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Biological Prospectors, Pirates, Pioneers, and Punks in the Andes Mountains: An examination of scientific practice in the Andean Community of Nations

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Contents

Abstract

This paper compares and contrasts two models for conducting science: that of the patent-driven intellectual property rights regime, and that of the popular-interest driven civilian science regime. To frame this comparison in less abstract terms, the paper presents maca (*Lepidium meyenii*) as a case study of the struggles of different interest groups to patent scientific innovation or keep it in the public domain. I find that for reasons of finance, human resources, and infrastructure, Peru and the other member-states of the Andean Community of Nations are pulled towards a patent-driven intellectual property rights regime. However for reasons of avoiding regional competition, maintaining national sovereignty, and fostering national pride these nations might seek to further develop civilian science programs. Ultimately I conclude that neither model, as practiced in the Global North, is appropriate for the Andean Community of Nations. Rather a hybrid of these two scientific regimes is required to address the specific issues of scientific innovation in a biologically megadiverse developing nation.

1. Introduction

In 2003 Dr. Richard Jefferson, the founder of CAMBIA[1], stated that "Biotechnology, the way it is right now, is needed in the developing world like a screen door on a submarine". As an alternative, Jefferson and the members of CAMBIA propose that the field of biotechnology must "democratize, decentralize and diversify" (Salleh 2003). These statements highlight frustrations felt not only by CAMBIA, but also many scientists, administrators, farmers, and citizens of both the Global North and the Global South. Specifically discontent with a patent-driven intellectual property right regime (patent driven IPR regime) is rooted in the restrictive, secretive, and exploitative manner in which scientific research is conducted. Since the 1990s a number of independent backlash movements against this patent-driven IPR regime have formed and instead favor the development of a civilian science regime. These backlash movements have included top-down international organizations such as CAMBIA, PIIPA[2], and PIPRA[3], as well as bottom-up popular science efforts such as the DIY Bio[4] and biopunk movements[5].

For their part, proponents of the patent-driven IPR science regime maintain that patenting protects and provides incentive for furthering scientific innovation and discovery. Over the last twenty years there has been an increasing effort to create sustainable systems for commercialization, to support regional ecology through conservation efforts, and to provide fair compensation and access for those who contribute towards scientific discovery.

The search for commercially viable biological innovation often leads research institutions to the highly biodiverse nations of the developing world. The countries of the Andean Community of Nations (ACN) together represent one of the most biodiverse regions on the planet. The diversity is

[1] Centre for the Application of Molecular Biology to International Agriculture
[2] The Public Interest Intellectual Property Advisors Inc (PIIPA)
[3] The Public Intellectual Property Resource for Agriculture
[4] "Do It Yourself" "DIY" is an acronym that can be applied to many different practices, and thus "DIY Bio" is used to specifically denotes "Do It Yourself Biology"
[5] All of the organizations referenced by footnotes in this section will be expanded on in the subsequent discussion

so great that they are distinguished as having "megadiverse" status. (United Nations 2002). Since the 1980s issues regarding the systematic search and patenting of commercially viable biological resources (including their genes, germplasm, or derived products) has become a matter of concern for the ACN. Such efforts, referred to as either "bioprospecting" or "biopiracy", are practices derived from a patent-driven IPR regime. Bioprospecting and biopiracy efforts, as supported by the World Trade Organization (WTO), are a way in which the Global North may impose scientific practices on the still-developing nations of the ACN.

This paper examines the clash between patent-driven IPR regimes and civilian science regimes by using the specific case-study of *Lepidium meyenii. L. meyenii,* more commonly known as "maca" is a root-crop found in the Andes Mountains. Beginning in the 1990s the plant was extensively studied for its properties in treating sexual dysfunction. Patents for macamides and their extraction methods led to international disputes between big pharmaceutical companies such as Pure World Botanicals and the Peruvian government. Subsequent efforts to protect access to maca and innovate further have led the International Potato Center (IPC) to create numerous civilian science programs such as Papa Andina and IssAndes. Thus a direct comparison between patent-driven IPR and civilian science regimes can be made. This comparison suggests that the ACN is 1) systematically ill-favored in a patent-driven IPR regime, 2) logistically not prepared to adopt a civilian science regime, and finally 3) best suited to take elements of both regimes.

As illustrated by the case of maca, the ACN is ill-favored in a patent-driven IPR regime of science, but is not logistically ready for a civilian science regime. Rather the ACN would be best served to combine aspects of both these scientific regimes to produce a hybrid system that will accommodate the needs of a megadiverse and developing nation.

Before delving into the greater topics of discussion about the contrasting cultures of science and the need to hybridize them in the context of the ACN, the author recognizes that the reader may not be familiar with some of the terms referenced in the paper's working thesis. Therefore the first section of the paper is devoted purely towards framing and defining the terms of our discussion: the Andean Community of Nations, the Global North, and the scientific regimes of patent-driven IPR and civilian science. It is the author's hope that the information presented here will be sufficient background to ground the reader in the later discussions of maca and the new cultures of science within the ACN.

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2. What is the Andean Community of Nations and why is it important?

The Andean Community of Nations (ACN) is a group of geographically neighboring nations found along the west coast of South America. The "Andean Community of Nations" are so named because of how the Andes Mountains runs through all of the community's countries. In addition to this, they also share much of the same cultural heritage from the indigenous peoples that first lived in these territories, including descendents from the Moche, Chavin, Nazca, Inca, Recuay, and Tiwanaku kingdoms (Britannica Online Encyclopedia 2012). In many cases these cultural groups span across international borders. The five nations that originally signed the Andean Pact in 1969 were Bolivia, Chile, Colombia, Ecuador and Peru. Four years later Venezuela joined the group, and three years after that Chile withdrew from the coalition with the coup by Augusto Pinochet. Today Chile, though not restored as a full member of the ACN, remains an associate. In 2006, President Hugo Chavez withdrew Venezuela from the ACN and the country is now moving towards re-joining (Helfer et al 2009). With all this in mind, for the purposes of this paper any reference to the ACN

will refer to the countries of Bolivia, Colombia, Ecuador, and Peru. Any references to Chile, Venezuela or other nations will be explicitly stated.

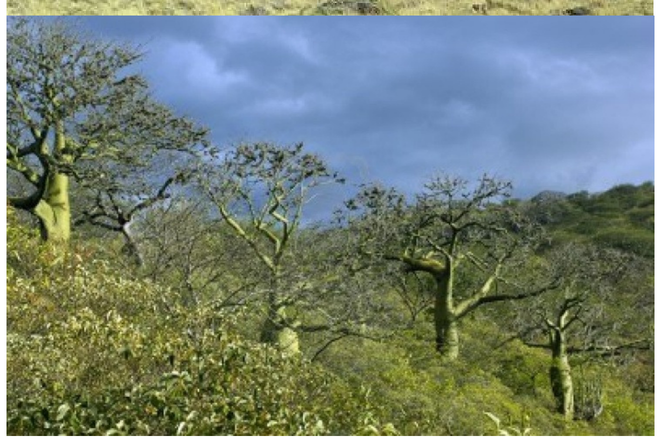
Image 1 The map below shows the countries of the ACN: Colombia, Ecuador, Peru, and Bolivia. The orange indicates the chain of the Andes Mountains, which runs through each of the ACN nations and has significantly shaped the ecology and culture of this region.

The importance of the ACN within the context of the issues of biology related innovation and research stems from the extreme levels of biodiversity that are found within these four, relatively small nations. Conservation International (2012) ranks the Tropical Andes as being in the top five biodiversity hotspots in the world. Reportedly 5% of all vascular plant species are endemic to this region, which include species such as the Andean bromeliad (*Puya raimondii*) that takes over 100 years to mature. The region also contains the largest variety of amphibians in the world, with over 450 of the 664 distinct species listed on the IUCN Red List[6]. Other endangered or endemic fauna include the Andean spectacled bear (*Tremarctos ornatus*), the yellow-tailed woolly

[6] The International Union for the Conservation of Nature's Red-list is the world's most comprehensive index of species and their conservation status. Those species found on the red-list are "critically endangered" (IUCN 2012).

monkey (*Oreonax flavicauda*), and the black-winged parrot (*Hapalopsittaca melanotis*) (IUCN 2012).

Much of the mega diversity that is found in the ACN can be directly attributed to the many different ecosystems found within the region. Most famous amongst these diverse habitats is the Amazon jungle (top image, **Image 2**) that is located on the east side of the Andes Mountains. At altitudes of 2,000-3,500 meters above sea level the tropical cloud forests exist (image second from the top, **Image 3**), and above that (over 3,500 meters above sea level) exists the Andean highlands which include the sierras, the puna, and páramo ecosystems (second image from the bottom, **Image 4**). Along the west coast of Peru, Colombia, and Ecuador there exists tropical dry forests (bottom image, **Image 5**) and wet forests which are intimately tied to the cycles of the Humboldt current and other oceanographic events such as *El Niño (*UNEP et al 2010)*.*



Over the past century, the ecologically viable habitats found within the tropical Andean regions of the ACN have been reduced to a quarter of their original size, with destruction of habitat increasing in rate over the last few decades. Causes of this habitat destruction include mining, timber extraction, oil exploration, the introduction of alien species, the creation of hydroelectric dams, agriculture expansion, and narcotic plantations (IUCN 2012). All of the nations in the ACN are considered to be "developing" (American Mathematical Society 2012) and most carry a considerable amount of debt. As such, pressures to continue to develop "unused land" such as much of what is found on nature reserves will continue and potentially increase (IUCN 2012). To try and offset the pressures of habitat destruction the ACN has attempted to market its environmental resources, either through eco-tourism or bioprospecting efforts[7]. In particular the rapid environmental destruction found within the Amazon Basin has made bioprospectors particularly keen to invest in research projects within the ACN before potentially lucrative biological resources vanish. Therefore in terms of studying bioprospecting, the countries of the ACN are one of the most relevant, high-stakes areas in existence.

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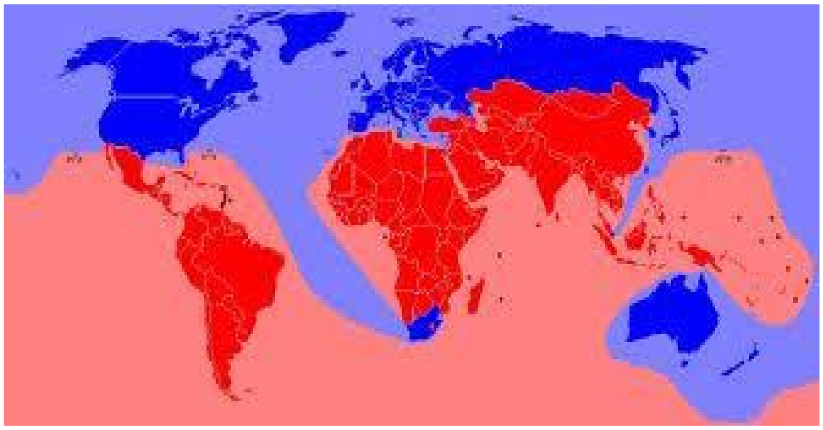
3. What is the Global North and why is it important?

Simply put, the Global North consists of the countries that are north of the equator. It is generally recognized that these nations are the most developed and wealthiest in the world. For the purposes of this paper the "Global North" will refer mainly of the United States and the countries of Western Europe from which the largest biotech companies are based. Any references to other nations of the Global North (such as Japan) will be specifically addressed.

[7] More will be said upon this issue later.

Image 6: This map below details the division between the Global North (blue) and the Global South (red). Note how the member nations of the ACN are all part of the Global South. For the purposes of this paper the "Global North" will refer mainly to the USA and the countries of Western Europe. Any references to other nations will be explicitly stated.



As of 2012 the United States alone was the home to over 1,300 biotechnology firms and led the world in market size and consumer demand for biotechnology. While many fields within the sciences have struggled in the last decade to maintain their funding (over three million US jobs were lost between 2001 and 2010), areas related to the private sector of biotechnology have shown steady growth (a 6.4% increase in the rate of employment in the equivalent time frame). Within the fields of biotechnology the largest is that of medical biotechnology—with key areas in diagnostics, drug and vaccine development. The industry even lasted through the economic crisis of 2007 and has increased the average number of research, testing, and medical lab jobs by twenty-four percent. With so much fast growth and pressures to deliver the newest in medical technology to the world market, growth in the biotech industry has been incredibly rapid and competition to capture markets is fierce (Select USA Commerce 2012).

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Having now established the major characters of the ACN and the Global North, I will subsequently introduce the subject matter that brings them together; scientific practice. References to "science" in this paper draw upon Gottlieb's definition which states that:

> "Science is an intellectual activity carried on by humans that is designed to discover information about the natural world in which humans live and to discover the ways in which this information can be organized into meaningful patterns. A primary aim of science is to collect facts (data). An ultimate purpose of science is to discern the order that exists between and amongst the various facts"
>
> (Gottlieb as referenced by Hussain 2010)

Though the common image of science includes conjuring up images of figures in white lab coats working at esoteric machinery and pipetting various colored liquids, "science", under this definition, may also include the experimental practices conducted by subsidence farmers, tinkerers in garages, or by organized groups of amateurs. Indeed, as we will soon see, there are *many* different ways in which science may be practiced. Herein I will examine two different models, or "regimes[8] of science". These regimes, referred to as patent-driven Intellectual Property Rights regimes (patent-driven IPR regimes) and civilian science are rooted in different parts of history, have different values, are supported by different institutions, and utilize different methods for achieving their goals. All these factors lend themselves towards defining a particular "culture" of scientific practice. As the case of maca in the demonstrates, the cultures of these two scientific regimes have the potential to conflict with each other or to hybridize. However before we begin, I will first define and address these different scientific regimes.

[8] "Regime" in this paper is defined as: (1) a regular pattern of occurrence or action (2) mode of rule or management (Merriam-Webster 2013)

4. What is a patent-driven IPR regime?

For the purposes of this paper the term "patent-driven IPR regime" will refer to the systematic and regular patterns with which scientific research is influenced, directed towards, and focused on lines of inquiry that would most likely led to the privatization and eventual commercialization of knowledge-based products. Furthermore, though "intellectual property" may also encompass ideas of copyrights and trademarks on products such as artistic or literary work , in this paper I will refer to patent-driven IPR regimes within the context of the biological and biotechnological fields.

Despite best efforts to define patent-driven IPR, as noted by Drahos (2013) matters relating to intellectual property, particularly those that deal with science, remain ambiguous and generalized because of how variable new discoveries and innovations can be. Therefore, to further help present a clear picture of what is meant by "patent-driven IPR" I will refer to what Brush (1993) calls "the culture of science". The following are values and practices that are characteristic of a patent-driven IPR regime.

1. Ultimate appreciation for those individuals who are the *first* to innovate or discover.
2. Competition between groups of scientists to be the first to innovate or discover
3. The pursuit of research that promises maximal monetary returns, either through preliminary investment or commercial pay-off from a produced product.

Of further importance to our discussion of patent-driven IPR is the prominence of this scientific regime over others. As described by Drahos (*ibid)*, patent-driven IPR has grown to become the dominant scientific paradigm. To gain a better appreciation for this, I will now briefly describe the historical and cultural origins of a patent-driven IPR system.

<u>A Brief History of Intellectual Property Rights with Respect to Biotechnology</u>

Earliest Years

The origins of IPR regimes are generally traced back to the Western Europe in 1421. At this point legislation was passed to allow guilds to protect their trade secrets and prosecute those that disseminated such secrets without express permissions. Similar laws were later passed in instances such as Britain's' 1623 Statute of Monopolies which declared all monopoly grants illegal except for those that were specifically for inventions or discovery (i.e. monopolies over knowledge) (Inkster 2009).

By the 18th and 19th centuries rudimentary IPR systems had grown up with the industrial revolution, but for many years they remained inefficient and difficult to enforce. However international competition, particularly between Britain, France, the United States and (later) Germany quickly pushed patenting systems to grow in size and complexity. Particularly important points in history included legislative changes in France in 1844 and Britain in 1883 which doubled and tripled the number of applications for patents respectively. Between 1842 and 1861 there were only 128,000 patents word-wide, and less than ten years later there were over 782,000 (Inkster 2009).

It is important to note that as the foundations of these scattered IPR regimes were beginning to take shape there was an important exception: the medical exception rule. This was implemented in England in the early 1800s for the purposes of preventing medical technologies from becoming licensed, horded trade secrets. It was specifically made for making knowledge of medical advances available to medical practitioners (Inkster 2009).

1980: The Bayh-Dole Act

Scholars such as Castle (2009) have suggested the 1980 passing of the Bayh-Dole Act (aka the University and Small Business Patent Procedures Act) as a key point in the history of IPR regimes in the United States and the rest of the World. Prior to the Bayh–Dole Act any research completed under United States federal research funding contracts and

grants became assigned to the federal government (thus making that research "public"). Under the Bayh-Dole Act universities, small businesses and non-profits could choose to pursue intellectual property rights over technology that arose out of government funded research projects in preference to government ownership (University of New Hampshire Law School 2013).

Prior to the Bayh-Dole Act the frequency and interest in scientific patenting in the United States in relation to the products of R&D development were quite modest. At that time there was no unified patent regime, but instead each individual organization (the NIH, the NSF etc) all had their own bureaucratic mazes and protocols for awarding (or more frequently denying) intellectual property rights. The system was deterring enough that despite heavy investment by the US into research and development, less than 5% of reported innovations were commercially patented (Council on Governmental Regulations 1999).

The Bayh-Dole Act caused a number of dramatic changes in the scientific infrastructure of the United States. In the two decades after the Act was put into place there was a 10-fold increase in institutional involvement in research and innovation projects, both from the academic institutions and private businesses. The ability to patent the results of government-funded research resulted in the awarding of 8,000 new patents to universities and the formation of 2,200 new companies that were involved in obtaining those licenses. Of those new licensed technologies, 70% of them were reported to be in the biological sciences and dealt with important matters of the public good such as diagnosing disease, creating new pharmaceuticals, and addressing other matters of public health. The passing of the Bayh-Dole Act paved the way towards creating a unified patent regime within the USA. In the coming years the Bayh-Dole Act would also serve as a framework for

creating the patent regimes of other countries as well such as in United Kingdom (Caesar 2010).

1980: Diamond v. Chakrabarty

At the same time as the Bayh-Dole Act was being ratified, the Supreme Court Case of Diamond v. Chakrabarty for the rights to patent life and man-made microorganisms was also reaching its close. In 1972 Chakrabarty filed for a patent for his work with creating a strain of bacteria that was capable of metabolizing oil. The patent included sections for the intellectual property rights for the method of producing the bacterium, the inoculums that contained the bacterium, its necessary medium components, and the actual bacterium itself (Robinson and Medlock 2005). The first two components of the patent were approved, but the last clause for the application to patent the genetically engineered microorganism was rejected as being un-patentable under 35 U.S.C 101. Chakrabarty appealed this decision to the Patent and Trademark Office (PTO), which confirmed this rejection. Further appeal to the Court of Customs and Patent Appeals overturned this decision, at which point the PTO filed for a writ of certiorari[9] to the Supreme Court. Finally, in 1980 the Supreme Court ruled in favor of Chakrabarty and concluded that a patent may be obtained for “anything under the sun that is made by man” (Robinson and Medlock 2005).

The final ruling on the Chakrabarty case did not have an immediate impact in the world of patenting. It would take another eight years for the 1988 case of Ex Parte Allen to strike the decisive note that would open the flood-gates for the patenting of living organisms, genes, and related products and methods for their generation. In the Ex parte Allen case, the rejected application for a patent for genetically engineered oysters was re-examined in the light of the recent Chakrabarty ruling. Although the patent application was

[9] An order from a higher judicial power to a lower judicial power

ultimately denied, the case did force the PTO to unequivocally state their position towards the patenting of life. In an issued statement, the PTO announced that:

"The Patent and Trademark Office now considers non-naturally occurring non-human multicellular living organisms, including animals, to be patentable subject matter within the scope of 35 U.S.C. 101 [sic].

The Board's decision does not affect the principle and practice that product found in nature will not be considered to be patentable subject matter under 35 U.S.C. 101 and/or 102 [sic]. An article of manufacture or composition of matter occurring in nature will not be considered patentable unless given a new form, quality, properties, or combination not present in the original article…

A claim directed to or including within its scope a human being will not be considered to be patentable subject matter under 35 U.S.C. 101 [sic]".

(PTO Notice 197087 as referenced by Walter 1997)

This announcement effectively removed all ambiguity from the issue of filing for patents for living organisms. Within a year other patents were filed for transgenic microorganisms such as the "Harvard Mouse" (US Patent No. 4, 736,866). Over the next 25 years there was an exponential growth in the number of biotech related patents filed. The case not only led to an increase in the number of patents applications, but also in the number of biotech companies formed, the investments into research and development, and the amount of revenue generated from the biotech industry. In the early 1990s US revenues from biotech were around 8 billion dollars, and ten years later it was nearly 40 billion dollars. Today the Chakrabarty case is heralded as the gate that opened up a golden age for the biotech industry (Robinson and Medlock 2005).

1993: The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS)

Passed in 1993, this act requires all member-states of the World Trade Organization (WTO) to introduce a minimal level of intellectual property right protection at the national

level. Matters of biotechnology were specifically addressed in Article 27.3(b) of the TRIPS Agreement in which requirements for the protection of biological processes and their extraction or refinement techniques. In particular new plant varieties were required to be protected by a national patent system or a *sui generis* patent system that was created specifically for that particular specimen (aka Plant Variety Protections or PVPs) (Castle 2009).

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We have now outlined what a patent-driven IPR regime is. In order to understand the future case-study it is now our task to focus on one of the practices of patent-driven IPR: bioprospecting. The following is a definition and explanation of what bioprospecting is and why it is important to both the Andean Community of Nation and the Global North.

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5. Bioprospecting: defining the parameters of our research

"Bioprospecting" is a word that historically has a very broad use. It has been used in cases that specifically reference specific biological species such as the potato to specific products of biological species such as the poison secreted by the vine *Strophanthus kombe* (Jacobs and Heidelberger 1929). There are many different definitions for "bioprospecting" because many nations or international organizations have chosen to independently define it on their own. The US Department of the Interior defines bioprospecting as

> Scientific research that looks for a useful application, process, or product in nature is called biodiversity prospecting, or bioprospecting. In many cases, bioprospecting is a search for useful organic compounds in microorganisms, plants, and fungi that grow in extreme environments, such as rainforests, deserts, and hot springs.
>
> (National Park Services 2012)

However other institutions give a more expanded definition of "bioprospecting", such as that detailed in the 7788 Biodiversity Law of Costa Rica. This law, and many others like it, encompasses not only "organic compounds", but also genes or complete organisms themselves. They state that bioprospecting is

> "The systematic search, classification and research for commercial purposes of new sources of chemical compounds, genes, proteins, and microorganisms, with real or potential economic value, which are found in biodiversity."
>
> 7788 Biodiversity Law of Costa Rica (Kate and Laird 1999)

For this particular investigation we will examine the practice of bioprospecting within the Andean Community of Nations. Therefore it is necessary to operate under a definition of bioprospecting that is specifically relevant to this region. Although the Andean Community Decision 391 on bioprospecting does not explicitly define the terms "bioprospecting" or "biopiracy", it can nonetheless be inferred from the definition of "access [to biological materials]". "Access" [to biological materials] is there defined as

> "The obtaining and use of genetic resources conserved in situ and ex situ, of their by-products and, if applicable, of their intangible components, for purposes of research, biological prospecting, conservation, industrial application and commercial use, among other things"
>
> (Muller 2000).

For the sake of relevancy to the ACN it is under this definition that this research will operate.

Though the practice of bioprospecting goes back far into human history, the actual word "bioprospecting" does not appear in any written text until the latter half of the twentieth century (Ngram Viewer 2012). Although the word is still considered to be more colloquial (in part due to its many different definitions), use of the word has grown abruptly since the 1990s. During this time bioprospecting left the exclusive circles of the scientific community and came into the

public eye with the publication of books such as *Protection of global biodiversity: converging strategies* (Guruswamy and McNeely 1998), *Plants and the Empire: Colonial Bioprospecting in the Atlantic World* (Schiebinger 2004), and *The Museum of Bioprospecting, Intellectual Property, and the Public Domain* (Vogel 2010).

***

Why Not "Biopiracy"?

At this juncture I feel that it would be prudent to address my choice of words. Specifically I would like to address why this paper will use the term "bioprospecting" instead of its commonly used cousin "biopiracy". There are many who feel that "biopiracy" more accurately describes the negative impact of the practice of obtaining and using biological resources for commercial value. They argue that "prospecting" is a term appropriate for searching for resources such as gold or oil, but not for discovering living creature. Furthermore, if indigenous peoples are already familiar with the uses of these biological resources (as we will later see is very often the case) "prospecting" does not give the indigenous peoples credit for the sharing of knowledge, nor condemns the "prospectors" for the stealing of cultural knowledge (Shiva 1997).

However others would still argue that "biopiracy" is too strong of a word that casts moral judgment prematurely. Many would argue that true bioprospecting results in a mutually beneficial relationship between the prospected and prospecting parties. Therefore, for the purposes of not passing early judgment and leaving the "good" or "bad" qualities of this relationship open for interpretation, the word "bioprospecting" and not "biopiracy" will be used in this paper. Only explicitly exploitative bioprospecting will warrant the term "biopiracy".

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The use of bioprospecting for commercial purposes (which is by far the more commonly disputed form of bioprospecting) is usually done with the hopes of gaining a patent for the genetic resources or their by-products[10]. Patents can be filed for genetic resources, their by-products, or

[10] Bi-products of genetic resources" can include the organism itself, as well as the product produced from that organism.

the extraction techniques used to acquire the desired product (Gollin 1999 as referenced by Landon 2007).

Bioprospecting is overall a contentious issue that is either condemned or applauded. The following are some of the positive and negative consequences that the practice of bioprospecting can create.

The Most Ideal Outcome for Bioprospecting:

The main motivation for engaging in bioprospecting is to discover and use biological resources for innovation and to create benefits for society. In the past bioprospecting has produced many different advances for society in fields ranging from agriculture to medicine. Such "discoveries"[11] have included Basmati rice (Woods 2003), hunger suppressants from the Hoodia plant of South Africa (Swart and Geldenhuys 2008), and the treatments for diabetes and Hodgkin's disease that are derived from rosy periwinkle from Madagascar (Hunter 1997). In the most ideal of bioprospecting scenarios, hunting through the natural world would continue to produce new technological advances that would overall better the entirety of the human race.

While the technological benefits that resulted from bioprospecting would ideally benefit all that needed them, another part of our ideal bioprospecting scenario would be that those that had invested the time and resources to do the initial research would reap the appropriate monetary awards for their hard-work. Specifically a pharmaceutical company would be rewarded for their investments and would have the incentive to keep discovering the cures to more diseases. Thus, the model of "do good by doing well" would still apply and act as an incentive to continue the virtuous cycle.

Additionally in the most ideal model of bioprospecting the prospected party would receive fair compensation for their contributions. In particular indigenous groups or other parties that may

[11] Bi-products of genetic resources" can include the organism itself, as well as the product produced from that organism.

have contributed through cultural knowledge to the prospected item would receive appropriate compensation for their input. This compensation would be ideally used in whatever way they would collectively deem fit (whether to modernize or to preserve their own culture). Finally, no group that had previously used the newly prospected technology would be deprived of its continued use.

Additionally some of this compensation may also be used for environmental conservation of the particular region from which the natural resources were obtained. Any land use dedicated towards the harvest or collection of the resources of interest would be protected and preserved as a thriving ecosystem.

The Least Ideal Outcome for Bioprospecting

The least idea scenario of bioprospecting could arguably be called “biopiracy” due to the polarized nature of the interaction. In this scenario biological resources would be taken from the “contributing” party through the use of deception or without any effort to gain informed consent. Resources would be secretively removed from the country of origin and analyzed in a lab far away. After that, the produced product, the method for its fabrication, and perhaps the organism itself would all receive an international patent. Enforcing this patent would mean that the people and/or nation from which the biological resource originated would be forced to pay large sums for the newly refined commodity as well as royalties for continued production for their own home-grown organisms.

In addition, in the least ideal situation of bioprospecting the ecological environment would suffer from the continued over-harvesting or extracting of the resources. The result may be the deposition of toxic materials within the soil and water, the ecological imbalance caused by the stripping away of a key resource, or transference to monoculture. In particular this last possibility would also lead the bioprospected nation into an economic situation in which they would be

completely dependent on the continued export of their raw biological resources for processing in the prospecting nation.

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As stated previously, while patent-driven IPR has risen with the help of the Bayh Doyle Act and the TRIPS agreements, it is not the only regime that models how to conduct science. We will now turn our attention to the other scientific regime to be discussed: the civilian science regime. The following explanation and history will hopefully provide the reader with an adequate understanding and context of this scientific regime.

6. Defining a civilian science regime

According to Dickinson and Bonney (2012), as of 2012 the term "civilian science" was (and as far as the author can discover in 2013, still remains) unmentioned in any official dictionary. However "civilian science" is a term that actually pre-dates many formal science programs—back to the times of Henry Thoreau and John Burroghs (Dickinson and Bonney 2012). Simply put, civilian science refers to the practice of scientific inquiry that is conducted by individuals outside of formal institutions of research (e.g. industrial research parks or universities).

As with patent-driven IPR, the definition of civilian science can further be elaborated upon by proposing a number of characteristic values and practices for this scientific regime. This creates a "culture" of civilian science which is characterized by the following:

1) Collaboration and cooperation between individuals that share a common interest (instead of other commonalities such as geographic location, professional credentials, etc.)

2) The belief in the sharing of research results and access to knowledge—often through the public domain. In the modern age this information sharing often has a technological component that allows for real-time development of a problem
3) Distrust of many formal science institutions and academic monoliths that are seen as being influenced by politics, career moves, and bureaucracy. As Wohlsen (2011) reports, biohacker[12] culture scoffs at "the pretense of professionalism and the cult of the expert".
4) Focus on problems that are relevant to the people, either through casual interest or un-addressed need.

Having now defined and addressed some of the characteristics of civilian science, we will look into the history and culture of this scientific regime

A brief history of a civilian science regime

Civilian science might well be considered to be the first scientific practice. Before there were large universities or research institutions, there were "amateur[13] scientists". Even after the institutionalization of science, civilian science remained a common enough practice. In the US, starting in the mid-1800s and spanning until the present day, civilian science projects relating to the environment and ecology have sustained a devoted following of interested amateurs. Examples of civilian science in North America include the National Audubon Society's Christmas Bird Count and the National Weather Service Cooperative Observer Program (Dickinson and Bonney 2012).

Despite the long historical practice of civilian science, in this paper I will specifically address the era of civilian science from the 1980s and onwards. During this time in history different sub-cultures of civilian science began to form. The first of these were the hackers—people that were particularly interested in deconstructing, editing, and modifying computer programming codes to create their own inventions. In the mid-1980s, the introduction of the first "personal computers" from IBM, Radio Shack, and Apple, ushered in the Golden Era of hacking. During this time spatially disparate individuals came together to form collaborative communities and the distinct "hacker

[12] Biohackers are members of a kind of civilian science movement that we will examine shortly
[13] The word "amateur" today carries a pergorative connotation, but its original meaning, derived from the Latin "amâre", meaning "to love" indicates doing an activity for the sake of interest and not for profession.

culture" began to develop. As was detailed in Steven Levys 1984 publication "Hackers: Heroes of the Computer Revolution", hacker culture put a value on the public domain of knowledge and on the ability of the people to fix and improve upon problems pertaining to the users. Their hacker's credo was as follows: "Access to computers, and anything that might teach you something about the way the world works, should be unlimited and total" (Clarke et al 2003).

Image 7: Though large and clunky by today's standards, the personal computers of the 1980s, such as the Apple II computer (above) allowed interested tinkerers of computer hardware and software to share their experiences and join communities of fellow hackers.

Though the digital hacker movement was the first of the STEM fields to undertake collaborative projects on the internet in a major way, others were quick to follow. Online-based research cooperatives such as eBird, the PolyMath blog, or the FoldIt protein folding game have created online sites of collaboration in tackling problems ranging from mathematics to environmental ecology. Other projects organized by Zooniverse have set users to the task of classifying cancer cells, translating ancient texts, identifying species of the sea floor, and detecting solar storms (Nielsen 2012).

While the collaborative science on the web has continued to grow, beginning around 2010 many civilian science programs began to jump from the digital world and into the real world. Movements like the biohackers, biopunks, and DIY Bio proponents pioneered the way towards providing the "user" with the physical tools and space to conduct research. DIY Bio was the first of these movements. In 2005 the unification of independent civilian scientists interested in

experimenting on DNA with household items formed the first generation of DIY biologists. Within the subsequent years the growing community of DIY biologists achieved recognition from formal academia and industry by presenting at major universities and at science competitions. Today twenty-five of lab spaces exist for DIY biologists (Jorgensen 2013). From the DIY Bio movement other off-branches of inquisitive civilian scientists, such as the tinkering biohackers, the more focused biopunks, and the new biocurious following[14] (Cowell in *The DIYbio Community* 2009). Though they work with limited resources and nowhere near the scale of companies that operate under a patent-driven IPR regime, biohacker solutions have already produced breakthroughs in new microbial imaging techniques and vaccines for common food contaminants.

Image 8: Active DIY bio groups across the globe

Image 9: Active biohacker communities in the United States (DIYbio 2013)

[14] The distinctions between biopunks, biohackers, and the biocurious are debated, and there is considerable overlap between the communities. The majority of the formal, published literature is about either the DIY bio movement or discussions of biopunks. For the purpose of this paper we will therefore refer more to DIY Bio activists or biohackers, but it should be noted that the communities implied by these terms expands to include these other groups as well.

Image 10: Biohacking spaces around the world sometimes reflect the informal and accessible nature of the people that work in them. The physical space in which biohackers can meet represents a significant jump of civilian science from the digital world and into the real world.

A number of these civilian science programs have specifically spawned in reaction to the political nature of what is referred to as "Big Science"[15]. In *A Biopunk Manifesto, a* speech that was delivered at UCLA, biopunk activist Meridith Patterson declared:

> *"We reject the popular perception that science is only done in million-dollar university, government, or corporate labs; we assert that the right of freedom of inquiry, to do research and pursue understanding under one's own direction, is as fundamental a right as that of free speech or freedom of religion.*
>
> *…*

[15] "Big Science" refers to large, multi-national research corporations which operate under a patent-driven IPR regime.

> *Curiosity knows no ethnic, gender, age, or socioeconomic boundaries, but the opportunity to satisfy that curiosity all too often turns on economic opportunity, and we aim to break down that barrier"*
>
> *Patterson* 2011

As articulated in this speech, frustrations with Big Bio[16] include matters of privatization of knowledge, excessive bureaucracy, elitist culture, lack of diversity in the sciences, and competing interests between the users and privatized science. This has led some civilian scientists to endeavor in project that they feel are being overlooked by Big Bio. These include developing cheaper, open-source solutions for diagnostic tests for genetic disorders, lab equipment, vaccines, and food related products (Cowell in *The DIYbio Community* 2009). Above all, the politically-minded biohacker seeks to better the world by making knowledge and the products of knowledge cheaper, more user-friendly, and available to all.

The DIY Bio movement is a movement that (with the exception of a few labs in Indonesia) is exclusive to the Global North. However the political agenda of the DIY bio and biohacker movements inspired the creation of a civilian science program dedicated to serving the needs of the Developing World. This movement, called the Bioneer movement (short for "Biological Pioneer), operates on the same principles of politically oriented biohackers: increasing the diversity of science, making knowledge and the means to innovate publically available, collaborating towards common goals, and better serving the needs of the people through science. Many of the problems in the developing world such as the need for clean food and water, a healthy diet, sustainable business models, agricultural techniques, and environmentally-conscious practices are popular topics amongst the circles of bioneers. Bioneers, along with international organizations such PIPRA, CAMBIA, and PIIPA (outlined below) formed to aid the developing world create civilian science

[16] A common term amongst biopunk and biohacker circles that refers to large, privatized, and heavily bureaucratic institutions of science. Patent-driven IPR regime is practiced by institutions that are considered to be "Big Bio".

movements. In many of these organizations (particularly CAMBIA) these companies were formed directly as a back-lash to the dominant patent-driven IPR regime (Nelson 2008).

> **The Centre for the Application of Molecular Biology to International Agriculture (CAMBIA):** This Australian-based NGO seeks to empower local researchers and innovators in agriculture through international collaboration. CAMBIA is best known for pioneering the Open Source Biology movement and calling for patent transparency (Boadi 2009).
>
> **The Public Intellectual Property Resource for Agriculture (PIPRA)**: This US-based organization has its main objective set in seeking to pool both patented and public technologies (particularly those that are agriculturally based) for further studies in research institutions in the developing world. Functioning mainly in Latin America and the Southeast of Asia, this organization conducts regular IPR policy analysis, develops both material and human resources relating to biotechnology, and makes provisions for research consortia support (Boadi 2009).
>
> **The Public Interest Intellectual Property Advisors Inc (PIIPA):** This international organization works to provide relevant information on intellectual property to people in developing nations. PIIPA has a wide network of IP volunteers that provide advice and representation for disadvantaged groups looking to navigate through complex, international IPR regulations (Boadi 2009).

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Having now established these two different regimes for conducting science, I will now apply this comparison to the case study of the bioprospecting of maca within Peru. I will examine how both the IPR regime and a civilian science regime were utilized and assess the compatibility for both of these practices within the context of the Andean Community of Nations.

6. The Case of Maca in the Peruvian Highlands

Natural History of Maca

Lepidium meyenii, commonly known as "maca" is, like other members of the mustard family Brassicaceae, a shrubby, flowering, perennial plant (Hermann and Bernet 2009). It is indigenous to the Junín and Pasco regions in the central sierras of Peru, and grows specifically in what is known as the puna[17] altitudes (above 4,000 m) (Brinckmann 2013). These extremely cold[18], wind-swept, and oxygen depleted zones have pushed the maca plant to become an extremely hardy and resilient crop. The ETC Group (2002) references maca as being the tuber with the greatest frost-tolerance known to man.

Image 11 (left): *Lepidium meyenii.* The useful part of the plant consists mainly of the tuber that grows underground. **Image 12** (right) the puna region of sierra the Andes mountains is, despite being so close to the equator, cold due to the high elevation. High levels of ultraviolet radiation, water run-off, wind, and extreme changes in temperature make this a stressful environment for botanical species. Additionally, isolation between other peaks of similar altitudes form individual "islands" that isolate species and results in the evolution of many indigenous, rare, and useful plant species such as the *Lepidium meyenii.*

6.2 Cultural History of Maca

[17] Sometimes referred to as the puña

[18] Maca will grow at temperatures below freezing—sometimes with a maximum monthly temperatures of minus 12 degrees Celsius (International Potato Center 2013)

For centuries maca has been cultivated by the indigenous peoples of the Andes Mountains. At least 180 different kinds of maca are domesticated and grown. Besides "maca", the plant may also be referred to as maino, ayak chichita, ayak, willku (indigenous names) or Peruvian ginseng (INDECOPI 2004). A study by the International Plant Genetic Resource Initiative (IPGRI) estimated that the cultivation of maca began between 1300 and 2000 years ago (IPGR as referenced by Ginin 2002). At the very least, the Peruvian government has produced records of cultural uses of maca dating back to the 1500s. At this time it was also introduced to the Spanish, who accepted it as a form of tribute from the indigenous communities (Landon 2007). Its traditional uses have been as a food crop and as a medicine for a wide variety of ailments (ETC Group 2002). Maca is most well-known for its properties as being a supplement for increasing libido, sexual endurance, but it is also commonly used to strengthen the immune system, lower stress, balance hormone levels, mitigate the effects of menopause, and as a mild stimulant. Additionally experiments have shown that the glucosinolates found in maca have cancer-preventing properties (International Potato Center 2013).

Image 13: *Lepidium myenii,* due to its unique ecological niches, grows endemically only in the provinces of Pasco and Junin in Peru. Those seeking to cultivate the plant elsewhere must mimic the very specific ideal growing conditions of the plant in order to reap comparable yields.

However in the 1980s agricultural experts declared that maca plants were in danger of domestic extinction. This specifically refers to how fewer and fewer growers were choosing to continue the cultivation of maca (it still grew quite well in the puna highlands, even without the domesticating efforts of humans) (ETC Group 2002). This led the National Research Council of the US to refer to *Lepidium meyenii* as "one of the lost crops of the Incas" (National Research Council as referenced by Gindin 2002). However later in the fight for the use and appropriation of maca,

advocates from the Indigenous Peoples Biodiversity Network would contest this statement and even try to turn it back against the peoples of the Global North[19].

Despite whatever international organizations may say, in the 1990s and 2000s maca surely made a come-back in popularity. Whereas in 1994 less than 50 hectares of maca were cultivated, five years later there was a 24-fold increase. As of 2002 the ETC Group estimated maca cultivation to be at over 2,000 hectares. This can be partially attributed to the international attention that the plant has received. Not only scientists, but also the Peruvian government and projects in the International Potato Center took to saving and selectively sowing maca plants of interest (ETC Group 2002). The hardy nature of the plant made it one of the few options for agricultural development in the third of the Peruvian territories which consist of largely un-cultivatable lands (Falconi 1996). In addition the cultivation of the plant has spread out of the original two provinces of Junín and Cerro de Pasco and into another six Peruvian provinces as well as the countries of Bolivia, Ecuador, and Argentina (INDICOPI 2004). This maca boom has been due to the increased hype around the plant. Unfortunately the hype led to depressed prices which have shifted the lucrative potential of the plant away from the farmers that grow it and more towards the companies that process it and the venders that distribute it in the Global North (ETC Group 2002).

On the local level, traditional indigenous groups continue to use the plant as a food source and medicinal resource as they have in centuries past. Extracts of the plant are common health drinks that can be purchased at road-side or market stands that sell other kinds of produce (ETC Group 2002). The root is most often boiled and mixed with fruit juice or milk to form a thick broth. Boiled extracts are often mixed with liquors as well and used in desserts (International Potato Center 2013).

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[19] Wrote Alejandra Argumedo: "Maca may be a forgotten crop in the minds of foreign agronomists, but it has never been lost to indigenous peoples of the Andes. … Ironically, now we are in danger of losing maca—not to extinction—but to predatory US patents" (ETC Group 2002).

Maca Comes to International Attention

Towards the end of the 1990s, *Lepidium meyenii* became the subject of bioprospecting efforts (or biopiracy efforts depending on who you consult) for its potential uses as a sexual enhancer and fertility drug. The first patent for intellectual property rights regarding extracts, extraction processes, and macamides[20], and therapeutic applications was filed from Pure World Botanicals Inc on March 3, 1999. The Patent was approved and published without incident to the Patent Cooperation Treaty (PCT) Gazette on September 8, 2000 as WO 00/515458. This patent was quickly followed by three others within the next eighteen months, and included "Extract of *Lepidium meyenii* roots for pharmaceutical applications" (US Patent 6,267,995; granted July 31 2001). The treatment of sexual dysfunction with an extract of *Lepidium meyenii* roots" (US Patent 6,428,824; granted August 6 2002) and "Compositions and methods for the preparation from Lepidium" (US Patent 6,552,206, granted 2002) (Brinckmann 2013). As of 2002 even more patents were being filed for even more uses and extraction methods and compounds of the plant, and the Peruvian government concluded that swift action was needed to protect this unique natural resource.

As of 2002 there was no established institution within the Peru to deal specifically with matters of biopiracy, and so a mix of many different groups including the Ministries of Foreign Relations, Foreign Trade and Tourism (MINCETUR), the National Environmental Council (CONAM), the National Institute for Agricultural Research and Extension (INIEA), the Peruvian Environmental Law Society (SPDA), Pro Biodiversity of the Andes Peru (PROBIOANDES), Peruvian Institute of Medicinal Plants (now Peruvian Institute of Natural Products, IPPN), the Association for Nature and Sustainable Development (ANDES), and finally the International Potato Center (IPC),

[20] A class of secondary metabolites that as of 2013 are found only within Lepidium meyenii (Malcollom MM et al 2005)

united as a Working Group to address three already-existing maca patents. In May of 2004, faced with not only the issues of maca but also the bioprospecting case of the camu camu plant, quinoa, yancón, ayahuasca, and others, the Peruvian government formed the National Commission for the Protection of Access to Peruvian Biological Diversity and the Collective Knowledge of the Indigenous Peoples[21] (Brinckmann 2013). In 2006 the Peruvian government named maca the number one priority for protecting against biopiracy efforts(ETC Group 2002).

How did these efforts to combat the biopiracy of maca pan out? The battles fought by the National Commission for the Protection of Access to Peruvian Biological Diversity and the Collective Knowledge of the Indigenous Peoples for the revocation of patents on *L. meyenii* have not been overwhelmingly successful. The biggest victory for fighting maca patents came against Pure World Botanical's[22] US Patents No. and 6,428,824, No. 6,267,995, and US Patent Application No. 878,141. These patents claimed the rights to the medicinal extraction and extraction techniques for cellulose-free maca that was identical to the technique traditionally used by the Andean peoples (Landon 2007). Moreover, assessments by members of the University of California Davis determined that this procedure is standard protocol for determining glucosinolates and isothiocyanates in crucifers of many different kinds of botanical species—not just maca (ETC Group 2002). However before the movement gained much momentum it was hurriedly swept under the rug when the French Company Naturex of Avignon acquired Pure World Botanicals. Anxious to save face with their new company gain, Naturex opened up all Pure World Botanical's maca patents to Peruvian entities. This allowed all Peruvians national research institutes to still have access to the *L. meyenii* for the both basic and applied uses (Douaud 2007). However the US Patents 6,428,824 and 6,267,995 still are upheld, and since then have been joined by patent 6,552,206

[21] Which may also be referred to as the National Nati-biopiacy Comission.

[22] Before its acquisition by Naturex, Pure World Botanicals was the largest botanical extraction facility in North America. Producing well over 1,000 different kinds of plant extracts at a rate of over 15,000 pounds a day, a patent from Pure World provided a reasonable threat to the continued, uninhibited use of maca within the public domain (ETC Group 2002).

(Compositions and methods for their preparation from lepidium) (USPTO 2003) and 6,878,731 (Imidazole alkaloids from Lepidium meyenii and methods of usage) (USPTO 2005).

While Peru did manage to rattle the cage of Naturex, there has been little response from the rest of the international community[23]. As of 2002 plans to challenge patents on maca in Japan, Australia, and Europe were allegedly being formed (ETC Group 2002). But since then there have been no major victories for Peru, and as reported by the IUCN (2005), the process of fighting against a patent is extremely slow and difficult. For patents established near the turn of the twenty-first century, it is possible that the twenty-year lifespan of a utility patent (Zies Widerman Malek 2013) will expire before a definitive conclusion can be reached.

It should be noted that regardless of the success rate of the National Commission for the Protection of Access to Peruvian Biological Diversity and the Collective Knowledge of the Indigenous Peoples, the people of Peru have continued to grow and utilize maca, and the Peruvian government has taken no action to deter this (ETC 2002).

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In the following analysis I will use the case of maca to examine the dispositions and needs of the ACN with regards to setting up its own science regime. I will examine the financial needs of the country with regards to research and development, matters of competition vs. cooperation within the region, as well as the issue of national sovereignty and cultural identity. I will apply the previously discussed topics of patent-driven IPR regimes and civilian science regimes. This analysis

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[23] There is one prominently featured article in the literature entitled "Peru's patent win strikes blow against biopiracy" (Portillo 2009). However this article makes no reference to a specific patent that was revoked, no mention of the specifics of the patent that was allegedly revoked, and no identification of the companies to which the revoked patents belonged. Attempts contact Portillo have not received any response. Furthermore after 2007 the amount of literature specific to *L. meyenii* runs comparatively dry. Consequently it is acknowledged that a number of maca patents are up for dispute, but most have yet to be resolved. We will subsequently confine most of our discussion to patents 6,428,824, 6,267,995, 6,552,206, and 6,878,731 as held by Naturex.

will lead us to the final conclusion that neither patent-driven IPR nor a civilian science regime can fully accommodate the needs of the ACN. Rather the ACN would benefit most from hybridizing these two scientific regimes to create a system specific to its needs as a megadiverse, developing nation.

THESIS

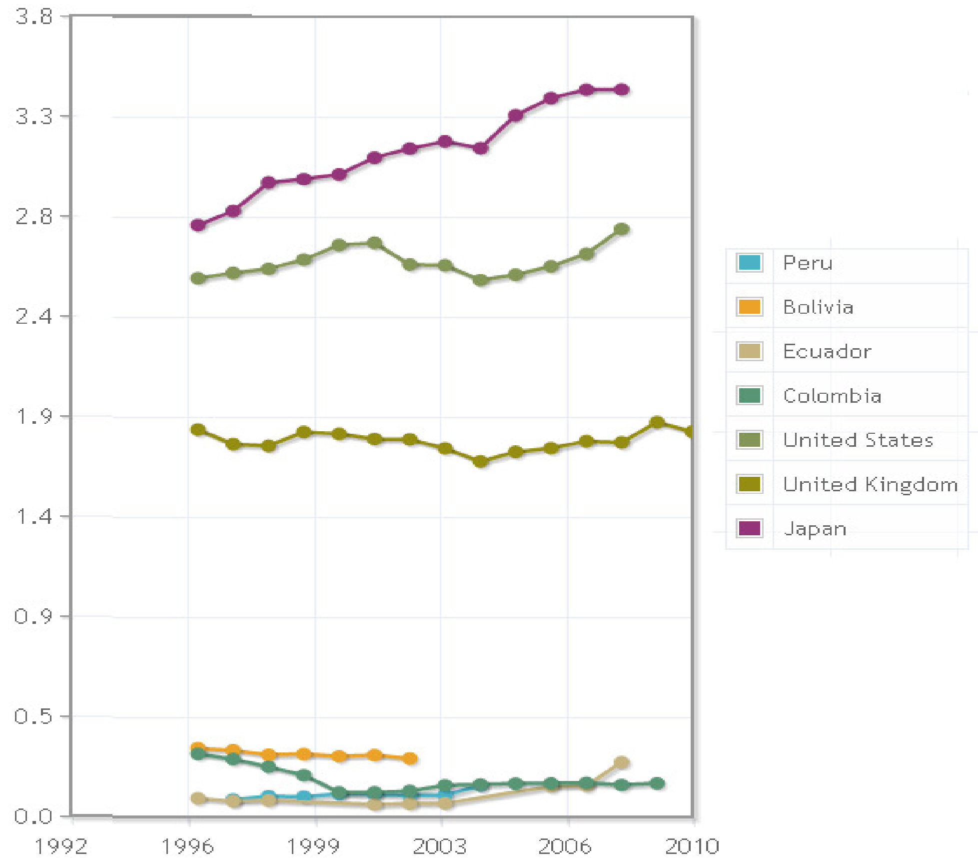
As illustrated by the case of maca, the ACN is ill-favored in a patent-driven IPR regime of science, but is not logistically ready for a civilian science regime. Rather the ACN would be best served to combine aspects of both these scientific regimes to produce a hybrid system that will accommodate the needs of a megadiverse and developing nation.

8. Financing Scientific Research

To begin, I will open our discussion about the maca bioprospecting case with discussions of finances. Though perhaps not the most colorful of subjects, any discussion on matters of scientific practice must constrain themselves to a realistic budget. Research on maca or other biological resources, whether through a patent-driven IPR regime or a civilian science regime, requires money. It is our aim therefore to examine the practicality of either model of science from a financial perspective. Ultimately I will conclude that patent-driven IPR brings in the funds and human resources that are required to get the research going in fields of study that civilian scientists would never consider to investigate.

Peru and other nations of the ACN have limited budgets to devote towards research, and thus could stand to benefit from investments from patent-driven IPR companies. Between 1996 and 2004 Peru's average expenditure on research and development was just over 0.1% of its GDP (which was on average 57.6 billion USD). This science budget totals around 60 million dollars—a small budget that has been cited as being a major impediment to Peruvian researchers (UNCTAD 2012). Of that budget, only a small percentage is devoted to agriculture biotechnology projects (only $0.43 million USD in 1995) (Falconi 1996). Other sources of funding for research and development come with constraints that make them unusable. For example, between 2004 and 2011 the mining industry awarded the Peruvian government USD $650 million that went unspent due to restrictions on its use. Years after the issues of maca had reached a stalemate Prime Minister Juan Jimenez launched a US $100 million dollar program to bolster scientific research. Though this is considered to be the biggest stride forward in Peruvian research and development, it is noted that this budget is still quite small when compared to other neighboring nations (see graph below) such as Chile or Brazil or nations of the Global North (Peplow 2012).

This graph (IndexMundi 2013, **Image 14**) compares the percent of GDP invested into research and development between countries of the ACN and those of the Global North between the years of 1996-2009. Note the obvious disparity found between the levels of investment of nations of the ACN vs. nations of the Global North.



As outlined by Asheim et al (2009), scientific research, particularly that pertaining to biotechnology, requires a significant amount of high-risk investment. Asheim suggests that the ten percent rule with regards to bioprospecting would be an accurate model of the high investment risks taken by bioprospectors. Of all the species that exist in a megadiverse nation such as Peru, only a small percent (roughly 10%) of those can feasibly be researched. Of those researched species, only a small percent will provide any insight towards a commercially viable product. Of those potentially useful organisms, only a small percent will actually be successfully made into a product that will bring returns on that initial investment. Thus the governments of the ACN have

only a limited amount of money to spend on R&D would be particularly wary of putting their money in such a high-risk investment. This being the case, the initial investment by bioprospecting companies such as Pure World Botanicals was a critical step towards first establishing that maca was a commercially viable product. In researching maca, Pure World Botanicals invested over $1 million in the first three years of research (Vecchio 2007). These levels of investment were matched and expanded upon by other interested companies as well such as the Química Suiza partnership and Santa Natura (Gindin 2002). Thus the companies of patent-driven IPR acted as a catalyst for starting scientific research. Without this initial investment, serious research into the properties of maca would probably never have begun.

Based upon this evidence, patent-driven IPR regimes of science are actually beneficial to the ACN in terms of bringing in initial investments for research. Could a civilian science regime match this program? In the case of maca, the answer is “no”. In fact prior to the interest of international bioprospecting companies, interest in maca was all but dying out. Long regarded as a “poor person’s crop” at the end of the 1980s the crop was described by the National Academy Press (1989) as being endanger of domestic extinction. In fact it was not until patent-driven IPR exposed the commercial value of the plant that farmers began to re-cultivate it (this led to a sixty fold increase the number of hectares devoted towards maca cultivation (Hermann & Thomas Bernet 2009). Consequently, although it is acknowledged that civilian science programs are significantly cheaper to operate, research still needs an initial catalyst to spark the interest of the people. In this way money is a necessary first of a science regime—even a civilian science regime.

To conclude the argument for finances, it would seem that in this case the governments of Peru and other member-states of the ACN might logically favor a patent-driven IPR regime. The high-risk nature of researching biological resources requires a substantial amount of initial investment that the developing nations may be unable or unwilling to budget for without hefty evidence for

returns. Furthermore, civilian science programs, which achieve scientific advancements in matters of interest to the public might never turn their eyes towards ever investigating resources such as maca without the original investment of patent-driven IPR science.

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9. Lack of ability to enforce patents

Despite the heavy investments made by Pure World Botanicals and other bioprospecting companies, the scientific private sector in Peru remains small when considering the nation's neighbors or its other economic achievements. This can largely be attributed to fears that corporations have with trying to protect their intellectual property. As previously noted, despite the restrictions on traditional use imposed by patents such US Patent No. 6,267,995 or US Patent No. 6,552,206, the Peruvian government has deliberately ignored their guidelines. This dismissal of intellectual property rights, while good for the Peruvian people, makes biotech companies reluctant to invest in Peruvian bioprospecting projects. In order to assuage some of these fears the Peruvian government has signed a number of different agreements that have guaranteed the protection of biotech-related intellectual property including Government Decree no 26017, ACN Decision 345, Resolution no. 344 on the Cartegena Agreements, and the TRIPS agreements (Falconi 1996). However the ability to enforce these decisions is quite limited, and on occasion the language of the agreement is ambiguous enough to still stir worries amongst investors (*ibid*). The case of maca suggests that the ACN governments might deliberately not enforce their end of the bargain in a patent-driven IPR regime. Thus we conclude that the ACN is not fully willing to commit to a patent-driven IPR regime.

10. Lack of Human Resources

Coupled with the problems with attracting the business of bioprospecting companies is the problem of limited human resources. Both a patent-driven IPR regime and a civilian science regime require scientists to function. In 1996 Falconi reported that there were only 30 professionals involved in agricultural biotechnology within all of Peru—only three of which were PhD holders. This issue is largely linked to the lack of funding not only for research, but also for graduate students and postdoctoral fellows. Without the ability to fund full-time researchers, any aspiring researchers Peru produces often leave the country and lose their connection to the Peruvian scientific networks (Alcázar-Román and Saito-Diaz 2011). The result is a Peruvian brain-drain which limits Peruvian interaction with professionals in foreign institutions (Falconi 1996).

The lack of human resources is also of course a potential impediment towards instituting a civilian science regime. Although within the civilian science movements of the Global North titles and rankings within academia are given little value, critical thinking skills and the ability to problem-solve on technical issues are the foundation upon which civilian science operates. Therefore one must further consider the lack of professional researchers as an impediment to both patent-driven IPR regimes and civilian science regimes. However it is worth noting that civilian science regimes do not put as much stake into professional or institutional training. Therefore, while still not ideal for implementing a civilian science regime, one might conceive of how member-states of the ACN are closer to achieving a civilian science model than a patent-driven IPR model that pulls heavily on human resources.

11. Avoiding the Race to the Bottom

Based upon the previous discussion of finances, one might conclude that the ACN would want to immediately adopt a patent-driven IPR regime of science because of the initial financial gains from cutting deals with the Global North. But as I will see in this section, the pressures to attract investments from international research corporations often can lead to what socio-economists call "the race to the bottom". This phenomena, associated with making deals cheaper or removing regulations for conscientious environmental or socially-just practices, overall leads to less net gain by the competing nations (in this case the member-states of the ACN). As I will discuss here, the ACN was formed specifically to prevent such a race to the bottom. These practices of regional cooperation work directly against the principles of patent-driven IPR regimes, and instead would favor a civilian science practices.

One of the major problems with implementing a patent-driven IPR regime within the ACN is that the ACN is a regional entity. Within the borders of the ACN there are many different ecological zones that span international boundaries. This means that bioprospecting companies from the Global North have their pick as to which nation to go to with offers of bioprospecting contracts. Furthermore, many of the indigenous groups within the ACN also span national boundaries. Thus individual groups can also be targeted and pitted against each other in terms of negotiating contracts for contributions and benefit sharing. This ultimately leads to a "race to the bottom" in terms of probing cultural knowledge and gaining permission for studying biological resources of interest (Muller 2000). This also means that, as seen in the case of maca, not all members of that culture agreed to sharing their heritage with researchers from Pure World Botanicals. Many of them were not even consulted or given any form of compensation (Landon 2007). This is evidence that such a patent-driven IPR regime is poorly suited to function within the ACN.

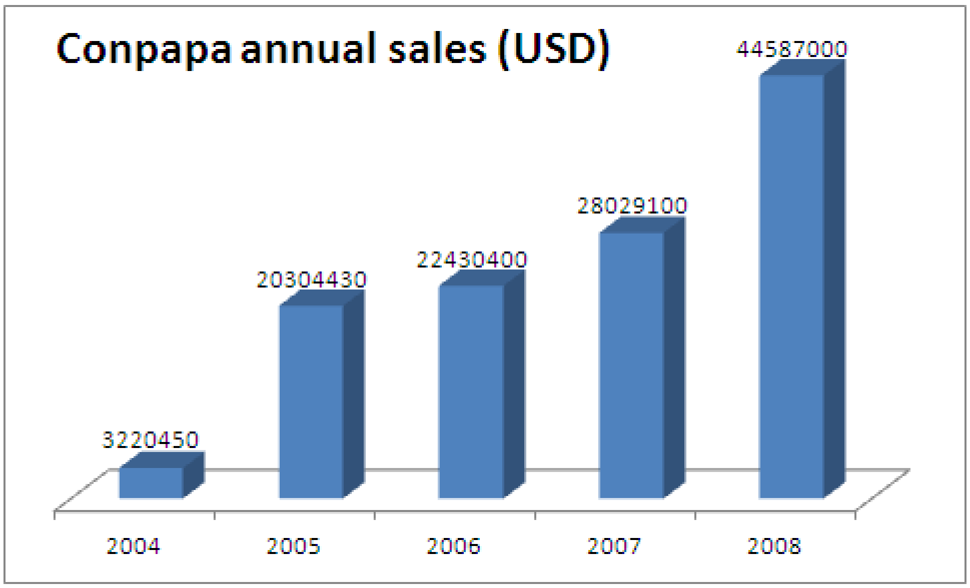
In fact avoiding the race to the bottom has been a matter of interest for the ACN since before the protection of maca became a concern. Since 1993 regional agreements including *ACN Decision 345 on a Common Regime on Plant Breeders Rights* and *ACN Decision 391 of the Andean Community on a Common Regime on Access to Genetic Resources* created the first regional framework for protecting the intellectual property of biological resources (Muller 2000). Thus, when bioprospecting companies would come to the ACN, they would operate in a way that would take into consideration the distribution of species and contributing parties across the region (Muller 2000). So despite the lure of initial investments in a patent-driven IPR regime, it is in the interest of Peru and other member-states of the ACN to avoid competing with each other in what will inevitably become a race to the bottom.

In contrast to the competitive nature of patent-driven IPR, the cooperation of a civilian science regime has been embraced by Peru. This can be seen in continued cooperation with the International Potato Center (IPC). The IPC's projects such as Papa Andina and IssAndes united over a thousand maca farmers that share similar farming strategies and cultural backgrounds from across the ACN[24] . To better achieve research and innovation on maca and other Andean tubers (primarily the thousands of different potato varieties that grow in the Andes) the IPC has coupled agricultural research with efforts to combat poverty. These efforts involve the development of market chains, creating niche markets, and the invention of new products. This provides incentive for farmers to conduct agricultural research to make their agricultural products pest-resistant, disease resistant, hardier, more flavorful, and longer lasting. As of 2009 the IPC's Papa Andina sub-projects such as the Potato Farmer Consortium (CONPAPA) had captured 7% of restaurant and processor demands and were experiencing 30-40% profit margins. Furthermore the IPC's concentration on developing new, niche markets for maca and other Andean tubers has maintained a steady demand for maca products. And while these efforts are ultimately driven by the desire for

[24] Particularly in Peru and Ecuador.

increased profits, maintaining guidelines for market chains has so far diffused competition between farmers and led to what the IPC considers being one of its greater ACN success programs (Devaux 2009). Thus, not only is the race to the bottom avoided, but cooperative research efforts in what amounts to a civilian science regime have acted to better the community.

Image 15 below shows the annual sales in USD from farmers associated with one of Papa Andina's new institutional organizations, CONPAPA. Steady growth in sales has been largely the result of diversifying into many lines of product and developing niche markets.



Images 16 (left) and **17** (right) show some new products that have allowed maca farmers to diversify and find niche markets for their produce.

To conclude the arguments for international cooperation over competition, it would seem to be in the better interest of the ACN to set up international organizations such as Papa Andina that unite farmers as commercially-driven innovators. This, while perhaps not producing quite as big of a pay-off as signing bioprospecting patents from the Global North, insures that all people that contribute to the production of cultural knowledge that contribute to bioprospecting will be fairly compensated. By creating organizations that cross international borders, the race to the bottom becomes a race to innovate.

12. National Sovereignty

A further concern for the Andean Community of Nations over the regime of patent-driven IPR is the effect that it has on each member-state's national sovereignty. Over the years the ACN has collectively passed a number of regional laws that are aimed specifically to protect and maintain national control of biologically-related resources. The most important of these laws was *Decision 391 of the Andean Community on a Common Regime on Access to Genetic Resources* which was first constructed in 1993 as a direct consequence of the Convention on Biological Diversity (CBD)[25]. The overall goal of Decision 391 was to provide a fair, regionally-based agreement that would 1) regulate access to benefit sharing (ABS) and 2) seek to provide adequate compensation for internationally distributed parties[26] that contributed towards bioprospecting findings. This formed the first regional cartel in the developing world to protect against the exploitation of biodiversity. It also emphasized respect for national sovereignties within the region was paramount (Muller 2000).

[25] Signed into effect three years later
[26] Such as indigenous groups that range across international borders.

Faced with a patent-driven IPR regime, the ACN has been pushed to pass increasingly restrictive laws to regulate its biological resources. In addition to Decision 391, further protective ACN agreements include ACN Decisions 486, 523, and the ACN Resolution on the Biocan Project. These Decisions not only imposed further restrictions and guidelines on the practice of bioprospecting, but also called for more regulation in future legislation regarding these practices. The Regional Strategy on Biodiversity for Tropical Andean Countries, also known as the ACN Decision 523, opened with this statement:

> "The Member Countries have sovereign rights over their own biological resources, pursuant to the stipulations of the Convention on Biological Diversity, and in particular over those resources of which they are the countries of origin; …
>
> It is necessary to intensify community action on the processes and international instruments needed to ensure more effective protection of the legitimate interests of the countries of origin of the biodiversity"

Andean Council of Foreign Ministers 2012

Such restrictions have been cited as major impediments towards the continuation of research and innovation within the ACN. This has been stated by not only researchers, but also by the Peruvian government. For example:

> *"Con el objetivo de ofrecer certidumbre a los usuarios de la biodiversidad y los recursos genéticos, y por tanto fortalecer el desarrollo comercial de la biotecnología a partir del uso sostenible de los recursos biológicos, genéticos y sus derivados y las inversiones en la cadena de agregación de valor,* ***es necesario adecuar y revisar la Decisión Andina 391"***
>
> In order to provide certainty to users of biodiversity and genetic resources, and thus strengthen the commercial development of biotechnology from the sustainable use of resources biological resources and their derivatives and investments in the value added chain, ***it is necessary adapt and revise Decision 391***[27]

Consejo Nacional de Política Económica y Social
de la República de Colombia

[27] Translation by author

The creation of these regional agreements, though limiting advancements in research and development, are enforced and regionally respected because of the concerns over national sovereignty. In the legal battle that ensued between the Peruvian Government and Pure World Botanicals, much of this protective legislation, including ACN Decisions 391, 486, and 523, as well as Peruvian Law 27811 were all presented by the Peruvian National Commission Against Biopiracy in defense for the revocation of maca patents US 6,297,995 (WIPO 2003). Despite these ample protections, the Peruvian government's struggles to keep maca within the public sphere demonstrate an effort that, as Hermann and Bernet (2009) note, not every developing nation will be able to match. Indeed, in their final closing remarks about the maca case, the Peruvian National Commission Against Biopriacy stated that the implementation of the TRIPS agreements and the regulations set by the CBD, while professing the values of national sovereignty, have been demonstrated through the maca case that these boundaries are ambiguous and not perfectly respected (WIPO 2003). Based upon this evidence, we are seemingly justified in concluding that concerns for national sovereignty are a valid reason why governments of the ACN might be disinclined to fully adopt a patent-driven IPR regime.

So if not a patent-driven IPR regime, how does a civilian Science regime compare in terms of national sovereignty? As demonstrated by the Papa Andina and IssAndes projects, civilian science, by its very nature of employing citizens, if anything enhances national sovereignty. As noted by the IssAndes projects, national sovereignty, particularly national food sovereignty and environmental sovereignty, are critical points that can make or break the civilian science programs (Paz et al 2010). These projects not only aim to make participating civilians independent and accountable for their own well-being, but also to care for the environment and the sustainability of their business practices. In contrast to the friction between the Peruvian government and bioprospecting companies, the Peruvian state has welcomed the efforts by the IPC to conduct research into the

many of its biological resources and to develop the social infrastructure around them. Examples of this agreement include the establishment of the world's largest potato park, the implementation of both the IssAndes and Papa Andina projects, (Shetty 2005) and the successful re-negotiation of the Host-Country-Agreements with Peru (IPC 2013). All this indicate that the civilian science programs with regards to maca and other Andean tubers do not threaten the national sovereignty of Peru to the extent as research under a patent-driven IPR regime.

To conclude, while a patent-driven IPR regime can cause concern over national sovereignty amongst the Peruvian government and amongst other ACN national governments, no such complaints over civilian science projects, such as those of ISSAndes and Papa Andina have been raised. This is because while a patent-driven IPR regime can infringe upon national and regional law, as seen in the case of maca, civilian science programs ultimately hold the citizens of the sovereign nation accountable for producing innovation to promote their own well-being. This is yet another argument for why a civilian science regime might be the preferred model for scientific discovery within the ACN.

13. National Pride

As a final reason for why a civilian science program would be better in the interests of the Peruvian government, I present the argument that such efforts often lead participants to develop a sense of pride. This national pride stems from recognizing the value in how one's culture provides modern insights to science. Participants may also gain a greater appreciation for their environment though continuous interaction. This sense of pride and identity is so important to the well-being of civilian scientists that Papa Andina has listed it in a separate section of benefits evaluation entitled "Livelihood outcomes". Particularly with reference to maca, farmers that are allowed to continue their cultivation and development of their crops report higher self-esteem from valorization of

maintaining their cultural assets (Papa Andina 2013). In contrast the appropriation of knowledge and access to knowledge that is found in the bioprspecting/biopiracy of a patent-driven IPR regime takes away cultural resources and identity. In the case of maca, the plant's temperamental life-cycle and preferred agricultural conditions were also part of the cultural knowledge that surrounded the plant. The threat of patenting, even for only a few years, meant that many of those culturally-derived agricultural practices were at risk of being lost (ETC Group 2002). By removing access to crops from the peoples that originally grew them future generations are dissociated from these biologically-rooted parts of their heritage. Thus cultural knowledge and the identity that comes with it are lost (*ibid*). Consequently, in terms of supporting the well-being of its citizens, Peru and the other member-states of the ACN might be better suited towards a civilian science regime rather than one of patent-driven IPR.

14. Summation of argument and concluding remarks

Despite remarks made by members of CAMBIA, evidence suggests that a patent-driven IPR regime of science does incur some benefits to mega-diverse countries of the developing world. As seen in the case of maca, patents motivate biotech companies from the Global North to explore the resources of countries like Peru and to commercialize those resources into new, marketable products. This increases the value of those bioprospected resources and thus creates a demand for them on the global market. However, as seen in the case of maca, many times the profits from increasing production or compensation for the cultural knowledge which led to innovation are not respected or adequately honored. Furthermore patents that restrict access or incur a fee to use the resources that were long-standing parts of a cultural heritage strike a blow against the giving nation's sovereignty and cause a loss of cultural identity.

In light of the negative effects caused by a patent-driven IPR regime, members of CAMBIA, PIIPA, and the IPC have suggested alternative ways to do science. One such alternative would be the regime of civilian science, which places a heavy emphasis on collective action, the sharing of information, and the distribution of benefits produced from the resulting innovation. Projects that have experimented with this alternative method of scientific inquiry have included the Papa Andina and IssAndes Projects of the International Potato Center. The projects have emphasized experimentation and innovation in the agriculture of maca and the development of niche markets. These efforts have not only led to innovations in pest-resistant crops, increased nutritional content, and hardier breeds of maca, but have also benefited the communities of some of Peru's poorest regions.

However civilian Science still has far to go before it could become the dominant scientific regime. For reasons of finance, communications infrastructure, and an educated populace, Peru and the other member states of the ACN are logistically not ready to drive their own innovation through a civilian science regime.

The case of maca indicates that Peru and the other member states of the ACN must strive for balancing the self-interested investment in innovation from the patent-drive IPR regime against the interest and benefits sharing of a civilian science regime. At present these two scientific models often compete and contradict each other. However, by selecting which parts of which regime are beneficial, the ACN would be able to create its own unique science regime. Such a regime would be fundamentally different from either science regime as it is practiced within the Global North. This would be a reflection of the unique interests and challenges that are part of doing science within a megadiverse and developing nation.

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