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Stealing from the past: globalisation, strategic formation and the use of indigenous intellectual property in the biotechnology industry

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ABSTRACT *Biotechnology has proven itself to be one of the most promising and volatile sectors in the world economy. From genetic engineering to the mapping of human cell lines, biotechnology is now a multibillion dollar venture. As a result the trade in biological specimens has increased, with researchers continually seeking new sources for specimens. The goal of our research is to explore two fundamental questions related to the biotechnology industry: (1) what has been the driving force behind the relatively recent explosive growth in the biotechnology industry; (2) what has been the impact on the developing world—which houses the natural resources that are the bases for many of these new biotechnology discoveries? We argue that globalisation has pushed governments, biotechnology firms and universities into strategic alliances that have unfairly included another partner in the creation of these new products: the developing world.*

Advances in modern biotechnology have provided researchers with tools that are now opening up new avenues for consumer products and medicinal treatments. But the advances made in this industry are still dependent upon natural resources as the major components in solving some of the puzzles scientists are exploring. Biological extracts and specimens provide the needed resources for research on products, therapies and procedures that could assist people in their everyday lives or in their battles against disease. At the same time the research is also a windfall for the biotechnology companies themselves, because the potential exists for new products and procedures to generate billions of dollars in corporate revenues. As a result the trade in biological specimens has increased, with researchers continually seeking new sources of specimens. The goal of our research is to explore two fundamental questions related to the biotechnology industry: (1) what has been the driving force behind the relatively recent explosive growth in the biotechnology industry? and (2) what has been the impact on the developing

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world—which houses the natural resources that are the bases for many of these new biotechnology discoveries. We argue that globalisation has pushed governments, biotechnology firms and universities into strategic alliances that have unfairly included another partner in the creation of these new products: the developing world.

While most of the technological developments in the biotechnology industry are centred within the developed world, most of the biological resources that are used in this research are located in the developing world. From the Congo basin to the Amazon jungle, from Madagascar's to Indonesia's rainforests, the practice of searching for the next big medicinal breakthrough has become commonplace among researchers. For many years, scientists have been sent to search the developing world in a process supporters call 'biodiversity prospecting'.[1] Raw materials are transformed through research and technological manipulation into medicines and other consumer products. However, critics call it 'biopiracy' and view it as just another example of how the developed world exploits the developing world.

Biotechnology has proven itself to be one of the most promising and volatile sectors in the world economy. From genetic engineering to the mapping of human cell lines, biotechnology is now a multibillion dollar venture.[2] The number of public biotechnology companies has doubled in the past decade, with sales rising from US$0.5 billion to $11 billion (Ho, 1998). Much of the material for this industry comes from resource-rich developing countries. Indeed, many scientists believe that the cures for maladies such as AIDS and cancer lie within these untapped ecosystems.

Once the resources are discovered in their raw form, they are collected and carried to the laboratories of the developed world where they are subjected to research for useful properties. If found, these properties form the basis of new patentable products and procedures. When pharmaceuticals or agricultural products do make it to market, companies often see a phenomenal return on their investment, but usually it is only the *companies* that see the profit while the community or country that is the source of the knowledge or the natural resources used in the new product is often left without any benefits from the discovery.

Theoretical premise

Traditional international relations theory has focused on state-actors and their conflict relationships (Waltz, 1979; Holsti, 1972; Morgenthau, 1967; Bull, 1995). In their seminal work on the changing nature of corporate–government relations, Stopford and Strange argued that international relations theorists must move beyond the unitary state explanation for international relations (Stopford *et al*, 1991; Strange, 1996). In part, structural changes in the world economy have led to a shift in international diplomacy: governments are forced to bargain, not only among themselves, but also with corporations, while corporations are forced to negotiate among themselves as well as with governments (Strange, 1996: 1). What this implies is that competition in the international system has changed fundamentally, forcing governments to place economic policy ahead of the tra-

ditional areas of foreign policy and diplomacy.

Strange argued that what has changed the nature of competition have been technological advances, capital mobility and improved transborder communications and transportation (Strange, 1996: 2–3). Competitive pressures are forcing governments to compete more actively for world market shares while trying to accommodate the needs of each other. Deregulation of the financial markets makes it easier to raise capital for investment in local ventures. Transportation and communication across borders decrease in cost, allowing for the easier establishment and maintenance of transnational ventures. Technological change has brought new capacity to producers to bring products to market faster. But on the downside, research costs have skyrocketed and product life cycles have dropped with the increase in technological capacity (Strange, 1996: 3–4).

As a result of the structural changes in the global economy, the nature of the relationship between companies and of that between states and companies has changed. The interests of companies and governments have converged, with both becoming allies in the global race for economic growth. Global corporations offer a source of technology, market access and capital, all of which states seek in propelling economic growth, while states provide territory and establish the 'rules of the game' by which companies may operate within that territory. Production, however, can be done in a number of different locations, so states compete to attract companies that can invest in productive capacities within their territories (Strange, 1996: 7). As a result, macroeconomic and industrial competitiveness policies have overtaken traditional state-security concerns in the foreign policy arena.

Companies have adapted to the new structural changes in the global economy. Each company brings special talents and productive capabilities to the negotiating table in an effort to forge new partnerships or alliances within their respective industries or across multiple industries (Strange, 1996: 7; Dicken, 1998: 227–228). Strategic collaborations are nothing new among firms, but what is important is that the collaborations have become central to many firms' global strategy. And, as Dicken points out, companies are not just forming dyadic alliances, they are forming networks of alliances (Dicken, 1998: 228). The theoretical construct established by Stopford and Strange concerning the structural changes in the world economy is paramount to understanding the impact of the biotechnology industry on the developing world.

The changing nature of the biotechnology industry

While the focus of international relations theory has been on the international system and state actors in the system, recent research has placed greater emphasis on the role of non-state actors in explaining international events. Globalisation has pushed scholarship away from unitary state actor explanations to more complex relationships that incorporate multiple levels of analyses and actors. In one view the current surge in production and investment in the industry can be attributed to the pace of technological evolution in the industry and the need for legal and bureaucratic institutions to maintain pace with those changes. Governments, industries and universities have subsequently played major roles in

the development of biotechnology, with the basic structural changes in the world economy forcing the three institutions into strategic alliances.

The biotechnology industry itself has its origins in the early 1970s, with universities being the primary engine for technological innovation in the field. However, the economic motivation for the biotechnology industry was provided in the 1980 US Supreme Court decision Diamond v Chakrabarty (*1980 447 US 303 447 US 303; 100 S Ct 2204 No 79–136*) and the implementation of Reagan administration policies that facilitated the transfer of technology between universities and the private sector.

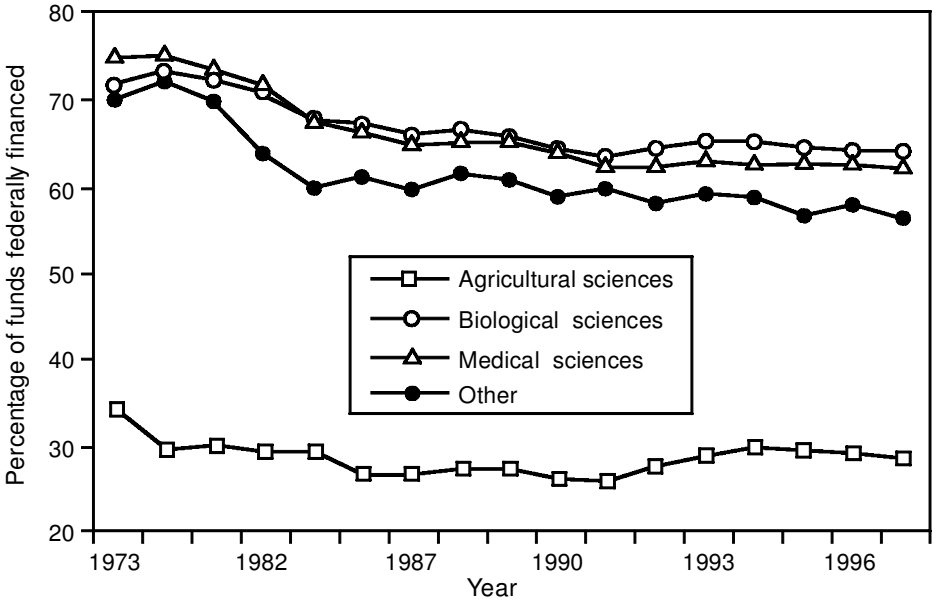
The Chakrabarty case concerned General Electric and an employee who was seeking a patent on a genetically altered bacterium that could digest oil. The US Supreme Court ruled in favour of General Electric's request for a patent. The court decided that life was patentable, stating that the 'relevant distinction was not between living and inanimate things, but between products of nature, whether living or not, and human-made inventions … [the] micro-organism is the result of human ingenuity and research' (Diamond v Chakrabarty *ibid*). The significance of the decision cannot be overstated—the court's action established the legal framework in the USA for the growth of the biotechnology industry during the 1980s and 1990s.[3] The fallout from the Chakrabarty decision penetrated investment circles in the USA and Europe. Leading transnational corporations invested in biotechnology research shortly after the court's decision. The biotechnology sector's potential for future profits propelled investors to commit billions of dollars to research.

Shortly after the Chakrabarty decision, the new Reagan administration established the Office of Productivity, Technology and Innovation (OPTI) in 1981, which advocated the use of research development and limited partnerships (RDLPS) between universities and the private sector (Krimsky, 1991: 33–34; Johnston & Edwards, 1987: 103–114). Referred to as the 'Marshall Plan for US Research and Development', the RDLPS at universities were designed as a means of generating non-federal research money, which allowed universities to diversify their funding base and to accelerate the transfer of federally funded technology to commercial use.

Diversification of funding became a primary concern for university administrators because of declining federal support for basic research. The end of the Vietnam War and the beginning of federal research money cuts made RDLPS even more important in the early 1980s. As Figure 1 shows, the percentage of federally financed academic research fell from the early to mid-1970s, and again in the early 1980s until it finally stabilised in the early 1990s. Reagan administration policies that changed the rules governing the transfer of technology funded by the federal government helped to alleviate the federal funding cuts to university research that the administration had also imposed. On the commercial side, the administration provided ample tax breaks to corporations that funded basic university research (Krimsky, 1991: 67–68). Both the RDLPS and the tax breaks were welcome news for biotechnology because it was the universities that possessed most of the technological knowledge in the industry.

Both the Chakrabarty decision and the Reagan administration's policy changes were directly responsible for the emergence of the modern biotechnology

FIGURE 1
Percentage of academic R&D funds federally financed, 1973–97.



Source: National Science Board, Science and Technology Indicators – 2000. Arlington VA: National Science Foundation, 2000 (NSB-00-01)

industry in the 1980s. During the period between 1982 and 1986 Wall Street investors funded the start-up of 54 biotechnology companies by selling $800 million in common stock to investors. Established firms across the various industries that constitute the biotechnology industry also benefited from Wall Street investments. In total roughly $3 billion was injected into the biotechnology industry over the five-year period (Kupor, 1991: 261–262). Investors perceived the biotechnology industry to be the future engine of growth in a number of industries, including the medical and pharmaceutical, agricultural and chemical industries, so the new biotechnology companies were under pressure to find new innovations and procedures that would pay off for investors.

The intensification of competition within the biotechnology industry coupled with accelerated advances in technological developments had consequences for both companies and universities. As genetic engineering and related technologies became more widely used, industries from varying sectors began to enter into strategic alliances, mergers and acquisitions. These strategic alliances provided companies with a way to collaborate in major research that would be difficult to undertake on their own. Between 1992 and 1997 the number of strategic alliances within the biotechnology industry increased from 32 to 325 (Ho, 1998). Overall, within the past 10 years there has been an increase of 400% in the number of deals associated with corporate strategic alliances, mergers and acquisitions (Oliver, 2000: 154).

The alliances often brought smaller biotechnology firms that were seeking revenue and market access in contact with larger firms which were seeking new products and technology (Sherblom, 1991: 216–217). While these types of collaborations were not new, what was new was that they became central to the global strategies of firms rather than fringe elements of them (Dicken, 1998: 228). Traditional boundaries among pharmaceutical, agricultural, food, chemical, cosmetic and energy sectors blurred or eroded in the face of increasing dependence on strategic alliances and mergers. Major corporations took advantage of complementary technologies to become dominant actors in many of these industrial sectors. The advent of strategic alliances and mergers allowed large firms to integrate existing technology into new products without the delays caused by the research process, while at the same time decreasing the turnaround time for the realisation of profits (US Congress Office of Technology Assessment (OTA), 1991: 54).

For example, many of the world's largest chemical corporations shifted from their conventional base to a stronger position in biotechnology related research and development fields (Kloppenburg, 1998; OTA, 1991). Monsanto Corporation closed more than 20 chemical-related businesses and acquired biotechnology firms G D Searle & Co ($2.7 billion), Delta & Pine Land Co ($1.9 billion) and Dekalb Genetics Corporation (60% stake for $2.3 billion) (OTA, 1991: 123; Monsanto acquisition faces extra antitrust scrutiny, Wall Street Journal, 1998: A8).

The alliances between universities and corporations produced at times, detrimental effects on universities and their researchers. In 1982 a Tufts University biotechnology study found that at major research universities not only was a large part of the faculty involved with the commercialisation of biotechnology research, but that researchers in the same department often worked for competitors within the industry. Research ethics and protocol were often compromised because of a decrease in peer reviews, which were limited under non-disclosure agreements between the researchers and the biotechnology firms that employed them (Krimsky, 1991: 74–78). The focus at universities shifted from the production of knowledge for the sake of knowledge to the production of skills and products for the sake of profits. This problem manifested itself as universities adopted corporate behaviour and attitudes towards possession of their research.

The agreements between universities and biotechnology firms also produced, at times, an unequal distribution of profits and royalties from the research, with the biotechnology firms reaping the lion's share (Oliver, 2000: 204). Many of the major universities developed in-house intellectual property monitoring for identifying patentable subject matter on campus. The universities' move towards protecting intellectual property was a reflection of corporate behaviour. This was particularly true when it came to the protection of a university's research results and the viability of those results in consumer markets.

In perhaps the best example of universities' corporate behaviour, in 2000 the University of Rochester announced that it had been awarded a broad patent covering the medical use of Cox-2 inhibitors, a new type of painkiller that is rapidly becoming the pharmaceutical industry's best-selling product. Officials at the university estimated that the patent could bring billions of dollars in royalties

over the life of the patent, making it the most lucrative patent ever held by a university. Upon receiving the news of the patent, the University of Rochester immediately filed a patent infringement lawsuit against Searle and Pfizer pharmaceutical firms, claiming that their drug, Celebrex, infringed on the patent granted to the university. While Celebrex is designed in a similar fashion to the University of Rochester's Cox-2 inhibitor, the company at the time did not know of the University of Rochester's pending patent. Today, Celebrex is used by over seven million people. In true corporate fashion, the point of the lawsuit is not to stop the distribution of Celebrex; rather, the lawsuit is designed to provide compensation to the University of Rochester for royalties from the sale of the drug (Pollack, 2000).

What the Celebrex case at the University of Rochester demonstrates is the enormous funding potential that successful research can bring to a university. Therefore, universities and corporations have an incentive to co-operate at some level because both have similar goals: for the corporation the goal is higher profits and for the university it is higher funding levels. Domestically, these goals are powerful forces, but when both corporations and universities confront globalised competitive forces, the aspirations and pressures to achieve these goals are magnified. Universities in this sense are faced with the same pressures as corporations in the global marketplace.

For the most part universities have always been international institutions. However, there is a difference between the university as an international institution and the university as a *globalised* institution (Currie, 1998: 16–18). Universities have been international in that they have always sought out faculty and students from around the world. The globalised university, on the other hand, is faced with market competition similar to that faced by corporations. In a competitive environment for funding opportunities, universities must compete not just domestically, but internationally, for funds. Research funding agencies are rarely concerned with the pursuit of knowledge for the sake of knowledge. They seek a payoff for their investment. Universities thus are not only faced with competition for funding, they are also drawn into competitive consumer markets where they must prove market viability for their research. This is a globalised institution, faced with both domestic and international competition.

Global competition, in this sense, forces corporations and universities to maintain a closer relationship in both the research process and the exploitation of that research in subsequent marketing. But the research process itself has become more complicated. As nations collectively move up the technological evolutionary scale, discoveries of new, viable products are few and far between. Corporations and universities must find new sources of products and the knowledge to create them. Thus, both have become involved in a process that could best be described as 'going back to the future', the reconsideration of traditional knowledge—particularly that of indigenous groups in the developing world—and updating it for modern use and applications.

Biotechnology and global bio-prospecting: the new gold rush

No longer is the traditional knowledge of indigenous people of the developing

world considered the ramblings of pseudo-science. Instead, universities and corporations see indigenous intellectual property as a fountain of potential research for consumer products. The change in Western research bias is a result of the increase in evaluative technology, which allows for a more detailed examination of traditional methods. Thus the contributions and lessons of indigenous and traditional approaches are now under reconsideration. The 'shaman' is no longer a 'crazed witch doctor' but someone who possesses knowledge of interest to corporations.

Corporations and universities have engaged in a massive effort to find new products through traditional knowledge in the developing world. While normally this would not be a problem in terms of simple research, the issues become murkier when the economics of the appropriation of indigenous intellectual property are considered. Often researchers 'discover' existing products or 'new' uses of them that have been in indigenous communities for centuries. They are then able to obtain patents for these products, which gives them exclusive rights over the products or procedure. As companies patent their products in multiple countries, the potential exists one day for indigenous groups to be prohibited from using their own cultural heritage and knowledge. The appropriation of scientific and technical knowledge, products and the genetic characteristics of indigenous peoples has become both notorious and contested, forming the heart of the current debate on biological diversity, indigenous rights and genetic resources.

With the introduction of life patents and the increasing consolidation of the biotechnology industry, it became necessary for firms to procure a source of new genetic materials to derive profitable products. Competition within the industry has focused on the procurement of these resources, which leads directly to 'bioprospecting' or 'biopiracy'.

Hence, questions relating to the ownership of these refined products have developed, with corporations and universities claiming patent rights to the products without any acknowledgement of their origins. In other cases, corporations and universities have introduced research to affect market relations between developed and developing countries directly. Biotechnology research has accentuated the unequal relationship between developed and developing countries. The unequal relationship manifests itself in three areas: exploitation of natural resources and human resources, and the use of biotechnology to alter market structures and conditions. Natural resources and human resources research are extractive processes by their nature; biotechnology research that targets market structures explicitly or implicitly seeks either to affect competition in a product market or consumers' spending behaviour in that market.

Natural resources

The renaissance of natural product screening and the recognition of the value of indigenous knowledge is fuelled, in part, by the realisation that species, their genetic material and the ecosystems of which they are a part are rapidly disappearing from the face of the earth. Scientists estimate that 1.75 million species have been identified, but there may be as many as 13 million species, with some

estimates ranging as high as 100 million (Convention on Biological Diversity, 2001). Deforestation, which threatens to destroy many species, has hastened corporations' screening, appropriation and patenting processes.

Historically, plants were used as a source of medicinal products. In recent times, well organised and funded plant collectors have ventured into the tropical forests in search of valuable genetic material for agricultural plant breeding. In the process of collecting the plant samples, the collectors learn of local knowledge of special plants and their traditional uses among the indigenous people. However, when commercial products are developed from this knowledge or from the indigenous natural resources, little, if any, of the profits go to the indigenous community.

In recent years, medicinal plants have yielded large profits for multinational biotechnology firms. A few examples illustrate this point. Researchers discovered that the rosy periwinkle plant, found in its highest quality in Madagascar, contains properties that combat certain types of cancer. Eli Lily derived two drugs from the rosy periwinkle: vinblastine, used in the treatment of Hodgkins' disease, and vincristine, used in the treatment of leukaemia (WRI, 2001; Hunter, 1997). Sales of the two drugs have exceeded $100 million with none of the money destined for Madagascar.

Several corporations, including W R Grace, have been granted more than 50 US patents on the neem tree of India and on the indigenous knowledge of its many uses, which include medicine, toiletries, contraception, fuel, insecticide and livestock feed (Shiva & Holla-Bhar, 1996; Marden, 1999). What makes the case of the neem tree noteworthy is that Indian society had known about its numerous uses for many generations. Indian scientists, in letters to the US Patent and Trademark Office, argued that Indian researchers and companies were using the neem tree in these ways well before W R Grace came to India. Indian researchers never sought a patent on these products and processes because the knowledge was the result of indigenous research and development that had evolved over centuries.[4]

While sugar was a driving force in the appropriation of labour from Africa in the form of slavery centuries ago, today sugar has been the driving force for the appropriation of capital from Africa in the form of sugar substitutes. While the Western world's acquisition of the sweet tooth helped drive the slave trade, it also perpetuated the acquisition of several inches to the waistline of Westerners as well. For years, the search for sugar substitutes has yielded few results except artificial sweeteners. However, the University of California and Lucky Biotech Corporation of Japan have been granted patents for the sweetening proteins of two African plants, katempfe and the serendipity berry (Roht-Arriaza, 1996: 923). The plants have been used for centuries by African peoples for their sweetening properties. The active ingredient in katempfe, a compound called thaumatin, is about 2000 times sweeter than sugar, making it the sweetest substance on the face of the earth, yet it is also calorie-free. The value of thaumatin and its further development in consumer products is expected to be worth at least $900 million a year (Odek, 1994; RAFI, 1997).

Human resources

Relying on the Chakrabarty decision, over the past decade the US Patent Office has allowed patents on human genes, cells and cell lines. The lure of patent profits has led a growing number of international gene-hunters on a quest for potentially profitable genetic material from indigenous peoples of the developing world. For example, in 1989 researchers filed a patent claim on the cell line of 24 Hagahai people in Papua, New Guinea. A cell line developed from the Hagahai may prove to be valuable in diagnosing adult leukaemia and related diseases.[5]

In the late 1960s and early 1970s US and European drug companies recognised the commercial viability of blood. Originally, most blood was bought from students on college campuses, incarcerated people, or homeless people in the USA. But as demand outstripped supply, it became necessary for the pharmaceutical industry to seek alternative supplies overseas. The industry collaborated with 'blood boutiques' to establish facilities in the most impoverished areas of Nicaragua, Haiti, Mexico, Colombia and southern Africa. Impoverished families sold their blood to middlemen who, in turn, shipped it to pharmaceutical laboratories in the USA. Popular press reports and a campaign by governments of affected people in conjunction with the International Red Cross eventually led to a 1975 World Health Organisation resolution that curtailed the blood trade (Starr, 1998; Kimbrell, 1996).

Human-based biotechnology has become more important with the acquisition of knowledge about human genes. The Human Genome Project, begun in 1990, is a planned 15-year international co-operative effort to first map and then sequence all three billion base pairs of the human genetic code. With the preliminary sequence for the human genome recently published (Celera, 2001), attention is increasingly focusing on genetics and the potential benefits from genetic research. While advances have been made in the link between human genetics and disease, the research can be viewed as an example of human genetic harvesting.

Most of the target population in the human genome project comprises Europeans or North Americans of European descent, largely because these are the regions in which the research has been done. If, however, a researcher is trying to find a rare gene variant—say a variant that causes a particular disease—the researcher will look for it among people who have a high rate of that disease in their population. Usually, that has meant family studies; in some situations it may mean studies of discrete cultural groups, including indigenous people. For example, much work has been done in looking for a genetic link to non-insulin-dependent diabetes with the Pima Indians of Arizona—a group that suffers disproportionately from this disease (Khan, 1999). As a result of this type of genetic harvesting, several thousand human genes, proteins and cell lines have been patented.

Market structures

For our purposes we have categorised the third type of research as market conditions. In this type of research, the researcher's goal is to change conditions

on the supply or demand side of a particular consumer market. This type of research has become important in the agricultural industry. A few examples again will illustrate the nature of this research.

In 1998 the Delta and Pine Land Company and the US Department of Agriculture received the first patent for a method of creating transgenic plants that contain a gene which can be controlled by application of a substance external to the plant, something that later became known pejoratively as 'terminator' technology. The terminator technology and the issues surrounding it have gained widespread public attention, as have Monsanto (which acquired Delta and Pine) and its competitors, who have rushed to develop their own versions of terminator technology.[6] Through genetic engineering, plants grow until the state before germination (maturity of the reproductive organs). At this point plant development ceases until it is exposed to a special releasing chemical manufactured and provided by the company. As this feature is a genetic component of the plants, it is passed on to future generations.

The purpose of this technique is to prevent farmers from planting second generation seeds from genetically engineered plants, thus protecting the intellectual property rights of seed producers. However, critics have charged that the terminator technology is directed at controlling world agricultural markets. As Ewens (2000) has noted, the technology has significant implications for the security of global food supplies. For smaller farmers, the technology poses major problems that could have greater impact in the developing world than in the developed world. Additional costs are encountered to purchase the activation chemical. Genetic technology designed to prevent farmers from saving seeds for future planting also threatens subsistence farmers and the livelihood of small farmers in the developing world.

In another example affecting market conditions, farmers are troubled at the harm caused to their crops by insects and the toxic pesticides they employ to eliminate them from their farms. Recently, another biotechnology advance has offered an alternative methods of crop safety. The University of Texas was awarded a patent for its invention of the GRIM gene (Chen *et al*, 1996; RAFI, 1998). A lethal gene called GRIM is inserted into a controlled insect population, which is then allowed to mate with wild members of the population. As a result, the next generation of offspring all carry the GRIM gene into their genome. When the gene is entrenched in the species population, scientists can then expose the group to a chemical and induce apoptosis (a programmed cell death) in the organisms. Activating the gene induces a cellular breakdown which destroys all organisms carrying the gene (Chen *et al*, 1996; RAFI, 1998).

Despite what may seem to be benefits, several important questions remain about the long-term impact of the GRIM technology. Can the gene be spread to other species? What environmental impact will there be from exterminating any species from a given region? Until additional research is done in these areas, the uncontrolled introduction of GRIM technology could pose a threat to biodiversity which will affect areas of the developing world disproportionately.

Conclusions

The process of globalisation has brought with it the need for technological advancement in order to maintain corporations' market share, or for them to become more competitive within markets. In this sense, Stopford and Strange are correct when they expand the analysis of international relations beyond the unitary state actor. The biotechnology industry is an example of how industries have taken on a greater role in the international system and the impact that such a role can have in the developing world.

The formation of strategic alliances between governments and corporations has produced unequal benefits for the developed and the developing world, with corporations extracting natural and human resources while returning little of their profits to the source community. They have also gone beyond mere resource extraction by seeking new ways to manipulate supply and demand processes in developing countries' markets. With advances in genetic engineering, corporations are developing ways to enhance their profits and their market share in nations that are disproportionately dependent upon the agricultural sector for their income.

The impact of strategic alliances involving governments, corporations and universities in the biotechnology sector has promoted a lopsided relationship between the developed world and the developing world. In particular, the alliances have promoted a greater decline in the sovereignty that governments of developing countries have over their own resources. The loss in sovereignty has occurred in two areas: natural and human (genetic) resources, and market structures.

By appropriating indigenous natural resources and genetic resources, the new strategic alliances potentially deprive governments of the ability to determine the appropriate use of those resources. At the same time, by allowing the extraction of indigenous resources and practices, developing countries are, in the long run, deprived of potential markets for those products. When corporations patent resources and products, they effectively block indigenous people from utilising their own resources and inventions. The economic impact can be significant. In one way 'new' products and inventions developed with indigenous resources and inventions create a loss for that country in terms of potential sources of income. Concurrently, as corporations profit from these 'new' products, the indigenous people responsible for their discovery are usually left out of the profit distribution. In essence, their resources, their knowledge and their heritage have been taken and sold to the first researcher at the patent office, without compensation and, in many cases, without consent of the indigenous people. The abuse has run from natural resources, to the very essence of human beings—their genetic make-up.

But the increasing inequality does not stop with the extraction of natural and human resources. New biotechnology research, developed by those within the strategic alliances, allows companies to control the supply and demand of products in critical markets such as food. The introduction of 'terminator' technology provides ample opportunity for corporations to monopolise agricultural production in developing countries, limiting economic independence and

promoting technological dependence. Overall, the end result has been a perpetuation of the inequitable nature of the relationship between developed and developing countries through strategic alliances in the new global economy.

Notes

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[1] Biodiversity prospecting refers specifically to the exploration of wild species, genes and their products with the goal of producing commercially valuable genetic and biochemical resources (Reid *et al*, 1993: 1; Sittenfeld & Gamez, 1993: 69).

[2] Biotechnology is the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services (Bud, 1993: 1).

[3] In 1997 the biotechnology industry also played a major role in lobbying to harmonise Europe's various life patent statutes in line with the broad patents given to life forms in the USA.

[4] In May 2000 the European Patent Office rejected a W R Grace patent on the fungicidal properties of the neem tree after objections were raised by the Green Group in the European Parliament. The office held that the techniques covered in the patent were well known to indigenous farmers and lacked any inventive steps that would warrant a patent (European Patent Office rejects neem tree patent, 2000).

[5] The case of the Hagahai people is most controversial. The Papua New Guinea Institute of Medical Research (IMR), collaborators at the National Institute of Health (NIH), and the primary researcher, medical anthropologist Carol Jenkins, have denied the charges by the Rural Advancement Foundation International (RAFI) of unethical behaviour in the use of the Hagahai's genetic resources. See Taubes (1995) and RAFI (1996) for specific information on the controversy.

[6] To date, 14 patents or pending patents related to the terminator concept exist: six owned by Syngenta (a newly created company emerging from the merger of Novartis and AstroZeneca), four owned by Monsanto, three by universities (Iowa State University, Cornell University and Purdue University), and one owned by DuPont (RAFI, 2001).

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