"). In fact, South Korea was in the process of developing over 300 new drugs as of 2003 (Rhee). Another sign of development is the significant rise in South Korean biotech patents. The number of biotechnology innovations patented in the United States has increased from 47 between 1994 and 1997 to 207 between 2002 and 2005 (Si-young). Domestically, South Korean biotech patents have also ballooned. In 2002 alone over 800 domestic patents were registered (Wong et al).

South Korea's international research presence has also dramatically increased due to government investment and planning. Between the years 1995 and 2005, South Korea's output of published biotech articles tripled (He-suk). In 2005 alone over 4,000 biotech papers were published in journals ranking South Korea 13th among all nations (He-suk). This growth of publishing output is second to only China (He-suk).

Politically, support for biotechnology has only strengthened over the years as South Korea has had to rebuild after its 1997 financial crisis. This has lead to broad based support of technological development as a panacea to South Korea's economic troubles. This is especially true of South Korea's most recent administration led by

President Roh Moo-hyun. Leading up to his 2002 election, he pushed policies to target the development of such “future-oriented industries as information technology, biotechnology, [and] nanotechnology…” (“Next Administration Needs to Address Income…”). Moreover, he campaigned that de-regulation had to be accelerated as to allow for South Korean industry to develop.

Clearly, South Korean government policy has quickly developed its domestic biotech sector into a globally competitive industry. However, its rapid development also had the result of leaving significant voids in regulation and ethics. This is well demonstrated by the recent scandal involving noted stem cell researcher Hwang Woo-Suk.

Hwang Woo-Suk had become nationally prominent after successful research into theriogenology—breeding pigs for human organ transplantation (Gottweis & Triendl). Soon he gained more influence, both at Seoul National University and at the Ministry of Science and Technology, directing the course of research projects and establishing outside projects (Gottweis & Triendl). However, it was his work on cloning that catapulted him to the status of national hero and international star, and consequentially gave the South Korean biotech industry both an economic and a publicity boost (DeBaets; Gottweis & Triendl). Unfortunately, the international prominence garnered by this attention did not shine light on the systemic flaws in the way science was conducted in South Korea. Scandal finally did break when papers published by Hwang Woo Suk in the Journal Science in 2004 and 2005 proved to be fabricated. In them, Hwang claimed to have successfully cloned embryonic stem cells; however, it later came to light that not only were there ethical breaches in how the research was conducted, but also there

were no actual cloned cells (DeBaets). Moreover, extensive conflicts of interests were uncovered between Hwang and key government officials working for relevant oversight committees, and the scandal itself revealed how little oversight there was over Hwang's research (Gottweis & Triendl). Surprisingly, the initial government and public response to the accusations of fraud were fiercely supportive (Chung-a). Some commentators have argued that the support was so stringent that it approached fascism as those who criticized Hwang were intensely castigated (Jin). Other commentators note how politically invested the government of Prime Minister Roh Moo-hyun had become in the biotech industry, and thus used Hwang's success as cover for government policies (Chung-a). However, what cannot be argued is the devastating impact the scandal had on the biotech sector with most biotech companies losing a third to half of their stock value in the month following the discovery of the research misconduct (Fuyuno).

Unfortunately, the lax ethical atmosphere that helped to create this scandal is not isolated to just star scientists, such as Hwang Woo Suk. Besides Seoul National University, several other universities have had prominent professors step down due to unethical research practices (Jin-seo). In a recent survey conducted by the Ministry of Education and Human Resources Development, only 15.6 percent of responding universities had developed ethical regulations at their schools, and approximately 8 percent of responding universities and educational institutes had established committees to review ethical academic conduct (Ji-hyun). Furthermore, the survey found that of the regulations and committees put in place, 50 percent were done so after the Hwang scandal broke (Ji-hyun). In September 2007, the Ministry of Education announced that 96 universities had established R&D verification out of over 900 such

facilities (Jin-seo; Ji-hyun). As universities play a key role in instilling a culture of ethics among students, this is a serious problem that has already made its way to the level of researchers. In another survey of 800 biotechnology researchers, 85 percent of respondents were unaware of the Declaration of Helsinki, which are a set of ethical principles for human experimentation developed by the World Medical Association (Cho et al). Similarly, 42 percent of respondents lacked knowledge on Institutional Review Boards, which are independent panels with the purpose of approving and analyzing the ethics of research and research protocols (Cho et al). This is a problematic flaw in South Korea's biotech industry.

As the career of Hwang Woo Suk demonstrates, the rewards are incredibly high for successful biotech scientists in South Korea. Combined with the lack of oversight and the lack of an ethical culture, and as Stanford bioethicist, David Magnus describes, "When rewards outweigh risks people will cut corners" ("Stanford Ethicists Explain…").

Yet in light of these realities the South Korean government has only taken limited actions to improve ethics in biotechnology research. In 2006 and 2007, the South Korean government strengthened its Life Sciences Law; however, measures were mostly limited to greater regulation of stem cell research and genetic testing (Hyo-lim). The South Korean government has taken weak measures to enhance ethics training in universities. One such measure would provide universities with an enhanced chance of getting funding for implementing ethics education (Ji-hyun). Another measure recently announced by the Ministry of Education and Human Resources would provide 200 million Won for ethics studies in universities, a sum barely above 200 thousand USD for the several hundred universities in South Korea (Shin-who). The Korean government's

latest move to improve research ethics in academia is sending a guidebook on research ethics to 500 universities (Jin-seo).

The Hwang scandal has uncovered several weaknesses in the South Korean research system: funding for biotech research is still often determined on political expediency instead of on the merit of research; institutional review and regulation is still lax in many areas, which leads to corruption and a lack of transparency; and there exists too few barriers between government officials and researchers. Although the South Korean government has been successful in creating a modern and globally competitive biotech industry, it is clear that without reforms more scandals will be created which may threaten both the trust in and the economic stability of the biotech sector.

Section 3 – Biotechnology and Scientific Research

The modern biotechnology industry had its birth in academia with research done in both American and British universities (Owen-Smith, et al 27). Since then global biotechnology research has been mostly guided by government funding and policy. However, the economic success of the United States model of corporate/university leadership has progressively drawn other nations to adopt United States practices, which in the United States have shifted research emphasis in universities towards applied biology (biotechnology) and negatively impacted how research is conducted in universities.

From the inception of modern biotechnology, there have been strong links between the biotechnology industry and university research in the United States. Early biotech companies, such as Cetus and Genentech, were started in part by university researchers (“Industry spurs university research on genetics”; or “Academic Research and Big Business: A Delicate Balance”). By the early 1980s, the US Supreme Court had decided it was legal to patent genetically modified organisms, and the US Congress passed laws, such as the Bayh-Dole Act, that allowed universities to patent the results of federally funded research (Rowe; Washburn). These government actions along with the economic success of early biotech start-ups created a frenzy on university campuses with researchers in biotech related areas signing lucrative consultant deals with biotech companies, and some universities starting independent for-profit biotechnology research centers (“Academic Research and Big Business: A Delicate Balance”).

Further impetus for Industry/University linkages was provided by the policies of the first Reagan Presidential administration. From 1976 to 1980, funding for basic scientific research increased at rates of 5.9 percent per annum. The conservative policies of the Reagan administration shifted much of this funding towards military applications, leaving a dearth of federal funding for research in areas, such as medicine and biology (“Academic Research and Big Business: A Delicate Balance”). By the 1984 United States’ budget, funding for basic research in health sciences was set to only increase by 3 percent, and even more problematic, the budget of the National Institutes of Health, which funded upwards of 66 percent of basic scientific research, was set to increase by a mere 1.8 percent.

On this back drop, biotechnology research in the early 1980s was just beginning to bloom with significant developments, such as the synthesis of insulin and interferon, an immune system regulator (“Academic Research and Big Business: A Delicate Balance”). Biotechnology companies quickly filled the financial void with millions of dollars of investments into prominent universities, such as Harvard, the Massachusetts Institute of Technology, and Washington University (“Academic Research and Big Business: A Delicate Balance”). However, these deals were made with the understanding that all commercially viable techniques and therapies resulting from research at these universities would be patented by the funding corporations.

Even then these policies had a chilling affect on biological research. In the early 1980s, a researcher at M.I.T. before a U.S. Congressional committee complained, “Individuals planning to profit personally from commercial development, by, for example, assigning patents to their own firms, tend to cut down communication with their colleagues” (Reinhold). In a 1983 Yale Symposium, Lawrence Crowley, Stanford University Hospital President, noted, “The motive force of industry is profit and the mode is secrecy and proprietary control of information. The motive force of the university is the pursuit of knowledge and the mode is open to an exchange of ideas and unrestricted publication. The question is whether these two worlds can be bridged . . .” (“Academic Research and Big Business: A Delicate Balance.) Even then this question was being answered. Robert Kennedy, then president of Stanford University and a former Food and Drug Commissioner, noted several occasions where a biologist would not disclose key techniques used in research during scientific symposia because said techniques were proprietary (Cohn).

In more recent years university/industry partnerships in biotechnology have only increased as a result of the amazing economic success of such partnerships for both industry and academia. Many have credited these varied and complex partnerships for the United States dominance of the global biotech sector leading in areas, such as R&D and revenues (Owen-Smith, et al; “Beyond Borders…2007”). However, at the same time funding for R&D in the United States has changed with corporate sources of funding now playing the leading role leaving research universities more dependent on non-government sources of funding (Washburn 66). In studies done by the Harvard Project, biotechnology faculty supported by industry funding were four times more likely to produce research “kept secret to protect proprietary value” (Streiffer). The Harvard Project in surveys of medical biotechnology companies in the 1990s reported that almost half had negotiated deals that required universities to withhold data and 25 percent required researchers to do the same (Streiffer).

Biotechnology in Europe developed in a dramatically different pattern due to both policy and legal differences. During the 1980s, while the United States began policies that enhanced industry/university contacts in biotechnology, European governments directly supported and financed their own biotechnology research (Chin and McDermott). Moreover, the organization of universities in Europe is much different than in the United States. European universities tend to be more centrally controlled with direct links to national governments (Owen-Smith et al). Also European universities are seen as institutions of pure knowledge advancement, as Paul van Grevenstein, a former president of the Association of European Science & Technology Transfer Professionals, noted, “European universities are more ivory tower than [universities] are

alleged to be in the US" (Blumenstyk). Combined these factors have led to an academic atmosphere where scientists and universities are far more concerned with the publication of research than the commercialization of research. However, this has slowly begun to change across Europe as more emphasis is now being placed on competing with the United States' biotechnology sector. Although Britain has taken an early lead with the support of technology transfer from universities to industry, nations in continental Europe have also recently begun to pass legislation similar in objective to the United States Bayh-Dole Act (Blumenstyk). Germany was the most recent nation to pass such legislation in 2002 leaving only a couple of nations in Western Europe without such legislation (Blumenstyk).

More recently European industry and universities have begun to draw up a system of guidelines to help universities form collaborations with industry, which model aspects of United States university/industry collaborations (Collins). A major aspect of the guidelines involves aiding universities in granting research rights to industry (Collins).

Beyond Europe, other regions have adopted technology transfer laws similar to the United States' Bayh-Dole Act in the attempt to create University/Industry partnerships. In 1999, Japan passed the Industrial Revitalization Law, known as the Japanese Bayh-Dole Act (Nurton and Barraclough). In 2001, India's Department of Science and Technology instituted reforms to allow for Universities to patent government funded research. Even Israel over the last five years has sought to enhance its technology transfer laws to more emulate the United States (Nurton and Barraclough).

Since the inception of modern biotechnology over 30 years ago, it has had a profound impact on how scientific research is done. In the United States with its strong emphasis on commercialization and its decentralized research system, the advent of biotechnology has led to an explosion of university/industry relationships. Although this has created a boon for the economic value of biotechnology in the United States, it has also led to system of ethical compromises which has damaged scientific communication and, arguably, scientific research. In many other nations, including South Korea and those of the European Union, such close contacts between industry and universities were not quickly created. Instead, governments took leading roles in the development of university research into biotechnology. This has created a competitive disadvantage in the economic value of their domestic biotech Industries, and as they attempt to catch up to the United States, some, such as South Korea, have yet to focus on the inherent ethical implications on science and society of blindly accelerating domestic biotech industries.

It is important to understand that biotechnology has become essential to both the global economy and to other varied fields including agriculture and medicine. Thus the future of biotechnology research depends not just on economic vitality but also the purity of scientific research. Governments, researchers, and society alike must begin to make commitments and regulations to prevent economic and political benefits from distorting the valuable science that created biotechnology and still creates its many benefits to society.

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