

# An Empirical Study of Bioprospecting: Ethical Issues in Conflict

Jennifer M. Jolly\*, Stephen L. Baglione\*\* and Thomas Zimmerer\*\*\*

*This study investigated the ethical issues which arise when significant conflicts exist among critical stakeholders involved in the collection of potentially lifesaving biodiverse resources. The research instrument was completed by 95 graduate students enrolled in a Masters of Science in Entrepreneurship program who had taken a course in intellectual property. Issues scored highest by the respondents were a belief that naturally occurring plants belong to all of the Earth's people and that the pharmaceutical firms should seek international agreements regarding the ownership of all intellectual properties which derive from the commercialization of indigenous plants. Additionally, the respondents recognized the disproportional investment that was being made in the lengthy and extremely expensive process required to synthesize the potentially valuable components of the plant and the commercialization of the final drug by the pharmaceutical firms.*

## 1. Introduction

This paper gains highly-educated respondents' input on a little known or discussed component of the health care debate: bioprospecting. In a world where illness and disease remains a challenge, these ethical issues arising from conflicts over cultural, legal, and economic issues must be resolved for the ultimate benefit of all stakeholders. At a deep philosophical level, do the plants of the planet belong to the people of the world or only to the inhabitants of the geographic region where they grow? If the world has an illness or disease that science might be able to cure if it had access to the genetic material of these plants, are barriers to this research justifiable? Should the general welfare of everyone trump the possible rights of a few? The paper is organized as follows: introduction, literature review examines bioprospecting, conflict inherent in it, and stakeholder goals; methods examines data collection; results include respondent demographics and attitudes; conclusion examines the implications of the study; and the last sections are limitations and future research.

## 2. Literature Review

Bioprospecting is the search for natural plants which, when scientifically synthesized, can produce drugs and health supplements that may prove to be effective in curing illnesses or diseases. It "covers a wide range of commercial activities that have

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\*Jennifer M. Jolly, University of South Florida, United States of America

\*\*Dr. Stephen L. Baglione, Saint Leo University, United States of America, Email: [stephen.baglione@saintleo.edu](mailto:stephen.baglione@saintleo.edu)

\*\*\*Dr. Thomas Zimmerer, University of South Florida, United States of America

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applications in different industrial sectors, including pharmaceuticals, food and beverage, biotechnology, seed, crop protection, horticulture, botanical medicines and cosmetics and personal care” (Afreen and Abraham, 2009, p. 123). “The possibility of future drugs based on traditional plant remedies is in large part rooted in historical examples—aspirin, antibiotics, and quinine being only a few of the more common” (Greene, 2004, p. 213). Current estimates for industry size range from \$17.5 million to \$30 million, but are expected to grow to \$500 million by 2050. Bioprospecting results in sales of \$3 billion in cosmetic and personal care, \$20 billion for botanical medicines, and \$75 billion for the pharmaceutical industry (Bishop et al., 2008). “Bioprospecting is primarily a high-technology, laboratory-based activity” (Kursar et al., 2006, p. 1007). “It is estimated that over 25% of the drugs sold in the developed world and 75% in the less developed countries are based on chemicals made by organism” (Firn, 2007, p. 207). The U.S. National Cancer Institute found only 1 percent of the 18,000 screened organisms had positive activity for anticancer (Firn, 2007). Through generations, the indigenous peoples have distilled what plants work for medicinal purposes. It is this knowledge that pharmaceutical companies will pay for.

### 2.1 Sources of Conflict

The sources of conflict between individuals, businesses, and governments are inevitably heightened when significant unresolved issues combine historic exploitation, global health, international intellectual property rights, profit, and governmental desire for increasing tax revenues. The global need for technologically advanced nations to provide effective drugs and health supplements to address the diseases and illnesses that afflict our growing populations is increasing exponentially. Health care is a “front burner” issue globally. The people of the developed nations seem to believe that science and technology can cure illnesses and diseases. These assumptions are based on the breakthroughs that the world has witnessed over the past decades. Many of the “miracle” drugs were initially derived from plants which were discovered to possess healing properties.

It is well documented that the knowledge of the region’s indigenous people is valuable in the identification of plants which have served to heal tribal members. In terms of a business concept, would this indigenous population be entitled to what might be described as a “find’s fee”? In times past the developed nations simply took what they wanted with absolutely no regard to the rights of the region’s indigenous people. The most aggravating issue in this dilemma is the historic scars remaining from European colonization. These scars run very deep and their cause will likely never be forgotten. To better grasp the treatment of the indigenous people by the occupying Europeans, we recommend that you read Joseph Conrad’s book “Heart of Darkness,” which details his observations of the moral degradation that marred the Dutch ivory trade at the turn of the 20<sup>th</sup> century. “The conquest of the earth, which mostly means taking it away from those who have a different complexion or slightly flatter noses than ourselves, is not a pretty thing when you look at it too much” (Conrad, 2000). Conrad personally witnessed the murderous results that greed and conquest produced in the Congo. The quest for riches and tribal subjugation led to genocide and unprecedented environmental damage.

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Conrad's story serves to clarify the historic basis for distrust by Africans. Bioprospecting is viewed by some as the 21<sup>st</sup>'s century re-colonization. Africans want to influence the decisions regarding the ownership of the genetic resources and the creation of a benefit-sharing model that will address their concerns. Yet, what is equally interesting is that tribal culture does not recognize individual ownership rights. Tribal culture is based on equitable sharing among all members. A final source of conflict for indigenous people is themselves. "The creation of unrealistic expectations about the market value of traditional knowledge, cultural property, and incorporated identities will continue to sow discontent not only between indigenous groups and various agents of development and modernity but between the indigenous constituency and its brokering leadership" (Greene, 2004, p. 224).

The people and environs of biodiverse regions still exhibit the damage caused by the rampant abuses perpetrated by multi-national trading companies that focused on increased efficiency and profit over humanitarian endeavors or sustainability of harvesting plant, animal, and mineral resources. Protecting limited resources and dwindling indigenous culture is the object of bioprospecting legislation, although in practice the resulting failure to account for the complexity of the technology commercialization process could create undue burdens on bioprospectors. It must be noted that in South Africa recent policy changes have created nearly 20 additional legal steps for bioprospectors (Crouch et al., 2008).

The next stakeholder is the pharmaceutical firms of the developed nations who have the research capability to investigate the genetic material in search of potentially valuable drug and health supplements (Crouch et al., 2008). De George (2005) argues they have an obligation to develop lifesaving drugs and make them available. These businesses must evaluate the bioprospecting activities from a cost/benefit basis. Many Europeans and Americans cling to the antiquated vision of Africa "that imagines indigenous peoples as forever teetering on the brink of cultural collapse and demographic destruction" (Greene, 2004, p. 211). These European and American executives are keenly aware that less than 1 percent of the plants harvested through bioprospecting ever result in a financially viable drug or health supplement. A recent study by Suresh et al. (2006) of Purdue University concluded: there is only minimal governmental financial support for basic research in these areas, and the cost of new drug development now ranges from \$800 million to \$1.7 billion per drug. In a separate study, DiMasi and Grabowski (2007) found "out-of-pocket (cash outlay) cost estimates of \$198 million, \$361 million, and \$559 million per approved new biopharmaceutical for the preclinical period, the clinical period, and in total respectively (in 2005 dollars). These figures include the costs of compound failures. Adding time costs to cash outlays, we found cost estimates of \$615 million, \$626 million, and \$1241 million per approved new biopharmaceutical for the preclinical period, the clinical period, and in total, respectively (in 2005 dollars)" (p. 477). The time from initial plant harvesting through research, testing, and market entry now exceeds 10 years.

The final party to this conflict is the African nations. They believe that the pharmaceutical companies of the developed countries need to pay ever increasing "up-

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front” fees for the right to prospect for new genetic resources which are unique to their countries, as well as contribute to what they believe is a significant percentage of any profits from drugs or health supplements to the “benefit-sharing” formula. These national leaders feel that they own the resources and that without permission to search for valuable plants the efforts to obtain them is biopiracy. The firms of the developed nations view these requests as extortion because governmental leaders fail to understand or recognize the total cost and risk involved in the entire developmental process. Increased “up-front” costs in the form of new taxes or fees negatively impacts the increasingly delicate “cost-benefit” analysis.

Many of the early writers in this discipline expressed opinions which seemed, on the surface, to be one-sided and judgmental. Shiva stated that “bioprospecting is merely a sophisticated form of biopiracy” (Shiva, 2007, p. 308). The heightened rhetoric and associated accusations of greed taking precedent over fairness has “stirred the pot,” but they have not contributed to conflict resolution.

### **2.2 Intellectual Property Rights: Two Different Viewpoints**

Bioprospecting is a phrase that denotes commercial interest in the potential profitability of resources found in biodiverse regions. The term, first coined by Walter V. Reid (Reid et al., 1993) “was created in response to the problematic relationship between global commercial interests, the biological resources, and indigenous knowledge of local communities—and to the epidemic of biopiracy, the patenting of indigenous knowledge related to biodiversity” (Shiva, 2007, p. 307). Critics contend that bioprospecting activities ultimately lead to greater poverty for indigenous people. They claim the protected intellectual property rights gleaned from native traditions create “monopolies on resources and knowledge that previously enabled communities to meet their health and nutrition needs” (Shiva, 2007, p. 308) and essentially force these communities to pay for local resources as commoditized property. Indigenous cultures are typically communal-based, meaning the knowledge, resources, and land are all shared in an equitable manner that ensures tribal members receives enough resources to survive without any one person or group holding dominant ownership rights.

Industrialized nations have evolved a completely different view: risks and rewards in commercial activity, innovation, and due diligence is rewarded with time-limited, exclusive rights to intellectual property developments. Patents, trademarks, copyrights, trade secrets, and other forms of intellectual property rights (IPR) protection are the basis of modern, innovation-based industries and financial economies. Indigenous cultures typically share knowledge and benefits within the collective and, thus, any protections created for IPR are viewed as selfish, even morally corrupt. The sentiment that “the technologically-rich developed world must transfer technology and share benefits from biodiversity commercialization is echoed in the current political atmosphere” (Wynberg and Laird, 2007, p. 23). Many newly-formed legislative bodies feel justified in creating hindrances and barriers to industry in the form of unclear legal definitions and complex bureaucratic time-consuming regulations, even when these restrictions ultimately restrain innovation and jeopardize the search for new valuable

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cures to illness and disease. The disparity between benefits gained from commercializing natural compounds and the past history of exploitation exhibited by multi-national corporations has led to stricter, evolving legislation aimed at mitigating damage to cultural institutions.

### **2.3 South Africa Case: Hoodia and the San**

South Africa is considered to be a mega-diverse country in terms of flora and fauna. The Cape Floristic Region (CFR) is the “one of the six most significant concentrations of plant diversity in the world, being the smallest but most diverse floristic kingdom known” with nearly 20,000 documented plant species (Crouch et al., 2008, p. 355). The potential for new products and beneficial compounds from South Africa is a beacon to bioprospectors, but there are a number of problems for industries seeking novel ingredients. The complex commercialization process already creates uncertainty for investors. “Uncertainty can be found in market variables, government regulations, legal battles, clinical hurdles, industry standards, and financial pitfalls” (Dorf and Byers, 2008, p.135). These complexities and uncertainties are compounded by legislative rules intended to preserve indigenous cultures, protect the environment, and make corporations accountable for sharing commercial benefits derived from the region.

An often-cited example of biopiracy occurred in South Africa, after the dietary benefit of Hoodia derivatives was successfully introduced to the consumer mass market. Colonial botanists noted that the San people had utilized the Hoodia plant for generations to suppress appetite during famine. In 1995, the South African Council for Scientific and Industrial Research (CSIR) concluded nine years of research and successfully isolated the natural compound in Hoodia responsible for appetite suppression. The South African group applied for relevant patent protection and signed a license agreement three years later with a company called Phytopharm in conjunction with Pfizer to commercialize the resulting purified products (Millum, 2010). The San (Bushmen) people were not involved in the agreements to commercialize products related to Hoodia, but due to pressure, CSIR entered negotiations with the San to divide subsequent profits equitably. Currently, industry players must properly identify, disclose research intentions, and partner with stakeholders on proposed intellectual properties from natural compounds prior to embarking on technology commercialization. Based on this important case, the issue of access-benefit sharing is receiving international attention (Millum, 2010).

### **3. Research Objective**

This survey is designed to gain respondents’ input on a little known or discussed component of the health care debate: bioprospecting. Many of today’s commonly used drugs have their origins in compounds derived from flora and fauna growing naturally. Pharmaceutical firms have developed new drugs based on plant species through the utilization of genetic material derived from indigenous plants. The search for plants which might have potential to become a safe and effective medicine is termed bioprospecting. This survey focused on international intellectual property issues

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involving the ownership of indigenous plants and compensation and equitable distribution of profits and bioprospecting. Pharmaceutical firms have been involved in bioprospecting for years to develop drugs that are proven effective and safe for treating illness and disease. The following facts were provided to the respondents to assist in answering survey questions:

- i) Less than 1 percent of the plants tested ever prove to have pharmaceutical value;
- ii) The cost per drug approval is \$802 million (Adams and Brantner, 2006);
- iii) The time from research to market now exceeds, on average, 10 years (synthesized and purified prior to undertaking the multistage testing required for approval by the U.S. Food and Drug Administration or FDA); and
- iv) Governments of developing countries do not have a record of directing fees earned from international firms to their indigenous people, although it is the indigenous people's knowledge that contributes to successful bioprospecting.

### 4. Methods

The survey to assess perceptions about bioprospecting was developed through a literature review, multiple iterations among colleagues at two U.S. colleges, and a pre-test using a protocol analysis with four faculty and two MBA students. It was administered at a southeastern public university to MBA students. Students completed the survey through paper and pencil.

The data were analyzed in SPSS Version 20. Data were recorded by one person and reviewed for mistakes by another. Frequencies were then examined to ensure no data were outside the range of feasible answers. Individual questions were tested against the scale midpoint of four in a one-sample t-test (seven-point scale). Questions were tested at the .05 and .10 levels. An independent-samples t-test was used when comparing across groups, again at the .05 and .10 levels. Pairwise deletion was used (i.e., deleted by individual by question). Since this is exploratory research, no hypotheses were created.

### 5. Results

The survey instrument was completed by 95 Masters of Science in Entrepreneurship students. These students have the world and educational experience to understand this complex issue. No surveys were unusable because of incomplete data, and no question had more than three omitted responses. Respondents were mostly males (58%) who majored in business as undergraduates (56%) (Table 1). More than half are single (53%) without children (86%). Almost three quarters work full-time with the median income and age between \$40,000 and \$49,999 and 25 to 26, respectively.

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**Table 1: Demographics (n=95)**

<i>Gender</i>					
Male	58% <sup>1</sup>	Female	42%		
<i>Major Business</i>					
Business	56%	Non-business	44%		
<i>Marital Status</i>					
Married	31%	Single	53%	Divorced	3%
Long-term committed		13%			
<i>Parent</i>					
Yes	14%	No	86%		
<i>Employed</i>					
Yes	74%	No	26%		
<i>Income</i>					
Under \$20k	19%	\$20k-\$29.9k	13%	\$30k-\$39.9k	8%
\$40k-\$49.9k	16%	\$50k-\$59.9k	7%	\$60k-\$69.9k	3%
\$70k-\$79.9k	7%	\$80k-\$89.9k	6%	\$90k-\$99.9k	3%
\$100k-\$250k	17%	Above \$250k	1%		

<sup>1</sup> Because of rounding error, totals may not sum to 100%.

According to respondents, naturally-occurring plants belong to all the Earth's people (Q1); however, this does not mean that biopiracy does not exist (Table 2). Respondents are neutral on whether "biopiracy cannot exist since exploiting resources no one owns is not a crime" (Q4). Respondents are neutral on whether indigenous people have stewardship duty to protect the plants from financial exploitation from pharmaceutical firms in developed nations (Q8).

It is unethical, according to respondents, to create barriers to the discovery of medicines that have the potential to cure diseases or prevent illness (Q7), and are neutral on whether firms that practice biopiracy and exploit native knowledge should be prosecuted if their research leads to products that improve the world's population health (Q10) or whether biopiracy is a crime (Q19).

The medicinal benefits of plants are identified by indigenous people (Q2) and made available through the technology of pharmaceutical firms in developed nations (Q3). For these substantial financial investments, pharmaceutical companies are entitled to the majority of net profits earned from these plants (Q5). When developing governments create extensive, costly, and time-consuming regulation and approval barriers, pharmaceutical companies will not produce the drugs (Q11). Expensive bioprospecting fees result in biopiracy (Q20). Respondents were neutral about

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whether a pharmaceutical company's CEO should pursue a bioprospecting agreement if fees increased from \$30,000 to \$500,000 ( $t(91)=-1.44$ ,  $p<.154$ ,  $M=2.85$ ).

Indigenous people are also entitled to a large percentage of net profits (Q6), although not a majority, and should be given part ownership in any patent or intellectual property that arises (Q14). Respondents believe that pharmaceutical firms should receive, on average, 59 percent of net profits. Indigenous people and developing governments split the remainder (23% and 19%, respectively). Pharmaceutical firms should ensure that indigenous people receive something when the indigenous people's government receives fees/taxes from the pharmaceutical firms (Q13). However, respondents were neutral on whether indigenous people and their government should receive limited monetary compensation from the pharmaceutical firms for plants when they lack the skills and resources to develop natural compounds into final, value-creating products (Q15).

Legal issues were more vexing for respondents. They were neutral about whether indigenous people have little rights to the region's plants because property rights by a collective are rare (Q9), that plants belong to the indigenous people where the plant grows, regardless of a lack of specific laws regarding property rights (Q12), and that intellectual property rights should be owned and protected only by the pharmaceutical firms of developed nations to avoid unlawful exploitation (biopiracy) because developed countries have superior capabilities to enforce property right (Q21). International agreements should be sought regarding bioprospecting fees (Q16), ownership of intellectual properties which derive from commercialization of indigenous plants (Q17), and maximum limit on revenues indigenous people can earn from bioprospecting (Q18). Regardless of the side negotiating (leader of a developing country or CEO of a pharmaceutical company), each should offer 25 percent of net profits as an initial fee to undertake bioprospecting. They differ on how much should be paid by pharmaceutical companies to begin bioprospecting: developing countries should request \$38 million and pharmaceutical companies should offer \$21 million. When protecting a drug with potential revenue of \$100 million against a competitor located in a country with historically weak recognition of intellectual property rights, respondents would spend, on average, about \$15 million to protect their rights.



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**Table 2: Independent-Samples T-Tests**

<i>Questions</i>	<i>mean (t-stat.)</i>	<i>p- value</i>
1) Naturally-occurring plants belong to all the Earth's people.	5.47 (8.18)	.000
2) Without the knowledge of the region's indigenous people (local inhabitants), the medicinal benefits of plants would have never been identified.	5.08 (6.68)	.000
3) Without the knowledge and technology provided by pharmaceutical firms in developed nations (e.g., North America, Western Europe, Australia, and Japan), the benefits of these plants would not be made available to anyone outside that area.	4.86 (5.44)	.000
4) The plants that grow naturally on the Earth belong to all the Earth's people, so "biopiracy" cannot exist since exploiting resources no one owns is not a crime.	3.89 (-0.59)	.560
5) The high cost of all the research needed to synthesize the critical plant components, complete all required FDA testing, and finally, produce a commercialized drug or nutritional supplement entitles the pharmaceutical firms the majority (50% or more) of the net profits earned.	4.82 (5.10)	.000
6) Indigenous peoples of developing nations are entitled to a large percentage of the net profits (25% to 50%) that result from successfully commercializing drugs or nutritional supplements from the traditional knowledge base developed over generations.	4.29 (1.81)	.073
7) The Cape Floristic Region (South Africa) is "the most diverse floristic kingdom known" with more than 20,000 documented plant species. It would be unethical to create barriers to the discovery of potential medicines that have the potential to cure diseases or prevent illness.	5.06 (7.08)	.000
8) Indigenous people have a stewardship duty to protect the plants from financial exploitation from pharmaceutical firms in developed nations.	4.23 (1.49)	.141
9) In countries where property rights by a collective is rare, the indigenous people have little rights to the region's plants.	3.78 (-1.40)	.165
10) Firms that practice "biopiracy" and exploit native knowledge must be prosecuted even if their research leads to products that improve the world's population health.	4.16 (0.97)	.337
11) Extensive, costly, and time-consuming regulation and approval barriers imposed by developing countries to raise revenues for the state will have a negative impact on the cost-benefit calculations made by pharmaceutical firms (e.g., will not produce).	4.65 (4.37)	.000
12) Plants, like any other natural resource, belong to the indigenous people where the plant grows, regardless of a lack of specific laws regarding property rights.	4.12 (0.77)	.445
13) Pharmaceutical firms should avoid, if possible, bioprospecting in developing nations where the indigenous people receive little or no	4.30 (1.75)	.084

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benefit from the fees/taxes paid to their government for bioprospecting rights.		
14) The indigenous people who identify the positive benefits of a specific plant should be given part ownership in any patent or intellectual property that arises.	5.23 (9.06)	.000
15) Indigenous people and their government should receive limited monetary compensation from the pharmaceutical firms for plants when they lack the skills and resources to develop natural compounds into final, value-creating products.	3.95 (-0.30)	.768
16) Pharmaceutical firms should seek international agreements regarding bioprospecting fees.	5.47 (10.75)	.000
17) Pharmaceutical firms should seek international agreements regarding the ownership of all intellectual properties which derive from commercialization of indigenous plants.	5.25 (8.98)	.000
18) Pharmaceutical firms should seek international agreements which set a maximum limit on the revenues indigenous people can earn from bioprospecting.	3.69 (-1.76)	.081
19) Biopiracy should be an international crime.	4.21 (1.23)	.224
20) Expensive bioprospecting fees result in biopiracy.	4.44 (3.05)	.003
21) Intellectual property rights should be owned and protected only by the pharmaceutical firms of developed nations to avoid unlawful exploitation (biopiracy) because developed countries have superior capabilities to enforce intellectual property rights.	3.75 (-1.55)	.125

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<sup>1</sup> Strongly Disagree (1) to Strongly Agree (7)

### 6. Conclusion

Respondents take a pragmatic view of drugs developed from plants in developing countries: develop plants to cure diseases or prevent illnesses. When world health benefits from biopiracy, respondents are neutral on whether a crime has been committed. Although less than 5 percent of our sample is 50 or older, their views match those of an aging population where medical miracles have been ubiquitous in their lifetimes.

These drugs are developed from a symbiotic relationship between the indigenous people's knowledge of plants and pharmaceutical company's technological prowess. Each should benefit financially, although pharmaceutical companies should get more based on their expertise in bringing product to market. Pharmaceutical companies should receive almost 60 percent of net profits, compared with a fifth each for the indigenous people (23%) and developing governments (19%). When negotiating the initial fee for bioprospecting, the developing country's leader or pharmaceutical CEO should offer 25 percent of net profits. This serves as a floor for negotiations and is in line with previous percent allocations of profits to involved parties. Pharmaceutical

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companies would be willing to spend about \$15 million to protect a drug with a potential profit of \$100 million, a substantial sum, considering the probability of success is unknown. However, dramatic increases in bioprospecting fees cause respondents to vacillate on whether pursuit is economically viable suggesting that development for pharmaceutical companies is still based on profitability. When unbalanced financially to favor developing governments, pharmaceutical companies will not produce drugs from these plants.

Indigenous people should be given part ownership in patents or intellectual property that arises. The onus is on pharmaceutical companies to ensure developing governments share the largesse with its citizen who are responsible for identifying these plants. It appears that many respondents lack trust in developing nations to compensate their people for discovering the medicinal benefits of indigenous plants, although this was not explicitly asked. International agreements should be sought by pharmaceutical companies regarding bioprospect fees, intellectual property ownership, and maximum revenue for indigenous people.

Agreements are predicated upon companies “certainty of ownership,” “a stable political environment”; and “clear and short time-frame for determining prior informed consent and granting access” (Afreeen and Abraham, 2009, p. 127).

### **7. Limitations**

Every research effort has limitations and this paper is based on a sample size of 95 college-education respondents who are pursuing their masters. This group has been “indoctrinated” into capitalism. By their commitment to graduate school while working (most work full-time), they are highly motivated and dedicated. Respondents use of lifesavings medications or that of friends and family was not measured. Respondents were not forced, for most questions, to select from alternatives.

### **8. Future Research**

Future research could compare respondents from developed and developing countries on their attitudes on bioprospecting. Within each country, old and young adults could be compared, since older adults are more likely to be taking lifesaving drugs derived through bioprospecting. Attitudes, regardless of age, could be compared based on whether family members are taking lifesaving medication. Alternatives could be created in a tradeoff analysis (e.g., conjoint analysis or discrete choice models) to determine the importance of initial fees, licensing agreements, and royalties. It could be examined whether consumers would endorse bioprospecting if it damaged the environment (Hunt, Vincent, and Ambio, 2006).

Scenarios could be created where who should share in the benefits with pharmaceutical companies and who should benefit when plants are indigenous to multiple regions is questionable. For example, drugs derived from Madagascar’s rosy periwinkle have made enormous profits for Eli Lilly, yet the plants have grown in the

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Caribbean for centuries (Dutfield, 2004). Since nature does not recognize national boundaries, how do you divide, for example, royalties for plants growing in continuous areas? An example does exist: the San people of Namibia, Botswana, and South Africa have established the San Hoodia Benefit Sharing Trust (Wynberg, 2004), but what if the indigenous people of these countries are different. “Inter-country competition will reduce the bargaining power of individual countries” (Dutfield, 2004, p. 9). Would consumers endorse cartels similar to OPEC for rich-biodiverse countries, since many believe pharmaceutical companies have a stronger bargaining position than biodiverse countries and their indigenous people (Afreen and Abraham, 2009, p. 151)? Even within countries, who owns knowledge: the entire community, subgroups, leaders, or individual creators (Dutfield, 2004)?

Finally, if respondents are neutral on whether biopiracy is a crime when world health benefits from it, would respondents believe intellectual property could be disregarded during a crisis? For example, the U.S. government threatened to violate the intellectual property rights of Bayer’s Cipro, the antidote for anthrax, during the anthrax scares in 2001 and 2002 (Werhane and Gorman, 2005).

## References

- Adams, CP and Brantner, VV 2006, Estimating the cost of new drug development: Is it really \$802 million?, *Health Affairs*, Vol. 25, No. 2, pp. 420-428.
- Afreen, S and Abraham, BP 2009, Bioprospecting: Promoting and regulating access to genetic resources and benefit sharing, *Decision*, Vol. 36, No. 3, pp. 121-158.
- Bishop, J, Kapila, S, Hicks, F, Mitchell, P and Varhies, F 2008, Building Biodiversity Business, London, UK and Gland, Switzerland: Shell International Limited and the International Union for Conservation of Nature, <http://data.iucn.org/dbtw-wpd/edocs/2008-002.pdf>, retrieved July 31, 2011.
- Conrad, J 2000, *Heart of Darkness*, The Norton Anthology of English Literature, editors, Abrams, MH and Greenblatt, S, New York: W.W. Norton & Company.
- Crouch, NR, Douwes, E, Wolfson, MM, Smith, GF and Edwards, TJ 2008, South Africa’s bioprospecting, access and benefit-sharing legislation: Current realities, future complications, and a proposed alternative, *South African Journal of Science*, Vol. 104, pp. 355-366.
- De George, RT 2005, Intellectual property and pharmaceutical drugs: An ethical analysis, *Business Ethics Quarterly*, Vol. 15, No. 4, pp. 549-575.
- DiMasi, J and Grabowski, HG 2007, The cost of biopharmaceutical r&d: Is biotech different, *Managerial and Decision Economics*, Vol. 28, pp. 469-47.
- Dorf, R and Byers, T 2008, *Technology Ventures: From Idea to Enterprise*, McGraw-Hill Higher Education, Second Edition.
- Dutfield, G 2004, *Intellectual Property, Biogenetic Resources and Traditional Knowledge*, London: Earthscan.
- Firm, RD 2003, Bioprospecting—Why is it so unrewarding?, *Biodiversity and Conservation*, Vol. 12, pp. 207-216.

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- Greene, S 2004, Indigenous people incorporated? Culture as politics, culture as property in pharmaceutical bioprospecting, *Current Anthropology*, Vol. 45, No. 2, pp. 211-237.
- Hunt, B, Vincent, ACJ 2006, Scale and sustainability of marine bioprospecting for pharmaceuticals, *Ambio*, Vol. 35, No. 2, pp. 57-64.
- Kursar, TA, Caballero-George, CC, Capson, TL, Cubilla-Rios, L, Gerwick, WH, Gupta, MP, Ibanez, A, Linington, RG, McPhail, KL, Ortega-Barria, E, Romero, LI, Solis, PN and Coley, PD 2006, Securing economic benefits and promoting conservation through bioprospecting, *BioScience*, Vol. 56, No. 12, pp. 1005-1012.
- Millum, J 2010, How should the benefits of bioprospecting be shared, *Hastings Center Report*, Vol. 40, No. 1, pp. 24-33.
- Reid, WV, Laird, SA, Gamez, R, Sittenfeld, A, Janzen, DH, Gollin, MA and Juma, C 1993, A new lease on life," In *Biodiversity Prospecting: Using Genetic Resources for Sustainable Development*, editors Reid, WV, Laird, SA, Meyer, CA, Gamez, R, Sittenfeld, A, Janzen, DH, Gollin, MA and Juma, C, 1-52, Washington DC: World Resource Institute.
- Shiva, V 2007, Comparative perspectives symposium: Bioprospecting/biopiracy, *Signs: Journal of Women in Culture and Society*, Vol. 32, No. 2, pp. 307-313.
- Suresh, P, Basu, PK and Venkatasubramanian, V 2006, *Impact of Improving Pharmaceutical Product Development and Manufacturing*, AICHE, Purdue University.
- Werhane, PH and Gorman, M 2005, Intellectual property rights, moral imagination, and access to life-enhancing drugs, *Business Ethics Quarterly*, Vol. 15, No. 4, pp. 595-613.
- Wynberg, R and Laird, S 2007, Bioprospecting: Tracking the policy debate, *Environment*, Vol. 49, No. 10, pp. 20-32.
- Wynberg, R 2004, Rhetoric, realism and benefit sharing: Use of traditional knowledge of hoodia species in the development of an appetite suppressant, *Journal of World Intellectual Property*, Vol. 7, No. 6, pp. 851-876.