Ethnomedicine in the Amazon: Importance and Endangerment

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Abstract: The Amazon rainforest is a region of the world that is both biologically and culturally diverse. Knowledge of both flora and fauna has greatly contributed to the creation of pharmaceutical drugs with biomedical utility. Concomitantly, indigenous populations tend to know the medicinal efficacy of local flora and fauna. Unfortunately, biologically diverse regions of the world, like the Amazon, continue to be bombarded with seemingly inexorable destructive forces, such as gold-mining, mercury contamination, and deforestation, which harm both flora and fauna and indigenous groups. Thus, it is more important than ever to collaborate with indigenous groups concerning the medicinal efficacy of local flora and fauna that may have profound biomedical significance. Any collaboration, however, needs to be done ethically and in a culturally appropriate way and must ensure that indigenous groups are justly-compensated for their knowledge.

Keywords: Amazon, Deforestation, Endangered, Ethnomedicine, Indigenous

1. Introduction

The Amazon rainforest is one of the most biologically diverse regions of the world containing neotropical vegetation (Vanderbroek et al. 2004; Finer et al. 2008) and “over one-third of the Earth’s
known species” (Heckenberger et al. 2007). Almost one-half of the world’s tropical rainforest is located in Greater Amazonia,¹ which is “over an area larger than Europe (nearly one-third of South America)” (Heckenberger et al. 2007). Unlike abiotic objects, living organisms release natural products, broadly defined, into the environment through numerous mechanisms, some of which are described below. The seemingly innumerable natural products that come from the panoply of flora and fauna that typify biologically diverse regions, such as tropical rainforests (Nettle & Romaine 2000), have greatly contributed to the fields of pharmacology and medicine and continue to do so.

Both natural products and natural product derivatives have been foundational concerning the production of the majority of current pharmaceutical drugs (Li & Vederas 2009). Towards the end of the 1980s, approximately 80% of drugs were either natural products or analogs of natural products inspired by them. Antibiotics (e.g., penicillin, tetracycline, erythromycin), antiparasites (e.g., avermectin), antimalarials (e.g., quinine, artemisinin), lipid control agents (e.g., lovastatin and analogs), immunosuppressants for organ transplants (e.g., cyclosporine, rapamycins) and anticancer drugs (e.g., taxol, doxorubicin) revolutionized medicine (Li & Vederas 2009).

Additionally, 73% of approved cancer-related drugs for approximately the last sixty years are non-synthetic, “with 47% actually being either natural products or directly derived therefrom” (Newman & Cragg 2007). Natural products and their derivatives have come from both flora and fauna from different regions of the world: cyanobacteria and various marine organisms have been analyzed for “neurotoxic and cytotoxic compounds” (Li & Vederas 2009); *Papaver somniferum* yielded morphine (ibid); fermentation products from endophytic fungi have been paramount for commonly-used antitumor agents (Newman & Cragg 2007); quina alkaloids laid the foundation for malaria drugs (Botsaris 2007); *Actinomyces* produce a compound commonly referred to as actinomycin D, which is used to treat some forms of cancer (Mukherjee 2010); etc. While not all pharmaceutical drugs grossing the same net revenue, pharmaceutical companies continue to make an incomprehensible profit (for more on the pharmaceutical industry, see Farmer 2005). Larkin (2011) and Newman and Cragg (2007) note that, for example, Lipitor, a cholesterol-related drug derived from a natural product, has continuously been one of the most successful drugs worldwide yielding billions of dollars in revenue. Given the surfeit of pharmaceutical drugs currently on the market derived from both natural products and their derivatives, maintaining and preserving the biodiversity of the earth, which includes the peoples that live in such biodiverse regions, may be critical for the continuation of novel drug development.

¹ The Greater Amazonia is the Orinoco and Amazon River basins (Heckenberger 2007).
2. Biodiversity and Linguistic Diversity

According to research conducted by Nettle and Romaine (2000), regions of biological diversity correlate to regions of linguistic diversity. The relationship between biological diversity and linguistic diversity form a “common repository,” which Nettle and Romaine (2000) refer to as *biolinguistic diversity*, or “the rich spectrum of life encompassing all the earth’s species of plants and animals along with human cultures and their languages.” Furthermore, indigenous peoples tend to inhabit areas with the most biolinguistic diversity (Nettle & Romaine 2000). Brazil’s indigenous populations alone, as a large presentation of the Amazon, comprise 206 societies with 195 different languages (Carneiro da Cunha & de Almeida 2000). From early *Australopithecines* to *Homo sapiens*, hominids have been biologically and culturally influenced by both plants and animals (Phillipson 2005). The influence ranges from dietary changes caused by climate changes, which may have led to the increasing complexity of the hominid brain (Kolb & Whishaw 2011), to a fascination with animals, which eventually culminated in artistic expressions of these animals on the walls of various caves in Africa (Phillipson 2005). Continuing through the present, plants and animals play a monumental role in cultures throughout the world. For example, in Orthodox Christianity, it is believed that the universe was created having mineral, plant, animal and human dimensions with “harmony between the human dimension and the mineral, plant and animal dimensions” (Greek Orthodox Archdiocese of America). It has also been argued that humanity’s interaction with both plants and animals has led to the development of religious thought, society, and culture and that this development eventually yielded traditional remedies for various forms of pathology (see, for example, Durkheim 1912(2001); Freud 1913(1989a), 1927(1989b), and for a counter-argument, see a classical critique of modern theories of religious development presented by Schmidt 1935).

3. Biodiversity Endangerment

While “many believe that the demands of the contemporary world will soon lead to the large-scale destruction of biodiversity and ecological integrity” (Heckenberger 2007), large-scale destruction is currently being witnessed both daily and hourly. Concerning animal species, the paleontologist Niles Eldredge and the biologist E.O. Wilson estimate, respectively, that anywhere from one species a day to three species an hour are becoming extinct (Nettle & Romaine 2000). Concerning the Amazon,
extinction of both plants and animals occurs due to environmentally destructive forces such as gold mining and deforestation (Mitten 1997). While much of the Amazon has been reserved for indigenous populations—for example, half of the Brazilian Amazon is “officially recognized indigenous land”—“high rates of deforestation in indigenous lands were generally associated with exploitation or invasions from nonindigenous populations that had occurred prior to reserve demarcation” (Nepstad et al. 2006). Peterson and Heemskerk (2001) note that deforestation caused by small-scale gold mining may be minor in the Suriname Amazon, but the impact is still severe since the “mined sites will remain deforested for at least a decade, if not longer.” Oil and gas projects in the Western Amazon are currently having direct social and environmental impacts; e.g., “direct impacts include deforestation for access roads, drilling platforms and pipelines, and contamination from oil spills and wastewater discharges” (Finer et al. 2008). Indigenous leaders from various groups have stated that U.S. companies have dumped “billions of gallons of toxic waste into the forest” (Finer et al. 2008). Some of these oil and gas projects are taking place in areas where indigenous peoples live in voluntary isolation. These groups are “extremely vulnerable because they lack resistance or immunity from outsiders’ disease…and first contact results in high rates of morbidity and mortality, with mortality estimates ranging between a third and half of the population within the first several years (Napolitano & Ryan 2007)” (Finer et al. 2008).

Li and Vederas (2009) have stated that “it has been suggested that 15,000 out of 50,000 to 70,000 medicinal plant species are threatened with extinction (Brower 2008).” Concomitantly, both Eldredge and Wilson give grim estimates, mentioned above, concerning the extinction of animal species. While it may be true that without flora and fauna the quest for new pharmaceutical drugs will be greatly diminished, we hope to also argue that another equally important quandary for continuous novel drug development is the loss of indigenous knowledge through various structural forces, such as deforestation and gold-mining.

4. Culture and Ecology

Influenced by the German and humanistic concept of Kultur (Bohannan & Glazer 1988; Buckley 1996), the “midmorning of the “museum age”” in anthropology (Jacknis 1996), and the tripartite conceptualization of the evolution of society, the famous English anthropologist Edward

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3 It has been estimated that if insects were to disappear altogether, “humanity probably could not last more than a few months” due to the adverse impacts on the entire ecosystem ranging from amphibians and mammals to the rotting of land surface (Nettle & Romaine 2000).
Burnett Tylor gave the following well-known and often-cited definition of culture in his book *Primitive Culture*:

Culture or Civilization, taken in its wide ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society. The condition of culture among the various societies of mankind, in so far as it is capable of being investigated on general principles, is a subject apt for the study of laws of human thought and action (Bohannan & Glazer 1988).

Another definition of culture comes from the famous postmodern anthropologist Clifford Geertz, who used a process he referred to as “thick description”—which “takes into account the fact that any aspect of human behavior has more than one meaning” (Bohanna & Glazer 1988)—to define culture as “one that denotes an historically transmitted pattern of meanings embodied in symbols, a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life” (Geertz 1973). Although there are numerous definitions of culture that either add or omit certain nuances, a general definition of culture as “the complex learned behaviors passed on from generation to generation” (Kolb & Whishaw 2011) is more than apt for the current discussion. Culture is a key component that aids in the transmission of knowledge from one generation to the next. That includes knowledge of the ecosystem that may have medicinal application.

It is through a “historical continuity of resource use practices” that indigenous peoples “often possess a broad knowledge base of the behavior of complex ecological systems in their own localities” that they are able to pass on from generation to generation (Gadgil, Berkes, & Folke 1993). Part of the reason indigenous peoples possess this knowledge is that, as Vanderbroek et al. (2004, emphasis added) state, “the tropical rainforest is a resource base for a plethora of indigenous communities who depend on knowledge of forest use for their livelihood.” Furthermore, medicinal plant knowledge is a “social product” that is part of the specific cultural system and is not evenly distributed to every member of a particular group; that is, there is usually a distinction between laypersons and specialists (Vanderbroek et al. 2004) in the same way there is a knowledge distribution in “developed” countries between laypersons and those with biomedical training. Vanderbroek et al. (2004) conducted a study comparing medicinal knowledge in an Andean community with an anthropogenic environment to an Amazon community in a relatively isolated environment. They observed that “social variables, specifically the healing tradition of the extensive family, rather than the level of plant biodiversity of the study area, are important for medicinal plant knowledge of traditional healers,” which further

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4 For more on what characterizes culture, see Kroeber and Kluckhohn (1952); Murdock (1965).
corroborates the significance of social transmission of traditional ecological knowledge.\textsuperscript{5} Both culture and the social transmission of cultural ideas are important factors as for the significance of the use of various forms of traditional medicine throughout the world.

In the American Southwest and Mexico, traditional medicine, in the form of herbal remedies, Shamans, and Curanderos, continues to play a vital role in ethnic and religious identity (see, for example, Perrone, Krueger, & Stockel 1993; Torres 2005, 2006). Curanderismo is also a supplement to or replacement for biomedicine, specifically when access to healthcare services is non-existence or when the efficacy of biomedical treatment is not readily apparent. The Hmong refugees living in California and Wisconsin also rely on Shamans and herbal remedies “for treating colds, fevers, headaches, and menstrual pains…if they (women) do not know how to cure the illness themselves, they have the principal responsibility to seek out therapies from other individuals who do know, usually an herbal specialist” (Koltyk 1998; for more on the dialogue between biomedicine and Hmong traditional beliefs, see Fadiman 1997).

The Ohlone and Pomo of California have a material and symbolic relationship with the mollusk abalone (Field 2008), and the Kayabi of Brazil believe “the most obvious causes of soul loss (which is suspected when one experiences prolonged or serious illness) involve the treatment and preparation of game,” which then requires intervention by a shaman since “The Masters of the Game are vengeful when one of their charges is not treated properly” (Oakdale 2005). Concomitantly, the Trinitarios of Bolivia, somewhat similar to the Kayabi, also believe that, in some instances, soul loss (susto) is related to the killing of an animal, which then results in upsetting the “master of the animal species,” who will “take revenge by taking one of the killer’s souls, or that of his kinsmen’s…” (Thomas \textit{et al.} 2009). Thomas \textit{et al.} (2009) further report that susto is caused by both social and biological factors and that the Trinitarios have an ethnopharmacological repository of 38 different species of plants that are used to treat susto.

To reiterate an important theme, flora and fauna are integral parts of culture and society throughout the world. Gadgil \textit{et al.} (1993) observe that medicinal and pharmacological knowledge is inexorably linked to a society’s worldview, which tends to be “closely integrated with moral and religious belief systems, so that knowledge, practice, and beliefs co-evolve.” Many have argued (see, for example, Harris 2004; Hitchens 2007; Dawkins 2008) that such belief systems should be relegated to ancient fairy tales that serve no ostensible purpose in modern society. Such vitriol disregards the structural violence—i.e., the pathogenic role of social inequality that manifests itself in biological pathology—that has birthed such belief systems and are primarily due to an unfortunate lack of

\textsuperscript{5} Gadgil, Berkes, and Folke (1993) define traditional ecological knowledge as “a cumulative body of knowledge and beliefs handed down through generations by cultural transmission about the relationship of living beings, (including humans) within one another and with their environment.”
thinking “historically deep and geographically wide” (Farmer 2005). Both communicable and non-communicable diseases have a preferential option for the poor, and the poor usually do not have or have inadequate access to healthcare services (for more on structural violence, see Boff 1987; Scheper-Hughes 1993; Farmer 2001, 2005, 2011; Rylko-Bauer, Whiteford, & Farmer 2009). The World Health Organization (WHO) estimates that up to 80 percent of the world’s population relies on plant and animal-based medicines (Alvez 2005; World Health Organization 2008) as indigenous knowledge remedies based on plant and animal parts and byproducts is a common practice and sometimes the only method of treatment available (Alves 2008). Seen through the lens of medical anthropology and public health, traditional medicine, for the vast majority of cultures and societies, becomes the last option (or the only option) to combat morbidity and mortality. Although it is beyond the scope of this paper to analyze the ontological and cosmological claims of indigenous groups and although not all ethnopharmacological concoctions have an ostensible physiological effect on biomedically-defined pathology, it is possible to briefly analyze the role of indigenous ethnomedicinal knowledge on the biomedical community and to see that it has, indeed, served a purpose in the modern era.

5. Indigenous Remedies with Biomedical Application

The antimalarial botanical drug quinine comes from the bark of Cinchona trees in South America, and it has antimalarial analgesic, anti-inflammatory, and antipyretic properties (Center for Disease Control and Prevention 2010). Quinine was first revealed to Europeans during the 17th century, but it was originally discovered by native Andeans in Peru and Bolivia to treat malarial fevers (Desowitz 1991; Center for Disease Control and Prevention 2010). Furthermore, quinine was the drug of choice to combat malaria until the 1940s when the synthetically-produced chloroquine became the primary pharmaceutical choice due to its prophylactic effect (Desowitz 1991). Prior to the Andean discovery of the efficacy of Cinchona bark to treat malarial fevers, practitioners of Chinese traditional medicine had discovered an even more potent antimalarial drug from the plant Qinghaosu (Artemisia annua) (Center for Disease Control and Prevention 2010). Desowitz (1991) writes of the rediscovery of Quinhaosu:

…in the 1960s the Chinese Communists were turning inward; Western thought—including the Western system of medicine—was rejected as wrong and corrupting. In 1967, the Chinese, under Mao, began a systematic search of their ancient medical manuscripts for remedies to expand their traditional herbal pharmacology. In a book written by Ge Hand in A.D. 340, The Handbook of Emergency Treatments, mention was made of the remarkable febrifugal properties of sweet wormwood (Artemisia annua) in the treatment of periodic fevers.
Chinese researches would then go on to discover the extremely potent antimalarial properties of Qinghaosu to develop a class of drugs known as artemisinins, which eventually would be used to treat chloroquine-resistant strains of *Plasmodium falciparum* and cerebral malaria (Desowitz 1991; Center for Disease Control and Prevention 2010). It is now a first-line drug against “uncomplicated falciparum malaria” (White 2008).

Upon recent analysis of records from an early 20th century Brazilian pharmaceutical laboratory, Flora Medicinal, Bostaris (2007) writes that “eight species are reported as antimalarial for the first time: *Bathysa cupsidata, Cosmos sulphureus, Cecropia hololeuca, Erisma calcaratum, Gomphrena arborescens, Musa paradisiacal, Ocotea odorifera* and *Pradosia lactescens*.” Interestingly enough, the medical doctor José Monteiro da Silva, who ran the laboratory, gathered ethnographic information which revealed that “some plants are referred to enhance the action of other herbs, which can indicate an increase on permeability of the *Plasmodium* membrane to antiparasitic substances, or an inhibition of pump mechanisms of eliminating drugs” (Bostaris 2007). Further collaboration with indigenous tribes that understand, through trial and error over the years (decades, and centuries), how certain combinations of plants can enhance the medicinal effect of other potent plants, could prove to be invaluable.

Antimalarials are not the only drugs inspired directly from indigenous knowledge of plants. Lizcano *et al.* (2010) analyzed the antioxidant activity of various Colombian Amazonian plants that are used in folk medicine, and they found that a handful of species—*Piper glandulosissimum, Piper krukoffil, Piper putumayoense* and *Brownea rosademonte*—“showed elevated antioxidant activities, thus representing promising sources of plant-based medicine.” In 1989, Loren McIntyre from *National Geographic Magazine* wrote an article on the Urueu-Wau-Wau tribe of the Amazon in which she described how the Urueu-Wau-Wau use a sap from the tiki uba trees to tip their arrows when hunting (McIntyre 1988; Posey 1998). Merck, the U.S. pharmaceutical company, “confirmed that the bark contained at least one compound that inhibited enzymes that cause blood clotting and efforts immediately began to commercialize a product (an anticoagulant) useful in heart surgery” (Posey 1998). Finally, the plant *Pilocarpus jaborandi*, originally used by the Guajajara Indians of Brazil, is continually exported for the purpose of treating glaucoma (Posey 1998).

Although the aforementioned examples deal exclusively with plants that have biomedical application, animals produce a vast array of unique chemical compounds that have been and in some cases may yet prove to be useful as treatments for ailments running the gamut from head and earaches to cancer or tuberculosis (Alves 2008; Costa-Neto 2010). Both animal byproducts (venoms, secretions, feces, urine, *etc.*) and anatomy and physiology (fats, bile, blood, leather, hair, feathers, suet,
etc.) in conjunction with medicinal plants have been used widely in traditional medicine and prior to the advent of biomedicine (Alves 2005; Costa-Neto 2005).

The indigenous populations of Brazil are known to use from 30 (Costa-Neto 2010) to 37 (Alves 2008) different medicinal animals in treatment of illness or pain, depending on the region surveyed, with a recorded total of over 180 species used in Brazil and surrounding countries (Alves 2005; Costa-Neto 2005). Many of these ethnopharmacological products have yet to be studied to determine their usefulness in biomedicine; however, the plethora of agents used lend to the potential ethnomedical significance of examining the compounds at work in these treatments (Alves 2005).

The use of dangerous toxins has also proved to be a source of biomedical raw material, the examination of which could create the next miracle cure. Of the approximately 150 prescriptions used in the US today, 27 have animal origins (World Resources Institute 2000). Study of these species needs to be done while they still exist and before they become victims to the aforementioned extinction rates. As shown by the rapid disappearance of the golden toad (Bufo periglenes) of Monteverde within the span of a few years, the presence of highly evolved chemical substances that can potentially be used for the creation of new biomedical treatments could disappear as well (Butler 2006).

Venom is a highly specific cocktail of unique proteins, enzymes, and short chain peptides (Karalliedde 1995). Each compound is specific for one designated target, commonly as a competitive inhibitor for an enzyme or for the purpose of targeting ion channels such as “pore blockers” or voltage mediators. Given these chemical properties of venom, venoms from snakes, scorpions, spiders, caterpillars, lizards and marine animals have proven to be a valuable source for understanding how ion channels operate (Bogin 2006). Venoms have hundreds of chemicals that target various potassium (K⁺), sodium (Na⁺), and calcium (Ca²⁺) ion channels, which can either stimulate muscle contraction to produce tetany, or block the passage of ions thus preventing muscular contraction by either inhibiting transmission of acetylcholine across the synaptic cleft or by causing paralysis in the affected muscle by preventing the transmission of action potentials at the Nodes of Ranvier in myelinated nerves (Karalliedde 1995). With the specificity of peptides in venoms, a multitude of potential drugs could be derived by the venoms found in the Amazon, provided the region remains preserved and the flora and fauna are responsibly harvested to prevent extinction or disturbance of natural balance (Costa-Neto 2005).

The usefulness of venom as a pharmaceutical agent is undeniable given the case of the Bothrops jararaca, commonly known as the Brazilian Pit Viper. Banana plantation workers in Southwest Brazil were known to collapse due to a rapid drop in blood pressure after being bitten by Bothrops jararaca (Patlak 2003). In 1970, at the Royal College of Surgeons in London, Sir John Vane and Mick Bakhle acquired a vial of venom from Sergio Ferreira, who was, at the time, a postdoctoral
trainee at the Faculty of Medicine of Ribeirao Preto of the University of Sao Paulo. They began to integrate the venom into their study of the renin-angiotensin system and discovered that it strongly inhibited angiotensin converting enzyme (ACE), which converts angiotensin I to angiotensin II. Soon after this discovery, they developed the ACE inhibitor Captopril (1975) for the pharmaceutical company Bristol-Myers Squibb Pharmaceutical. Captopril is used to treat high blood pressure by preventing the conversion of angiotensin I to angiotensin II by ACE (Patlak 2003).

A few venom toxins have been approved by the Food and Drug Administration (FDA) as therapeutic drugs, and many are in clinical trials to treat pain for both neurological and cardiovascular diseases (Bogin 2006). A potential natural alternative or supplement to Viagra that is derived from the venom of the Brazilian Wandering Spiders (*Phoneutria fera*) is now being tested. The venom from the bite of the Brazilian Wandering Spider commonly causes individuals to be afflicted with four hour long priapism (Saez et al. 2010). While Viagra prevents penile blood from exiting the appendage and thus prolonging erection, the venom actually promotes nitric oxide to stimulate the entry of blood into the spongy tissue of the penis, potentially making it an alternative for those who don’t respond to Viagra (Saez et al. 2010). Components in scorpion venom are being studied in the treatment of inflammatory neuropathies, autoimmune disorders (as an immunosuppressant), and cancer (Petricevich 2010). Concomitantly, Saw Scaled Snake (*Echis carinatus*) venom is known to have anticoagulant properties and could potentially be used to develop drugs to treat strokes or embolisms (Karalliedde 1995). Similar effects are noted from envenomation by *Lonomia* caterpillars in Brazil (Malaque 2006).

Like venom, frog poisons contain many potentially useful compounds, including steroidal alkaloids and peptides, and have demonstrated anesthetic, analgesic, and tranquilizing properties (Patocka 1999). Raw, un-altered poisons are used by shamans of indigenous tribes to promote well-being and a heightened state of awareness; such is the case at the Campinas Indian Reserve in Brazil where the Katukina tribe uses the Kambo frog (*Phylomedusa bicolor*) to hunt (Prada 2006). The frog vaccine, as the Katukina refer to it, is not a vaccine, though it has interested pharmaceutical companies abroad who already have toxins from this frog patented for testing potential pain killing or tranquilizing effects (Prada 2006). The study of the long term effects of this toxin on humans can be undertaken by directly studying the tribal people (particularly hunters and shamans) of the Katukina, and a broader understanding of the toxin itself could be derived from studying its natural environment.

The Poison Dart Frog’s name comes from the indigenous tribes of the Amazon who use the secretions from the back of this species on blow darts for the purpose of hunting (Patocka 1999). Frogs from the family *Dendrobatidae* do not produce their own toxins; rather, they acquire it through the insects that they eat which contain various alkaloids that the frog can process and store for release during secretions (Alto 2011). Likewise, the secretions of *Phylomedusa*, called dermmorphin, have
been shown to be 1000 times more effective than morphine at equal dosage levels (Costa-Neto 2005), which could mean both a cheaper and more effective pain treatment for intractable pain than already exists, given that proper research is conducted into the chemical basis behind these analgesic effects.

Poison dart toxin could be easier to study than venom. Unlike snake, fish, mammal and insect venoms, frogs are relatively harmless given proper handling and protection. The delivery system for venoms involve penetration of an organism’s cutaneous layer by means of a bite or sting to inject the toxin, whereas the frog toxin is designed for defense against predation when the frog is ingested as opposed to the toxin being injected (Patocka 1999). It is much simpler to lightly scrape the toxic slime from the back of a frog that will not bite than to illicit a bite response from a snake in order to “tap” the fang of its resources.

For many of these treatments, there is prospective value for the medicinal properties. Studying the treatments’ efficacy and to examine whether the remedies actually hold any medicinal value or are just a psychosomatic response to the intended result, as in a placebo, could result in not only better medication, but may also be a major source of revenue for the developing countries in which they originate (Prada 2006). Drugs such as ephedrine and digitoxin have been discovered through the application of indigenous knowledge of the animals from which they are produced (Alves 2005). Unfortunately, indigenous knowledge, flora, and fauna in the Amazon are more endangered now than ever before. Deforestation and gold mining have put numerous species at risk, such as the caiman and the alligator (Brazaitis et al. 1996) whose skin and leather is used to treat epilepsy and rheumatism, respectively, in native traditional medicine (Alves 2008; Costa-Neto 2010). These crocodilians live in the direct path of the fallout caused by gold mining and deforestation (Brazaitis et al. 1996). Unfortunately, indigenous populations in the Amazon are also profoundly affected by many of the factors that threaten flora and fauna.

6. Structural Violence and Ecological Destruction in the Amazon: Gold-Mining

Ever since their first contact with Europeans through Spanish conquest of the “New World”, the indigenous peoples of South America have been faced with many challenges which must be overcome in order to maintain their sense of cultural identity and knowledge. Some of the challenges which indigenous South Americans have been faced with include: acculturation through various political and religious means (Mitten 1997; Andersen 2010), exposure to devastating illnesses

6 Historically, the Catholic Church and educational institutions have also been used to “modernize” indigenous people, though liberation theologians have been making numerous strides for over the last half-century to both identify and ameliorate structural violence (for more on liberation theology in South America, see Boff 1987; Gutierrez 1988; Farmer
(Tierney 2002), political conflicts concerning land and human rights (Andersen 2010; Farmer 2011), and deforestation (Mitten 1997; Diamond 2005). In many countries in South America, indigenous peoples have been given few rights and live as subalterns (Mitten 1997); e.g., the Chilean Mapuche’s struggle for cultural integrity and a political voice (Schlosberg & Carruthers 2010); the Brazilian Xavante’s pragmatic inability to inhabit the land their ancestors once lived on (Nepstad et al. 2006); the enslavement and dislocation of the Ashaninka of the Peruvian and Brazilian Amazon for the purposes of the rubber trade industry (Salisbury et al. 2011). When biological factors, such as pathogens, afflict indigenous peoples, loss of culture and knowledge may be seen on a large scale as societies begin to rapidly diminish in size and number (see, for example, Mitten 1997; Tierney 2002; Diamond 2005). While the biological factors may show a means by which loss of knowledge may be more obvious, factors involving environmental, social, and political challenges may not be as obvious.

Gold mining in the Amazon provides an example of such structural forces.

A major reason for the Spanish conquests of Central and South America in the early sixteenth century was the legendary Aztec and Inca hoards in Mexico and Peru, respectively, and prior to about 1830 a large proportion of the world’s stock of gold was derived from ancient and South American civilizations (Greenwood & Earnshaw 1994). The modern production of gold depends on the mining of the gold-containing rock. The gold-containing rock is crushed to a fine powder to liberate the metallic grains. These grains are extracted either by the cyanide process, or by amalgamation with mercury (Hg), after which the mercury is distilled off (Greenwood & Earnshaw 1994). In 1979, a major “gold rush” began in the Brazilian Amazon, and, over time, that brought several hundred thousand persons to the region searching for riches. However, biogeochemical studies showed that these uncontrolled gold-mining activities released thousands of tons of mercury into the environment. Increased levels of this metal were reported in water, sediments, and fish, and gold mining became synonymous with mercury pollution (Passos & Mergler 2008).

Mercury contamination of the large Amazon Basin has been a very concerning subject over the last two decades (Passos & Mergler 2008). Mining of gold is an important anthropogenic input of mercury to the environment (Mousavi et al. 2011). However, gold mining in the developing world...
also causes the major environmental threat of deforestation (Swenson et al. 2011), and studies have shown that Amazonian soils constitute major natural mercury reservoirs that release substantial amounts of the metal into the aquatic ecosystems through soil erosion and leaching resulting from deforestation practices, such as “slash and burn” agriculture and/or cattle raising (Passos & Mergler 2008). It is noteworthy that Swenson et al. (2011) find that since 2003, recent mining deforestation in Madre de Dios, Peru, is increasing nonlinearly alongside a constant annual rate of increase in international gold price (~18%/yr).

In 1999, symptoms of Minamata disease were found in fishing villages of the Amazon rainforest (Pearce 1999). Minamata disease is monomethylmercury (HgCH$_3$+) poisoning, named after Minamata, Japan, where industrially related mass poisonings, debilitation, and deaths occurred between 1950 and 1975. The poisonings which occurred in Minamata resulted from consumption of locally caught fish and seafood that had been contaminated by monomethylmercury, a neurotoxic species (Mousavi et al. 2011). It was unclear whether the mercury poisoning found in the fishing villages of the Amazon rainforest came from gold mining or the leaching of mercury from soils following deforestation (Pearce 1999). However, in a study of mercury in fish-eating communities of the Napo River Valley, Ecuadorian Andean Amazon, a region without gold mining but with significant deforestation and volcanic soils with naturally high mercury levels, Webb et al. (2004) conclude that the high rates of deforestation in the region leads to concerns of rising mercury levels in aquatic ecosystems because of the factors particular to the region which exacerbate erosion.

7. A Seemingly Infinite Divide: Ethics and Any Future Collaboration

According to Li and Vederas (2009), the last 15 years has seen a decline in pharmaceutical research into natural products due to the “high probability of duplication” and the pressure to produce blockbuster drugs in a relatively short time-frame. With most of “nature’s “treasure trove of small molecules” remain[ing] to be explored” (Newman & Cragg 2007) and the current rates of deforestation and species extinction, continued research into natural products for pharmaceutical and medicinal purposes is more important than ever. Indigenous ethnomedical and ethnopharmacological knowledge

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11 Minamata disease is one of the numerous diseases that plague the regions of the Amazon, and the history of the destructive forces of gold mining in the Amazon has had other profound effects. Gold mining has also been linked to a high percentage of HIV transmissions due to numerous causes, such as gold miners bringing HIV from cities or becoming infected with HIV from “commercial sex workers in small towns near the mining areas” (Faas et al. 1999; Palmet et al. 2002). The compounded effects of both mercury and malaria pathogenicity (Cromptom 2002; Silbergeld et al. 2002; Silva et al. 2004) and indications of autoimmune dysfunction due to mercury exposure (Silva et al. 2004) have been noted as well.

12 As Peterson and Heemskerk (2001) note concerning the regeneration of the forest where gold-mining occurs: “the massive repeated soil movement that accompanies mining greatly slows regeneration, and produces vegetation cover that is qualitatively different from that in nearby old-growth forest.” With slower rates of regeneration and a qualitatively different environment, the potential subsistence, medicinal effects, and cultural effect on indigenous peoples look grim.
can potentially eliminate the high probability of duplication as well as help guide an otherwise aimless analysis of different plant and animal species. It has been estimated that “research and development costs could be cut by as much as 40%” with the help of traditional knowledge of both flora and fauna (Posey 1998). Unfortunately, indigenous populations do not have any legitimate reason to trust, at least at the present time, any monetary collaboration with multi-billion dollar research industries.

As some politicians (see examples from Carneiro da Cunha & de Almeida 2000 and Farmer 2005) and academics (Harris 2004; Dawkins 2008) assert, indigenous knowledge and “superstitions” are obstacles to ‘progress’. As Posey (1998) notes:

In short, these “backward and primitive” peoples are barriers to development, learning and civilization. Armed with those assumptions, governments—and even scientists and environmentalists—have found it easy to justify the dispossession of Indians and peasants from their land and resources in the name of development, conservation, and progress.

This ideology and discourse has led to a number of human rights and ethics violations committed against both the indigenous peoples of South America and the destitute poor for the so-called advancement of scientific knowledge and, of course, personal gain. Although the Yanomami controversy is arguably one of the more obvious and well-known human rights and ethics violations committed against an indigenous group living in the Amazon, numerous indigenous groups have either been fought against or been murdered by outsiders for their land for various reasons (see, for example Chagnon 1996; Mitten 1997; Rival 2002; Tierney 2002; Diamond 2005). Furthermore, pharmaceutical companies have taken advantage of indigenous knowledge in the past as well, which usually involves appropriating indigenous knowledge without appropriate compensation. Posey (1998) notes a few of the many issues that plague indigenous populations: the Urueu-Wau-Wau of the Amazon are not properly compensated for the development of an anti-coagulant from the *tikuba* tree; the Guajajara are faced with “debt peonage and slavery” at the hand of Brazilians in order to export *Pilocarpus jaborandi*, a plant used to treat glaucoma; and the patenting of cell lines of indigenous populations without their direct knowledge. Despite all of the reported cases of unjust compensation for indigenous knowledge, not to mention the role of intellectual property rights in the legal system that can prove to be an obstacle concerning appropriate compensation (Brush 1993; Roht-Arriaza 1995; Posey 1998; Marinova and Raven 2006), it is difficult to imagine all the unknown, unreported cases of such misappropriation. Clearly, any future collaboration concerning research will need to find a way to bridge this seemingly infinite trust divide.

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13 For a phenomenal analysis of the debate concerning Patrick Tierney’s (2002) accusations against the anthropologist Napoleon Chagnon (1996) and geneticist James Neel’s conduct among the Yanomami, see Brofosky et al. 2005.
8. Conclusion

Indigenous populations have much to offer modern society, including their traditional medicinal knowledge for biomedical advancement as well as their culture for enriching the diverse tapestry of society. The biodiversity of regions such as the tropical rainforest, as we have mentioned, is correlated to cultural diversity. With current rates of deforestation and other destructive processes, such as gold-mining, both biodiversity and cultural diversity are being destroyed. As we have shown through this literature review, indigenous peoples have contributed substantially to pharmacological advances in biomedicine and can continue to do so. To maximize any future efforts with indigenous peoples concerning biomedicine and pharmacology, a system needs to be set in place that will keep track of, monitor, and govern all collaboration and financial efforts. Such a governing body should have indigenous individuals, both educated and non-educated, which both represent and are a voice for their respective peoples. Further research is needed to determine if indigenous groups in the Amazon are interested in potential collaborations in which they are justly compensated, monetarily speaking, for their knowledge. Finally, research can and should continue to be conducted to demonstrate the value of indigenous traditions in other areas of knowledge. Such work may help in the continued efforts to sustain indigenous cultures and educate non-indigenous people, both lay and academic, about the fundamental importance of continued cultural diversity.

References


