Lawful Avoidance of ABS:

Jurisdiction Shopping and Selection of non-Genetic-Material Media for Transmission

Sociedad Peruana de Derecho Ambiental / Peruvian Society of Environmental Law

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Introduction:

The sheer scale of a phenomenon can make it new and emerging. Biologists know this about extinction and physicists, about weapons of mass destruction. Similarly, the issue of "jurisdiction shopping and selection of non-genetic-material media for transmission" has many antecedents, some of which pre-date the 1992 Convention on Biological Diversity (CBD). Nevertheless, the "lawful avoidance of ABS" (access and benefit sharing) is truly new and emerging due to the scale of the shopping and of the selection, and the synergy between them.

For Users, jurisdiction shopping and selection of non-genetic-material media of transmission have eclipsed Material Transfer Agreements (MTAs) and other contracts as the means of access in Research and Development (R&D) in biotechnology. It is no small irony that Providers enabled such lawful avoidance through a narrow interpretation of sovereignty based on the "country of origin" of the "genetic material" rather than the "countries of origin" of "natural information." The former has meant bilateral negotiations between Users and Providers for the conclusion of an MTA; the latter now implies "bounded openness" as the modality of the Global Multilateral Benefit-sharing Mechanism (GMBSM), which is the title of Article 10 of the Nagoya Protocol (NP).[1]

Bilateralism reinforces the definition of "genetic resources" as "genetic material" in Article 2 of the CBD. As long as the object of access is defined as material, MTAs will seem appropriate and a GMBSM, inappropriate.[2] However, "hard-core reality" cannot be ignored.[3] Thinking

[1] Political scientist Chris May elaborated "bounded openness" without succinctly defining it (2010, 142-146). To facilitate policymaking, the Peruvian Society of Environmental Law suggested the following definition: "Legal enclosures which default to, yet depart, from *res nullius* [property of no one] to the extent the departures enhance efficiency and equity, which must be balanced when in conflict" (2016, 2, fn2).

[2] Marco D'Alessandro of the Switzerland Office of the Environment explains the logic in the Online Discussion Groups on Article 10 of the Nagoya Protocol:

> In my understanding, in the context of the Nagoya Protocol, we are however neither talking about species, subspecies or any other taxonomic entity, nor are we talking about information. In the context of the Nagoya Protocol we are talking about genetic resources. And a genetic resource is defined as genetic material of actual or potential value according to Article 2 of the Convention. It is hard to imagine how a genetic resource as material can occur in two or more countries at the same time. I believe that in principle it should always be possible to determine the source of a specific material, and therefore the bilateral approach is probably applicable in most cases, no matter whether material with similar properties is found in different countries [Comment #4953] CBD Secretariat (2013b).

Alessandro's phrase "material with similar properties" implicitly refers to information. However, scientists usually do not list information among the many properties of matter (see, for example, Helmenstine, 2017). The ontological position that "[i]nformation is not about something, it is something itself" (Ananthaswamy 2017) coheres with R&D in biotechnology.

abstractly, the object in R&D is almost always "natural information," as exemplified in the burgeoning "-omics" disciplines. Prompted by the drumbeat of "synthetic biology" since COP 10 (ETC Group 2010), many stakeholders and Parties are now intoning "digital information" as if it were the most useful theoretical construct to address the reality of R&D.[4] The term must be examined vis-a-vis "natural information."

The issue of "lawful avoidance of ABS" through "jurisdiction shopping and selection of non-genetic-material media for transmission" is presented below according to the schema provided by the UN Secretariat to the CBD in NOTIFICATION No. 2017-014 of 20 February 2017.

Information which should, where possible, accompany any proposals for emerging issues (From paragraph 11 of Decision IX/29)

(a) Why the issue needs urgent attention by the Subsidiary Body on Scientific, Technical and Technological Advice (including how it impacts biodiversity);

Selection of non-Genetic-Material Media of Transmission:

"Moore's Law" derives from the mid-twentieth century observation that the ratio of processing power per unit cost had been doubling every 18 months due to technological improvements (INTEL 2017). The Law can also describe the advances in biotechnology of the late twentieth and early twenty-first centuries. The Human Genome Project is a favorite example of the Law: the US Congress budgeted USD 3 billion for the sequencing of the human genome in 1990 and set a time horizon of 15 years. The project was completed 10% below budget and two years ahead of schedule.[5] Since 2003, the technology has improved so greatly that the cost of sequencing whole genomes is approaching the target of USD 1,000.[6]

The implication of Moore's Law for ABS is enormous. A seldom cited example is the value added to the naked mole-rat (*Heterocephalus glaber*) for which eight patents have been granted and thirty more are pending.[7] The "BLAST[ing]" of the mole-rat in 2014 enabled scientists to

[3] Any policy which denies the nature of a phenomenon commits the "post-modern fallacy" (Soros 2010, 66-68). In the Online Discussion Groups on Article 10 of the Nagoya Protocol, several scientists would not brook any challenge to the definition of "genetic resources" (for example, ibid). They are perhaps unaware that legal scholars have long recognized how unscientific is such obeisance: "the development of law by judicial precedents is precisely the opposite of the development of principles of science. In the law, the principle is deduced from examination of one particular case; in science all possible manner of cases must be examined before a scientific principle is admitted." (Kuzenski 1922, 67). Some economists are also unduly deferential. The TEEB reports begin with the disclaimer: "In the TEEB assessment, we largely follow the definitions of the United Nations 1992 Convention on Biological Diversity" (de Groot 2010, 15).

[4] In a widely read blog entitled "Reflections on 2016 UN Biodiversity Conference (Part III): new challenges related to fair and equitable benefit sharing under the Nagoya Protocol," authors Elisa Morgera and Elsa Tsioumani refer to "digital information" sixteen times and "natural information," zero. See, http://www.benelexblog.law.ed.ac.uk Similarly, "digital information" appears six times in Bagley (2017) and "natural information," not once.

[5] See http://www.genome.gov/11006943, https://www.technologyreview.com/s/417628/a-moores-law-for-genetics/biotechnology

[6] See http://www.nature.com/news/technology-the-1-000-genome-1.14901

[7] According to a google patent search conducted on 3 March 2017, the following patents had been granted: CN2013506930U, CN203280387U, CN2013505265U, CN201506930U, CN2013280387U, CN2013505265U, CN203506920U, KR101289134B1, RU2533846C1, RU2590715C2 , US938252B2

conduct R&D without ever having to handle any genetic material or even having to identify themselves as working on the genome.[8] According to The Naked Mole-Rat Genome Resource: "There are no restrictions on the use of our portal or the genome data."[9] Similarly unencumbered was a graphic designer who embedded a highly significant sequence of *H. glaber* on the keys of an image of a keyboard; the clever design graces the book cover of *Recursos Genéticos como Información Natural*, the Spanish translation of *Genetic Resources as Natural Information* (Ruiz Muller 2017 and 2015, respectively).[10] In the example of the naked mole-rat, one sees that the value added to natural information can enjoy distinct intellectual property protections simultaneously, albeit with commercial potentials which may differ by orders of magnitude.

Urgent attention is required to distinguish the media of transmitting natural information from the natural information itself, whenever intellectual property protection is sought over the value added.[11] An example of non-digital and non-genetic-material transmission, which pre-dates the CBD, is the poison dart frog (*Epipedobates anthonyi*) (Angerer 2015). Its story encapsulates multiple facets of ABS. John Daly, a pharmacologist from the US National Institutes of Health, collected samples of the poison-dart frog during a field trip to Ecuador in 1974. He peeled the skins from the bodies of the frogs and preserved them cryogenically, awaiting improvements in laboratory instrumentation á la Moore's Law. The decision proved prescient. Only years later did technology improve sufficiently to characterize the toxin found in the skins. The molecular structure appeared in the non-genetic-material medium of print, viz., a path-breaking article in Science (Bradley 1993). Having read the article, scientists at Abbott Laboratories "design[ed] a library of more than 500 optimized compounds related to the mechanism of action" (Angerer 2015, 101). On return visits to Ecuador, Daly found descendants of the population sampled in 1974 but none exhibited significant quantities of the toxin (Daly et al 2000). The re-finding of the population and the subsequent non-finding of the toxin are significant for "bounded openness" as the modality of the GMBSM. The dispersion of natural information over taxa, geography, and time is an empirical question that will have to be resolved case by case, whenever the value added so warrants.

In addition to the digital and print media employed to transmit natural information, are film recordings, sound-analog recordings and, more fundamentally, gas, liquid and light for the sensory perceptions of smell, sound, taste, touch and sight. Although the media of film, sound-analog, sound, gas, liquid and light are less deployed to transmit natural information in R&D than are digital or print, much value can be added from natural information so accessed. Consider the following examples: photos of burrs from the greater burdock (*Arctium lappa*) would have been more than sufficient to inspire the rudimentary sketches submitted in the 1958

[8] For the foundational paper, see Keane et al (2014). The commercial potential of future research on the naked mole rat is even evident in the popular press coverage. See Vonberg (2017). The neologism BLAST is the acronym "Basic Local Alignment Search Tool." See https://blast.ncbi.nlm.nih.gov/Blast.cgi

[9] See http://naked-mole-rat.org

[10] If not work for hire, the copyright of a book cover will reside with the graphic designer. "Book cover design by Fabricio Pachiardi. The sequence embedded in the keyboard is from accession number AFSB00000000. See Eun Bae Kim et al, 'Genome sequencing reveals insights into physiology and longevity of the naked mole rat,' *Nature*. 2011 Nov 10; 479(7372):223-7" (Ruiz Muller 2015, title page)

[11] Should no intellectual property protection be sought for a value which has been added to natural information, one may argue that the public-domain status of that value was the shared benefit.

patent application of Velcro®[12]; sound recordings of "bats" and/or "dolphins" have been cited in 347 patent applications on "echolocation"; "tactile" and "plant" in 21,600 patent applications; "flower" and "fragrance", in 36,000 patent applications; "flavor" and "natural" in 200,000 patent applications.[13] Several patents even reference the "waggle dance" of bees.[14]

Patents are only one of several intellectual property protections which can be enjoyed simultaneously when value has been added to natural information (Oduardo-Sierra 2015). After patents, the most economically significant seems to be copyright, followed by trademarks, geographic indications, trade secrets and so on.[15] Via media-streaming websites, inspiration for adding value to natural images, sound, and motion is just a few clicks away.

Moore's Law for biotechnology means that transmission through any one of the many non-genetic-material media will soon become accessible for almost all natural information. Evidence that digitization has become the preferred medium are the ExPASY bioinformatics resource portal and the NIH genetic sequence database GenBank®.[16] The volume of digitized natural information legally accessible on either site is truly vast. How does it compare with the natural information legally accessed through the traditional medium of genetic material? The question is empirical as Nicolas Pauchard (2017) signals in the subtitle of his rigorous article: "What Can Some Numbers Tell Us about the Effectiveness of the Regulatory Regime?"

Of the 465 ABS agreements concluded from 1996 to 2015, 217 were for commercial research (Pauchard 2017, 11). In just the last year of the interval examined, 915 patents were granted for biotechnology inventions in the European Union.[17] Had natural information been recognized as an object of access in R&D, subtraction of 217 from 915 indicates that almost all of the patents granted over the twenty-year period would have been in non-compliance with the ABS obligation of the CBD.[18] For every patent issued on value added to natural information, one estimates that there were as many as six orders of magnitude more instances of access to genetic

[12] One need only compare high-resolution photos of the burrs with the crude sketches submitted to the USPTO. See http://www.todayifoundout.com/index.php/2011/09/velcro-was-modeled-after-burrs-of-the-burdock-plant-that-stuck-to-velcros-inventors-pants-after-a-hunting-trip/ and https://www.google.com/patents/US3009235?dq=velcro+patent&hl=en&sa=X&ved=0ahUKEwjk9PSGwLDSAhUJfiYKHaG8Bk4Q6AEIGzAA).

[13] Hits from a Google Patent Search conducted on 5 April 2017.

[14] The Nobel Prize in Physiology or Medicine was awarded in 1973 jointly to Karl von Frisch, Konrad Lorenz and Nikolaas Tinbergen "for their discoveries concerning organization and elicitation of individual and social behaviour patterns." The dance of bees figures largely in the award acceptance speech. See http://www.nobelprize.org/nobel_prizes/medicine/laureates/1973/. Some patents that correspond to natural motion observed are: "Interactive pet toy having extendable and retractable flexible target," US 8109239 B1;"Method of forming a personal mobile grid system and resource scheduling thereon" US 8296765 B2; and "Unmanned helicopter flying control platform system based on QNX" CN 104765377 A.

[15] The movie AVATAR illustrates the pecuniary reason why copyright leads the list. The computer simulated creatures "are entirely speculative and in some cases are modeled closely on familiar animals" (Switek 2009); box office revenues reached USD 760 million by 2010 (IMDB 2017).

[16] The portals are, respectively, http://www.expasy.org/proteomics and https://www.ncbi.nlm.nih.gov/genbank/

[17] See, Bioentreprenuer, http://www.nature.com/bioent/2016/160701/fig_tab/bioe.2016.7_F1.html

[18] The calculation is inspired by a similar point made by Pauchard (2017).

resources in non-compliance with the "prior informed consent" of the CBD (Article 15) and of the NP (Article 5-7,10, 13-17).[19]

Rather than grappling with the foundational flaw of defining "genetic resources" as "material", a circumlocution has emerged. A shift of emphasis is underway to make "utilization" the basis for bilateral ABS. Ostensibly, MTAs would be preserved. For example, Tvedt et al (2016) write:

> Returning to the CBD/NP definition, "genetic resources" are defined as genetic material of "actual or potential value." When utilisation of biological material aims at capturing the value of the genetic material, then this criterion in the definition is met. In biotechnology, typically the value is mostly connected to the use of the genetic structure and information, so this element of the definition would not make any of the examples discussed above fall outside the scope of the obligations (231).

Does "utilization" survive examination? Although Users may utilize genetic material as the medium for natural information, it is the natural information to which they are adding value. The modification of "genetic materials" as being "of actual or potential value" in Article 2 of the CBD is a false premise. As long as no other media exist to transmit the natural information, the genetic material will indeed appear to be of actual or potential value. Technically, the information could not yet be separated from the medium. Nevertheless, the goal of industry is total synthesis, at which time the value of the genetic material is completely lost as manufacture replaces collection or harvesting.[20] In other words, the premise that genetic material is of "actual or potential value" is not only false but obviously so as other media become perfect substitutes.[21] So, an equivocation fallacy[22] undergirds MTAs and contracts: "genetic material" is misunderstood as if it were the true object utilized.

Upon examination, "digital information" fares even worse than "utilization." Prima facie "digital information" does not distinguish the provenance of the object of access as either natural or artificial, despite the latter being outside the scope of the CBD and NP. More subtly but no less significantly, the term evades an economic literature about "natural information," which pre-

[19] Due to financial insolvency, the Instituto Nacional de Biodiversidad de Costa Rica (INBio) was transferred to the State in 2015. It once tended collections "which number 3.5 million items and [were] estimated to cover nearly one third of Costa Rica's biodiversity" (Hammond 2015). A search on its web engine on 3 March 2017 produced only one hit that speaks of four patents held by an enterprise from South Korea; a search of INBio on the google patent engine the same day generated zero hits.

[20] In pharmacology, one sees a transition in the media of transmission in taxol, which is the principal agent isolated from the pacific yew (*Taxus brevifolia*); in agriculture, in the flavor of the vanilla bean. Before the molecular structures were known of the respective agents, bark from the yews was being stripped (New York Times 1987) and vast plantations of the bean, planted. Total synthesis has not yet happened for either poster child of natural products chemistry. To date, the semi-synthesis of taxol uses needles from *T. baccata* rather than the bark of T. brevifolia (Radcliff and Fox 2009); similarly, artificial vanilla is far from a perfect substitute for the many compounds that render the flavor of real vanilla (Spector 2014). However, the continued necessity of genetic material in the production of taxol or of real vanilla does not alter the fact that the object of R&D is natural information.

[21] Perfect substitution is achieved in synthetic biology. "The citing literature reveals an expanded landscape involving 78 countries, approximately 3,000 organizations, and an estimated 19,751 researchers" (Oldham et al 2012).

[22] For an explanation of the fallacy, see http://www.logicalfallacies.info/ambiguity/equivocation/

dates the CBD and has continued steadily to the present.[23] Thinking linguistically, the choice of "digital" to modify "information" creates the mental frame of a phenomenon somehow apart from other members of its class. The correct expression would have been "digitized natural information," whereby the participle modifier indicates that only one of many media is being identified.

In ABS, as in all of science, analysis must mean separation of a whole into its component parts.

Jurisdiction Shopping:

The new and emerging issue submitted by SPDA in 2015 for COPXIII concerned a bioprospecting initiative of the Puerto Rico Science, Technology & Research Trust (PRSTRT) (Peruvian Society of Environmental Law 2015). Since 2015, the initiative has taken shape under the name of the "Puerto Rico Center for Tropical Biodiversity and Bioprospecting." Given the desire of the Center to digitize, the threat to ABS of transboundary resources, identified in the 2015 submission, has become even more urgent in 2017:

> The comparative advantage of "jurisdiction-shopping" for transboundary resources in a non-Party warrants urgent attention inasmuch as (1) Parties which hold transboundary resources will not share in the benefits of future utilization of the transboundary resource accessed in the non-Party (2) the USA, being both a mega-diverse Provider and leading User, will impact many Provider Parties by facilitating free access (*res nullius*) to transboundary resources within its jurisdiction and (3) the COP, according to Article 24 ("Non-Parties") of the NP, may "encourage non-Parties to adhere to this Protocol" (Peruvian Society of Environmental Law 2015, 1).

Five objectives are listed in bullets on the home page of the Puerto Rico Center. The last four are consistent with "Jurisdiction Shopping and Selection of non-Genetic-Material Media for Transmission":

- A legal framework to protect biodiversity resources and the sharing of any benefits arising from biodiversity;
- A strategy for the establishment of a searchable, curated collection of either biological specimens or environmental genomic data;
- A database to enable the sharing of such information on biological/data collections;
- The identification of existing bio-prospecting initiatives with high probabilities of commercial advancement;
- The establishment of links with analogous efforts in the Caribbean region (Puerto Rico Center for Tropical Diversity and Bioprospecting 2017).

The Puerto Rico Center inspires hope for stakeholders in the CBD by the positioning of its objectives: ABS is the first bullet! Alas, the Steering Committee of the Center took deliberate

[23] For the trajectory of the application of the "economics of information" to "natural information" on its Silver Jubilee, see Vogel (2015).

actions in 2015 against the sharing of benefits from transboundary resources as is discussed in response to letter (d) (see below).

(b) How it affects the attainment of the objectives of the Convention (citing relevant articles);

Selection of non-Genetic-Material Medium of Transmission:

The second articles of both the CBD and of the NP define genetic resources as "genetic material of actual or potential value." However, the object of access in activities which add value and seek intellectual property protection is almost never "material" as elaborated in the response to item (a) above. The object of access is "natural information" for which there are diverse media for transmission. Whenever genetic material is not the medium of transmission, any activity which adds value to natural information and seeks any type of intellectual property protection, will lie outside of the scope of the CBD and NP. This new and emerging issue effectively eviscerates ABS, the third objective of the CBD, and thereby erodes conversation and sustainable use, the first two objectives of the CBD.

Jurisdiction Shopping:

The response to the same question (b) in 2015 by the SPDA in the submission for "New and Emerging Issues for COPXIII" also takes on a new urgency as the "Puerto Rico Center for Tropical Biodiversity and Bioprospecting" advances in 2017:

> By exploiting the *res nullius* status of transboundary resources in a non-Party, the PRSTRT frustrates Article 1 (Objective) and Article 5 (Fair and Equitable Benefit Sharing) of the NP as well as Article 1 (Objectives) of the CBD, specifically "the fair and equitable sharing of the benefits arising out of the utilization of genetic resources." The USA, also a signatory country to the Vienna Convention on the Law of on Treaties (1969), is obliged "not to defeat the object and purpose of a treaty prior to its entry into force."
>
> Also relevant to the objectives of the CBD and NP is Article 11 (Transboundary Cooperation) of the NP. Article 11 does not contemplate "instances where the same genetic resources are found in situ within the territory of more than one Party" and a non-Party; the lacuna is a loop hole for User compliance of fair and equitable benefit sharing. The User and the Provider non-Party may cite the definition of "genetic resources" as "material" (Article 2 "Use of Terms" of the Convention on Biological Diversity) to argue that physical "material" cannot be in two jurisdictions at once. Therefore, the meaning of "transboundary" turns on the definition of "genetic resources." Rigorous examination of the current definition versus the proposed alternative, viz., "natural information," is merited (Peruvian Society of Environmental Law 2015, 2).

(c) Thematic programmes of work and/or cross-cutting issues that could contribute to the resolution of the issue;

Selection of non-Genetic-Material Media of Transmission:

The issue of genetic resources as "natural information," easily transmissible through non-genetic material media, has appeared and disappeared in thematic programs and cross-cutting issues in recent years. It appeared prominently in the "Expert Meeting on Article 10 of the Nagoya Protocol" held at the Secretariat from 17 to 19 September 2013. In Point 15 of the Report about the Official Synthesis:

> Experts identified three points that were raised during the online discussions but that they considered had not been adequately reflected in the synthesis:
> (a) The concept of the 'economics of information';
> (b) The question of the definition of genetic resources from the Convention;
> (c) The issue of transaction costs, including transaction cost [sic] that may be appropriate (CBD Secretariat 2013c, 3).

In the closing Point (26) "Areas for Further Examination":

> The experts also suggested that it would be useful if Parties and others could be invited to provide possible scenarios on modalities for a GMBSM as well as information regarding the implications of these scenarios (CBD Secretariat 2013c, 5).

Despite the above points identified by the experts, any recognition of "genetic resources" as "natural information" disappeared. Vogel et al note:

> Two years later, any hope engendered by Points 15 and 26 was dashed by Notification 2015-023, which requested written submissions of views on the very same themes vetted in the 2013 Online Discussion (CBD Secretariat 2015a). Volunteer participation was lower by almost an order of magnitude.[24] Nevertheless, a twelve-member group of experts, under the acronym of ABSSG, submitted an extensive view. Its introduction is reminiscent of Point 15 (b) above, which in turn reflects some twenty-five years of economic analysis on genetic resources as information:
>
> > A globally functional legal/commercial regime can only function on the basis of clear and unambiguous international consensus on critical components. Legal principles can only apply if the parties, negotiators, arbitrators and courts are able to clearly determine whether or not a particular resource is included within the ABS regime, and how the 'resource' in question is characterized – in this case as a chemical, a piece of encoded information, or as a hybrid embracing both aspects (Young and Minnis eds 2015, 1).
>
> Despite the prominence that ABSSG placed on resolving the definition of genetic

[24] Sixteen submissions can be counted (CBD Secretariat 2015b) versus the 143 participants to the 2013 Online Discussions (CBD Secretariat 2013b).

> resources---appearing on page one of the twenty-two page document--- [the issue was eliminated from the official Synthesis and not] restored in the subsequent Expert Report (CBD Secretariat 2016a, 2016b). This time the point was not to be restored in the subsequent Expert Report (CBD Secretariat 2016a, 2016b). Curiously, unlike the experts who met in 2013 to evaluate the official Synthesis of the Online Discussions [CBD Secretariat 2013a], those chosen in 2016 did not find the official Synthesis of the written submissions non-representative of what was submitted (Vogel et al 2017, forthcoming).

The theme of information as the object of R&D also appeared in various submissions to the "Updated report and synthesis of views in response to paragraph 7(b) of Decision XII/24 on new and emerging issues: Synthetic biology" (CBD Secretariat 2015c) and, in the case of New Zealand, disappeared suddenly.[25] The submission by The Peruvian Society of Environmental Law offered a definition of synthetic biology which is cross-cutting with ABS:

> Synthetic Biology: the extremely intensive use of artificial information in the manipulation of natural information (Peruvian Society for Environmental Law 2016, 3).

Ockham's Razor is wielded. Through conceptual reduction, the discussion of ABS in high-tech biotechnology falls into place with the cross-cutting issue of biosafety.

Jurisdiction shopping:

The response to question (c) in 2015 by the Peruvian Society of Environmental Law in the submission for "New and Emerging Issues for COPXIII" remains relevant for the 2017 submission by the SPDA:

> "Access to Genetic Resources and Benefit Sharing" is the primary cross-cutting issue. Of the seven thematic programs of the CBD (Agricultural biodiversity, Dry and sub-humid lands biodiversity, Forest biodiversity, and so on), all are relevant to "Preventing 'Jurisdiction Shopping' for Transboundary Resources in a Non-Party" with the possible exception of "Inland Waters Biodiversity."
>
> The "Global Taxonomy Initiative" could also contribute to the resolution of what transboundary resources (*stricto sensu* "natural information") are found in the US Commonwealth of Puerto Rico.
>
> The concept of genetic resources as information was a linchpin in "Potential Positive and Negative Impacts of Components, Organisms and Products Resulting from Synthetic

[25] Vogel et al ask: "Did the position of any of the other 32 submitted views about the 'Updated report and synthesis of views' on synthetic biology cohere with that of the SPDA, i.e., with bounded openness? Analyzing each, Vogel perceived common ground between the submission of the SPDA and that of New Zealand, which he communicated to the Lead Adviser of the New Zealand Ministry of Foreign Affairs & Trade (Vogel 2016). The response was as unexpected as it was unequivocal: the Adviser asked Vogel not to quote the New Zealand submission and formally requested that the Secretariat delete it. The Secretariat obliged not only to un-publish what had been in the public record but also to upload a replacement file (New Zealand National Focal Point, CBD Secretariat 2016c), submitted more than a month after the deadline" (Vogel et al 2017, forthcoming)

Biology Techniques on the Conservation and Sustainable Use of Biodiversity," the new and emerging issue of COP 12.

Resolution of "'jurisdiction shopping' for transboundary resources" for COP13 could also cut across the issue of disclosure of the geographic origin of genetic resources utilized in R&D. The following excerpt from Nuno de Pires Carvalho, Director, Intellectual Property and Competition Policy of the World Intellectual Property Organization, presents a nexus for discussion of "jurisdiction shopping":

> The requirement that applicants for patents in the field of biotechnology disclose the source of the genetic resources eventually used as raw materials or tools in the inventive activity and, in addition, provide information (and evidence, if any, by means of contracts or licenses) on prior informed consent is not a new concept...
>
> The manner of obtaining genetic resources used in the development of inventions is an external condition. The outcome of the inventive activity is indeed independent of the ways and means employed to reach it. The situation that arises from an invention derived from the use of genetic resources that have been illegally extracted from their in situ environment is similar to the situation of an invention that has been developed with the assistance of a stolen microscope. This event would infringe the common law but not patent law under article 27.1 of the TRIPS Agreement. In both situations inventors would still be entitled to the patent, provided the conditions of patentability were met (Carvalho 2000, 374-380).

Carvalho argues that the requirement of disclosure of geographic origin would not be a substantive requirement of patentability as established in TRIPS, thereby frustrating the monitoring of patents which utilized genetic resources. In other words, Parties of transboundary resources that are also Parties to TRIPS cannot require disclosure of geographic origin in national patent applications without violating TRIPS as well as the CBD, which establishes that all measures "shall be provided on terms which recognize and are consistent with the adequate and effective protection of intellectual property rights" (Article 16.3) as well as "in accordance with international law" (Article 16.5) (Carvalho 2007, 255). Nevertheless, the analogy in the above passage between a stolen microscope and an illegally extracted genetic resource holds only because the CBD has misdefined genetic resources as "material," in other words, similar to a microscope.

Rather than challenge the arguments against mandatory disclosure of geographic origin, one can vacate them with an alternative object of disclosure: simply whether or not "natural information" was utilized (yes or no). The proposed requirement would fall within the first two criteria of patentability, viz., novelty and inventiveness. Is the compound patented sufficiently novel? Inventive from what occurs in nature? An inventor whose patent application progresses through examination, would subsequently be asked to disclose the natural information to the Patent Office. Although the information will usually be a molecular structure, it could also be the phenotypical expressions utilized in biomimicry. Failure to disclose whether or not "natural information" was utilized in the application would be grounds for revocation. After successful commercialization of the patent, the self-interest of Users is to also disclose the geographic location of the species of origin,

inasmuch as a royalty would be charged regardless of the additional disclosure. Such cooperation helps to assure sustainablity of the habitat for the User's access to the genetic material. Incentives are aligned.

As "genetic resources" are recognized as "natural information" for the purpose of adding value through R&D, "species of origin" will replace the notion of "country of origin." Once the species of origin is/are identified, the notion "countries of origin" (note well the plural) becomes essential for the fair and equitable sharing of benefits (Peruvian Society of Environmental Law 2015, 2-3).

(d) Work already under way by relevant organizations addressing the issue; and

Selection of non-genetic-material media of transmission:

The illustrious naturalist E.O. Wilson is fond of citing a Chinese saying that "the first step to wisdom is getting things by their right names" (1998, 4). Many non-governmental organizations (NGOs) have gotten "natural information" and "lawful avoidance of ABS" by the wrong names, viz., "digital information" and "loop hole." Among them are the Rural Advancement Foundation Institute (RAFI) / Erosion Technology Concentration (ETC), the Third World Network (TWN) and The Woodrow Wilson Institute. By failing to distinguish the media of transmission from the object of access and by deploying a highly inappropriate metaphor for evasion,[26] none of the aforementioned NGOs has explicitly taken up the issue of the submission at hand.

Prominent members within the International Union for the Conservation of Nature (IUCN) have taken up the issue, while others have not. Evidence of uptake: endorsements of three books that explore various aspects of the issue; publication of an extensive article in English, French and Spanish in the series *IUCN Environmental Policy and Law Paper*;[27] and a collective submission of the IUCN Joint SSC-WCEL Global Specialist Group on ABS (Young and Minnis eds 2015), which highlighted the issue in a 10-page annex (Vogel et al 2015). Evidence of not taking up the issue: the conspicuous absence of the "natural information" and the "economics of information" in the influential *An Explanatory Guide to the Nagoya Protocol on Access and Benefit-Sharing* (Greiber et al, 2012). In a similar vein, the International Barcode of Life (iBOL) and the International Development Research Council (IDRC) have taken up the issue as evidenced by sponsorship of panelists to discuss it at the second and fourth International iBOL Congress[28] as

[26] "Loop hole" is an understatement of the phenomenon so extreme as to render "new and emerging" the neutral description "lawful avoidance of ABS." An appropriate metaphor for the sheer scale of the avoidance is "Undara," an Australian aboriginal name for the most capacious lava tube in the world. See https://www.thalabeach.com.au/undara-lava-tubes/

[27] Former Chief Officer of the IUCN, Jeff McNeely, wrote a comment of Advance Praise for the book jacket of *Genes for Sale* (Vogel 1994); former President of the IUCN, Yolanda Kakabadse, wrote one for *The Biodiversity Cartel* (Vogel ed 2000); Alejandro Iza, Head of the IUCN Environmental Law Centre, wrote one for *Genetic Resources as Natural Information* (Ruiz Muller 2015). A comprehensive article about the institutionalization of a biodiversity cartel appeared in the series *IUCN Environmental Law and Policy Paper* (Vogel 2007).

[28] Research for "iBOL as an Enabler of ABS and ABS as an Enabler of iBOL" (Vogel 2009) was sponsored by the International Development Research Council (IDRC) of Canada and presented at the Second International Conference of iBOL, Mexico City, November 2009 (see, http://vimeo.com/10721027). At the 4th iBOL Congress held in Adelaide, Australia, December 2011, Vogel presented "How MUBIO [Museum of Bioprospecting, Intellectual Property and the Public Domain] benefits iBOL [International Barcode of Life], tremendously so,"

well as collaboration in a high-impact open-access refereed publication authored with members of iBOL and IDRC (Vernooy et al, 2010). However, since 2011 neither iBOL or the IDRC has engaged on the issue, perhaps due to budgetary reasons.

The only NGO that has sustained the issue over the yearsis the Peruvian Society of Environmental Law (SPDA, by its acronym in Spanish), as evidenced by the publications cited in this submission as well as by workshops sponsored at various fora of the CBD and other venues.[29] In recognition for its endeavors on combatting biopiracy, the SPDA was awarded The Danielle Mitterand Prize of France in 2014 (Fondation Danielle Mitterand 2014).

Governmental organizations (GOs) currently grappling with "digital information" and/or "loop holes" are the World Health Organization (WHO),[30] the Food Agricultural Organisaton (FAO)[31], and the CBD Secretariat. However, by failing to distinguish the media of transmission from the object of access as "natural information," not addressing the relevant economics and understating the legal avoidance of ABS, one can also make the case that none of the GOs has so far taken up the issue of this submission.

The COP and Secretariat merit elaboration. First-hand exposure to the arguments that underpin the issue has ocurred at side events since COP 3.[32] The low attendance at the events reflect a generic difficulty of powerful arguments to persuade (Vogel 2013). Perhaps due to the meteoric rise of synthetic biology, the phsyical room for the side event about the issue at COP 8 was filled to the seating capacity of one hundred people.[33] Many delegates and seasoned stakeholders were in attendance. An audio and transcript of the presentations and responses to questions are downloadable from the the SPDA.[34]

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which touches on themes from *The Museum of Bioprospecting, Intellectual Property and the Public Domain* (Vogel ed 2011) and "Architecture by Committee and the Conceptual Integrity of the Nagoya Protocol" (Vogel 2012, 181-188).

[29] For a comprehensive overview, see Ruiz Muller et al (2010).

[30] The notion that the sheer scale of use of the digital medium makes an issue "new and emerging" can also be inferred from the "Review of the 2016 Pandemic Influenza Preparedness [PIP]," World Health Organisation, EB240/16, 29 December 2016. "[A]s technology advances, GSD [genetic sequence data] is becoming increasingly critical in influenza research, and can in some cases substitute for physical samples for pandemic risk assessment and the development of commercial products. Therefore, clarity is urgently required on the handling of GSD under the PIP Framework" (15). The economics of aligning incentives among Users and Providers of human pathogens was elaborated in Vogel et al (2013).

[31] See http://enb.iisd.org/biodiv/cgrfa16/

[32] The chronology of exposure to the application of the "economics of information" to "natural information" at COP side events: Vogel, J.H. "The Rationale for a Cartel over Biological Diversity in Bioprospecting" 3 November 1996 (COP 3); Vogel, J.H. "The Transaction Costs of the Biodiversity Cartel," Workshop on ABS, 24 February 2006; Vogel, J.H. "The Transaction Costs of the Biodiversity Cartel" 23 March 2006 (COP 8); Vogel, J.H. "Logic Should Prevail," Workshop on ABS for COP 9, 24 March 2010; Vogel J.H., "Wronged by the Wrong Language," 21 October 2010 (COP 10); Vogel, J.H. "The salient implication of the economics of information for ABS: Bounded openness," 9 December 2016 (COP 13).

[33] "New Approaches to Access and Benefit Sharing: The Case for Bounded Openness and Natural Information." COP 8, 9 December 2016. See http://www.iisd.ca/biodiv/cop13/enbots/9dec.html#event-4

[34] See http://www.spda.org.pe The presentations developed issues found in Angerer (2015), Dutfield (2017), Ruiz Muller (2017, 2015), Safrin (2004) and Vogel et al (2017).

Written recognition of the issue is evidenced in the "Note by the Executive Secretary" by the former Executive Secretary of the CBD Secretariat, who suggested that the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) "may wish to recommend that the Conference of the Parties decide not to add to the agenda of the Subsidiary Body in the coming biennium a new and emerging issue pursuant to the procedure established through Decision IX/29" (Dias 2016, 2). The fact that the former Executive Secretary used the phrase "may wish" indicates that the dismissal was without prejudice and, therefore, may be taken up by SBSTTA in 2017.

Point 9 of the Note states: "The crux of the issue raised by the 2015 submission is the lack of universal membership of the Convention on Biological Diversity" (Dias 2016, 2). The statement lends itself to a simple test: remove "in a non-Party: The case of Puerto Rico" from the full title of the 2015 submission: "Preventing 'Jurisdiction Shopping' for Transboundary Resources in a Non-Party: The Case of Puerto Rico." After removal of the aforementioned fragment, does the true "crux of the issue" still hold? It clearly does. Diffusion of information encourages jurisdiction shopping regardless of whether or not the Provider is a Party to the CBD. The shopping has only been exacerbated in the case of Puerto Rico because of its territorial/colonial status in a non-Party and its location in the neotropics. The genetic resources (*sensu stricto* "natural information") of Puerto Rico are transboundary with those of many Parties. In other words, the price of access for neotropical transboundary resources is zero de jure in US territory/colony of Puerto Rico and approaches zero de facto elsewhere.

Absent in the Note by the former Executive Secretary was any reference to the "economics of information," which was a central theme to the 2015 submission:

> Three academics, working independently from one another, have long perceived how market pressure among Providers would drive the price of access of natural information down to the marginal cost of collecting the material in which it is stored, essentially nothing (for the trajectory of the idea since 1990, see Vogel 2015). In other words, the simple application of "the economics of information" to genetic resources predicted that bilateralism would fail to achieve the objective of the CBD for a "fair and equitable sharing of benefits." As early as 1997, the need for a multilateral "Special Protocol" over ABS to the CBD was advocated in the context of the threat posed by competition among Providers and epitomized through "jurisdiction shopping" in a megadiverse non-Party:
>
> > Even more troubling is the fact that the major country of demand for biological samples, the USA, has not ratified the CBD and can bioprospect many of the same organisms in reefs within its own jurisdiction (e.g., the US Virgin Islands, Puerto Rico, and the Florida keys; or in the example of papuamine, Hawaii, Guam, and Samoa). In the long run, multilateral accords will probably emerge that recognize the rights of countries of origin to participate in economic rents whenever they could have supplied the same organism (see Bioprospecting [Case 6] for a similar argument regarding plant medicines). Cooperation toward such multilateral accords is extremely important inasmuch as one quarter of marine biological diversity lies in the reefs... (Vogel 1997, 14) (Peruvian Society of Environmental Law 2015, 4-5).

By arguing that the "crux" of the issue is something other than that which could be reasonably inferred, the Note had set up a "straw man."[35] Because some readers may not read past the title of the 2015 submission, the title of the 2017 submission does not include "in a non-Party: The case of Puerto Rico." The words "jurisdiction shopping" suffice. The illogic of Point 9 of the Note is compounded with the illogic of Point 10:

> [T]he issue of digital genetic resource information was raised in the context of the Ad Hoc Technical Expert Group on Synthetic Biology (see, in particular, UNEP/CBD/SYNBIO/AHTEG/2015/1/3, paragraph 66(i))[36] as well as in discussions on Article 10 of the Nagoya Protocol (see the synthesis document prepared for the Expert Meeting on Article 10 of the Nagoya Protocol on Access and Benefit-sharing, UNEP/CBD/ABS/A10/EM/2016/1/3) (Dias 2016, italics added).

Simple word substitution on "digital genetic resource information" with the CBD definition of "genetic resource" as "material," renders an oxymoron so obvious that it requires no explanation: digital material information. More subtle is the "red herring"[37] embedded in the oxymoron: evasion of the economic literature associated with "natural information," which could resolve ABS.[38]

The SPDA submissions of both 2015 and 2017 are informed by economics, which is a "powerful tool of abstraction" (Heilbroner 1972, 99). However, a predicament emerges: economics is not diplomacy yet many COP delegates are diplomats. To soften the harshness of correcting what is clearly economically wrong, magnanimity is prudent. Whether the acceptance by the SBSTTA of the former Secretary's recommendation in 2016 was *ad verecundiam*,[39] some sort of American-style log-rolling or a lack of due diligence, is now unimportant. "Let bygones be bygones" is the "sunk-cost principle" taught in any principles course of economics.[40] Letting bygones be bygones also coheres with the perennial aspirations of professors of economics to inculcate "cool heads but warm hearts" (Marshall, quoted in Pigou ed 1925, 174). For these reasons, Genetic Resources as Natural Information begins with a Turkish proverb that epitomises the sunk-cost principle: "no matter how long you have traveled on the wrong road, turn back" (Ruiz Muller 2015, 5). Happily, Article 10 of the 2010 Nagoya Protocol (GMBSM) is the pivot toward the right road, which the COP has just begun to travel.

<u>Jurisdiction shopping:</u>

The relevance of the following passage from the 2015 SPDA submission has become more pertinent in 2017:

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[35] For a definition of the fallacy, see http://www.nizkor.org/features/fallacies/straw-man.html

[36] See https://www.cbd.int/doc/meetings/synbio/synbioahteg-2015-01/official/synbioahteg-2015-01-03-en.doc

[37] For a definition of the fallacy, see http://www.nizkor.org/features/fallacies/red-herring.html

[38] See Oduardo-Sierra el al (2012) and Vogel et al (2011).

[39] For a definition of the fallacy, see http://www.nizkor.org/features/fallacies/appeal-to-authority.html

[40] Samuelson and Nordhaus explain the term in question 3 of Chapter 8 "Analysis of Perfectly Competitive Markets"(2005, 164).

As of September 2015, the Global Multilateral Benefit-Sharing Mechanism (GMBSM) of Article 10 of the Nagoya Protocol has not taken form. Dr. Manuel Ruiz Muller, Director of the Program of International Affairs and Biodiversity at the Peruvian Society for Environmental Law (SPDA) crafted the following language to prevent invocation of "retroactivity" should the US ratify the CBD and should the COP adopt a GMBSM based on the economic implications of genetic resources being information for the purposes of R&D:

Once a multilateral system is established for access and benefit sharing that reflects the transboundary nature of genetic resources and their essence as natural information, the agreements and bilateral contracts will be subject to the principles and rules of this new international system.

Joseph Henry Vogel, PhD, Professor of Economics at the University of Puerto Rico-Río Piedras, a member of the Steering Committee at the time, presented the language of Ruiz Muller to the other members on 6 February 2015. He posed two short questions for the paid consultant to the Initiative in an email communication of 2 March 2015:

> (a) If you are in agreement with the suggested language, in what documents do you recommend that it be incorporated so that it may become binding on the Initiative? Please send your reply by email with a detailed justification.
>
> (b) If you are not in agreement, what are the bases for your disagreement, citing economic or other arguments that would support your opposition. In such a case, please let us have the documents by email with detailed justification supported by the literature [Translation from the Spanish].

No answers to the questions were ever provided. The director of the PRSTRT responded the same day by "excus[ing]" Vogel from the Steering Committee. A reasonable inference is that the PRSTRT intends to lever "jurisdiction shopping" of transboundary resources to attract transnational Users (Peruvian Society of Environmental Law 2015, 3-4).

(e) Credible sources of information, preferably from peer-reviewed articles.

Publications about the application of the "economics of information" to "natural information" draw on a reservoir of refereed literature, from both journals and academic presses. Much of it is cited in this submission. A more comprehensive bibliography can also be generated through compilation of the references found in the articles and books cited in this submission.

Criteria to be used for identifying new and emerging issues related to the conservation and sustainable use of biodiversity
(From paragraph 12 of Decision IX/29)

(a) Relevance of the issue to the implementation of the objectives of the Convention and its existing programmes of work;"

The objectives of the Convention and its existing programs of work on ABS are essentially eviscerated due to the non-resolution of the issue, as explained in the response to (b) in the above cluster "Information which should, where possible, accompany any proposals for emerging issues".

(b) New evidence of unexpected and significant impacts on biodiversity;

As noted in the response to (a) in "Information which should, where possible, accompany any proposals for emerging issues," the volume of natural information accessible for R&D is vast, whether transmitted through non-genetic-material media or through genetic material sourced in the non-Party. Every intellectual property right over the value added to natural information so transmitted or sourced, is a rent lost which could have helped align incentives for conservation. One hastens to add that competition among jurisdictions to conclude an MTA will also have eliminated rents for those few MTAs ever concluded. As mentioned in the response to (a), patents are just one of many intellectual property rights for which ABS could be sought. In the year 2015 alone, some 4,275 patents were granted for biotechnology inventions.[41]

At the aforementioned COP 8 side event, panelists and participants discussed economic rents.[42] The potential of lost rents was illustrated through Glumetza, a patented drug for diabetes acquired by the multi-billion-dollar upstart pharmaceutical company Valeant, Inc. Glumetza utilizes the natural information found in the French lilac (*Galega officinalis*).[43] The annual cost of treatment with Glumetza per patient is $10,020, which had increased in just a few months from a previous cost of $896.[44] The ability to drastically increase the price illustrates the "inelasticity of demand"[45] for medicines with no other indicated therapies.[46] At the prices traditionally set by the pharmaceutical industry, demand is almost perfectly inelastic, which implies that the industry would lose no sales revenues with a 15% royalty levied as its ABS obligation.[47] The royalty would be absorbed by the consumers, which can be argued as both equitable and efficient.[48] With global pharmaceutical sales having surpassed the USD 1 trillion mark in 2014 (Statista 2017a), the potential for rents through ABS is on the order of tens of billions of USD annually.[49]

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[41] See http://www.nature.com/bioent/2016/160701/fig_tab/bioe.2016.7_F1.html

[42] The question of economic rents appeared in Decision IX/12 but disappeared en route to Nagoya (CBD Secretariat 2008).

[43] See https://www.ncbi.nlm.nih.gov/pubmed/16402501

[44] See https://www.nytimes.com/2015/10/05/business/valeants-drug-price-strategy-enriches-it-but-infuriates-patients-and-lawmakers.html

[45] "Price-inelastic demand (or inelastic demand). The situation in which price elasticity of demand is below 1 in absolute value. In this case, when price declines, total revenue declines, and when price is increased, total revenue goes up. Perfectly inelastic demand means that there is no change at all in quantity demanded when price goes up or down" (Samuleson and Nordhaus, 2005, 748).

[46] For an economically friendly explanation of pharmaceutical pricing and rhetoric, see Scannell (2015).

[47] The suggestion of 15% royalty appears in Vogel (1994, 37). Due to the favorable public relations of a green image through ABS, the demand curve for pharmaceuticals could even shift rightward, meaning that the royalty could conceivably increase sales revenues.

[48] "[T]hose who benefit, pay the costs associated with the benefits...Unwillingness to pay not only violates the baseline ethic, but means less consumption for the consumer and fewer profits for the corporations" (Vogel 1994, 5).

[49] "Profit maximization by a monopolist occurs at the price where marginal revenue equals marginal cost, which is located in the elastic region of the demand curve. Any pricing in the inelastic region is paradoxical but explicable.

(c) Urgency of addressing the issue/imminence of the risk caused by the issue to the effective implementation of the Convention as well as the magnitude of actual and potential impact on biodiversity;

The impact on biodiversity is through the opportunities lost to raise funds which would compensate Providers for having foregone changes in land use. Lack of financing was a central theme in both COP 12 and COP 13. The third bullet of the Press Release from the UNEP News Centre (2016) at the opening of COP 13 read: "Countries to focus on the value of biodiversity to engage other economic sectors as a means of halting degradation."

(d) Actual geographic coverage and potential spread, including rate of spread, of the identified issue relating to the conservation and sustainable use of biodiversity;

Due to Moore's Law, one suspects a cheap and accurate hand-held sequencer of long genomes will become available in the near future. An imprecise hand-held sequencer of short sequences debuted in 2014 for USD 1,000 (Hayden 2014; Guardian 2015).

The penetration rate of internet usage enhances transmission of natural information digitized in the Provider country and uploaded to the web for instantaneous global access. Statistics show that from the period 2000-2017, the world total growth has been 924% with the greatest growth in the area also characterized by greatest mega-diversity, viz., Africa at 7,331% (Internet World Stats 2017).

(e) Evidence of the absence or limited availability of tools to limit or mitigate the negative impacts of the identified issue on the conservation and sustainable use of biodiversity;

Encryption can deny any tool to monitor transmissions of natural information and impose a Certificate of Origin. The practice of encryption is rising worldwide. For example, 61% of Germans encrypt internet communications (Statista 2017b). The exclusionary mechanism foreseen in "bounded openness" as the modality of the GMBSM is through mandatory disclosure at the moment of an application for or assertion of intellectual property protection over the value added to natural information. Monitoring and tracking are only warranted should the intellectual property be commercially successful.[50]

(f) Magnitude of actual and potential impact of the identified issue on human well-being;

Full exercise of monopoly power risks a public backlash and price regulation. Nevertheless, restraint in pricing can break down as newcomers to the industry perceive the potential for windfall profits, as has occurred in the USA (see, for example, Cha 2015). For ABS, the traditional inelasticity of demand in pharmaceuticals means that industry could have passed on any significant royalty to consumers. So, an unresolved paradox is industry reluctance to embrace bounded openness" (Vogel et al 2017, fn xi).

[50] Voluntary disclosure in patent applications is grossly insufficient (Hammond 2014). Other forms of intellectual property will require adaptation of the mechanisms to enable disclosure. For example, the symbols for copyright and trademark, respectively © and ®, could be altered with the letter "N" to represent "natural," i.e., $^{(NC)}$ and $^{(NR)}$. The potential for revenue from intellectual property other than patents should not be dismissed, see fn 16.

The potential impact of leaving unaddressed "Jurisdiction Shopping and Selection of non-Genetic-Material Media for Transmission" is the evisceration of the third objective of the CBD, viz., ABS, as explained in the response to (b) "Information which should, where possible, accompany any proposals for emerging issues." Address of the issue in the light of the economics of information would have a transformational impact on the first two objectives of the CBD, viz., conservation and sustainable use.

(g) Magnitude of actual and potential impact of the identified issue on productive sectors and economic well-being as related to the conservation and sustainable use of biodiversity.

The profitability of the economic sectors that utilize genetic resources vary, as do the types of the intellectual property protection sought. The economic implication is that the COPs will have to negotiate a fixed royalty percentage for common combinations of the relevant characteristics. Conservation would emerge as incentives are aligned through the distribution of royalty income according to the share of habitat extant in the countries of origin for commercially successful products that enjoy intellectual property protection over the value added to natural information. The modality of the GMBSM can be illustrated through a numerical example:

> [A]t least 240 distinct combinations (6x10x2x2) exist for which the COPs must negotiate flat royalty rates [six economic sectors, ten types of intellectual property, presence/absence of substitutability of inputs in R&D, directness in derivative use or indirectness in research streams]. Thinking like an economist, negotiation should begin over the percentage royalties for the combinations which hold the highest mathematical expectation, i.e., the probability of the event multiplied by its value. Undoubtedly, the highest expectations will be those combinations which include the pharmaceutical sector. To prevent the summed royalties from utilization of multiple ensembles of information becoming prohibitively costly, the royalties for each ensemble would have to be weighed proportional to some cap.
>
> An example may make the math more comprehensible. Suppose a blockbuster medicine is developed which utilizes four distinct ensembles of natural information. Suppose further that the COP decides on a royalty of 5% for the combination 'pharmaceutical/patent/non-substitutable input/directness in research stream' and 2% for 'pharmaceutical/patent/non-substitutable input/indirectness in research stream', with a cap of 15% on the sum of all royalties paid on any patented product. Of the four distinct ensembles of natural information utilized, imagine further that ensembles one to three correspond to the first combination, and the ensemble of the fourth, to the second combination. Without the cap, the total royalty would be 17% ((3x5%) + (1x2%))... To stay within a cap of 15%, the percentage long advocated by Vogel for pharmaceuticals (1994, p37), the weighted rate would be (3x15/17x5%) + (1x15/17x2%). The sharing among countries of origin would be proportional to the geographic range of the species which harbor the natural information accessed (Vogel et al 2017).

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