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REVIEW PAPER

A pervasive denigration of natural history misconstrues how biodiversity inventories and taxonomy underpin scientific knowledge

Fenton P. D. Cotterill · Wilhelm Foissner

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Abstract Embracing comparative biology, natural history encompasses those sciences that discover, decipher and classify unique (idiographic) details of landscapes, and extinct and extant biodiversity. Intrinsic to these multifarious roles in expanding and consolidating research and knowledge, natural history endows keystone support to the veracity of law-like (nomothetic) generalizations in science. What science knows about the natural world is governed by an inherent function of idiographic discovery; characteristic of natural history, this relationship is exemplified wherever an idiographic discovery overturns established wisdom. This nature of natural history explicates why inventories are of such epistemological importance. Unfortunately, a Denigration of Natural History weakens contemporary science from within. It expresses in the prevalent, pervasive failure to appreciate this pivotal role of idiographic research: a widespread disrespect for how natural history undergirds scientific knowledge. Symptoms of this Denigration of Natural History present in negative impacts on scientific research and knowledge. One symptom is the failure to appreciate and support the inventory and monitoring of biodiversity. Another resides in failures of scientiometrics to quantify how taxonomic publications sustain and improve knowledge. Their relevance in contemporary science characteristically persists and grows; so the temporal eminence of these idiographic publications extends over decades. This is because they propagate a succession of derived scientific statements, findings and/or conclusions - inherently shorter-lived, nomothetic publications. Widespread neglect of natural science collections is equally pernicious, allied with disregard for epistemological functions of specimens, whose preservation maintains the veracity of knowledge. Last, but not least, the decline in taxonomic expertise weakens research capacity; there are

F. P. D. Cotterill: Formerly Principal Curator of Vertebrates, Natural History Museum of Zimbabwe, PO Box 240, Bulawayo, Zimbabwe.

F. P. D. Cotterill (✉)
AEON—Africa Earth Observatory Network, Departments of Geological Sciences and Molecular and Cell Biology, University of Cape Town, Rondebosch 7701, South Africa
e-mail: fenton.cotterill@uct.ac.za; fcotterill@gmail.com

W. Foissner
FB Organismische Biologie, Universität Salzburg, Hellbrunnerstrasse 34, 5020 Salzburg, Austria

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insufficient skills to study organismal diversity in all of its intricacies. Beyond weakening research capacities and outputs across comparative biology, this Denigration of Natural History impacts on the integrity of knowledge itself, undermining progress and pedagogy throughout science. Unprecedented advances in knowledge are set to follow on consummate inventories of biodiversity, including the protists. These opportunities challenge us to survey biodiversity representatively—detailing the natural history of species. Research strategies cannot continue to ignore arguments for such an unprecedented investment in idiographic natural history. Idiographic shortcuts to general (nomothetic) insights simply do not exist. The biodiversity sciences face a stark choice. No matter how charismatic its portrayed species, an incomplete 'Brochure of Life' cannot match the scientific integrity of the 'Encyclopedia of Life'.

Keywords Biodiversity knowledge · Denigration of natural history · Taxonomic inventories · Idiographic and nomothetic science · Genomics · Microbosphere · Tentelic specimens · Scientiometrics

> "Perhaps this is merely an unsurprising remnant of the pervasive tradition for the status ranking of scientific disciplines in which the arrow of arrogance unfailingly soars from the nomothetic domain to impale innocent idiographers." (Jenner 2008, p. 109).

> "Evolutionary biology is an historical science. But what does it really mean, when we say that a science, or science in general, is historical? And what is science? So far as the Darwinian Revolution is concerned, we must reject the traditional philosophical notion that science is about classes rather than individuals. Science deals with both laws of nature and particular material bodies, events, and other individuals. It has both its nomothetic and idiographic aspects. The relationship is reasonably straightforward with respect to physics and astronomy. There is no good reason for denying that astronomy, plate tectonics, palaeontology, genomics, or the study of evolutionary theory are sciences. There are of course bad reasons, including the tradition of dissociating the philosophy of science from objective reality." (Ghiselin 2005, p. 133).

Introduction

The idiographic–nomothetic mutualism that underwrites scientific knowledge

The plight perceived in natural history has garnered repeated attention over the past three decades, with common concern expressed over a global collapse of taxonomic research capacity, poor support for biotic inventories, and a general decline in the skills to study organismal diversity in all of its intricacies (Bartholomew 1986; Futuyma 1998; Dayton and Sala 2001; Arnold 2003; Greene 2005). It appears that its impacts on the research capacities that undergird comparative biology ramify outward, affecting all the life sciences. In this respect, criticisms of Cotterill et al. (2008) by Baveye (2009) highlight the central question—what epistemological role do biotic inventories hold in science? The answers turn out to be profound, not least in diagnosing pervasive flaws in the prevailing state of science.

A responsible answer to any such question about how science works—pertaining to the knowledge generated by inventories in this case—should, ideally, be couched in metaphysics. The gravity attached to how we apportion investments into science reinforces this need for the firmest metaphysical foundations available, especially where certain arenas of research and teaching are supported at the expense of others. These decisions need to be framed in an encompassing explanation of the structure of science itself, which follows from understanding how the sciences discover, classify and maintain knowledge. A critical need is to understand the material make up of the natural world, and especially how this ontology influences epistemology. It is this ontological fabric of nature that especially challenges us to explicate how science deals with particulate materials and contingent events (individuals) alongside its quest for natural laws. Here it is critical not to muddle the distinction between roles of history (on which the existence of individuals is contingent) from laws of nature applied to groups and kinds of individuals (Ghiselin 1997, 2002). But how then does this overarching endeavour, to elucidate how ontology structures epistemology, relate to the Scientific Method? Its explication not only encompasses but underpins all those truth seeking operations (including hypothesis testing) that characterize the research methodologies ably explicated by Gauch (2003), and notably the methods that Darwin inaugurated to empower the historical sciences (Ghiselin 2003; Gould 2002; Jones 2009).

Fortunately, the insightful analysis by Ghiselin (1997, 2005) constitutes a robust metaphysical framework, which draws a fundamental distinction between the ontology of classes and individuals.[1] This is the Individuality Thesis that constitutes the very foundation of natural science. Its core tenets explicate how the natural sciences create and classify knowledge, distinguishing two sets of processes that share complementary roles in knowledge generation. The processes integral to idiographic science comprise the one arena, which discover, process and classify descriptive facts about individuals; these are analyzed and synthesized into encompassing generalizations through nomothetic research that seeks out aetiological explanations. The Individuality Thesis explicates why descriptive facts (revealed in idiographic research) constitute the empirical foundations that underwrite the very existence of nomothetic (law-like) generalizations; nevertheless, contemporary science and society invariably judges nomothetic science as the more charismatic and successful of endeavours in the realm of knowledge generation.

We term this epistemic interdependency among the sciences the "Idiographic-Nomothetic Mutualism"; this is the philosophical platform that frames our argument, which applied to the protists (Cotterill et al. 2008), endorses consummate[2] inventories to improve biodiversity knowledge. The Idiographic-Nomothetic Mutualism justifies the funding, and expanded taxonomic capacity especially, to enable consummate inventories of biodiversity that do indeed constitute "Big Science".

Denigration of natural history

The failure to appreciate how inventories (and equally the collections of specimens they produce) hold an integral role in generating knowledge, and the underwriting of its integrity, is a singular failure we diagnose in Baveye (2009); for we cannot identify any scientific justification in criticisms of "blind inventories" of protists, dismissed as "a

[1] Distinguishing abstract classes from concrete individuals, the Individuality Thesis is embraced in a philosophy of Absolute Realism. The class of individuals includes each unique particular material in the broadest context, encompassing processes (what individuals do, including events) alongside bodies with substance (Ghiselin 1997).

[2] The label 'consummate' is selected deliberately to describe the credentials of an inventory, which obtains idiographic knowledge of representative scope and reliability; these facts obtained about the natural history of constituent species details the real diversity of a clade, phylum or biota.

stamp collector's dream of characterizing all protist species". This is especially bizarre because Baveye complains that we don't know where to search for protists; yet an inventory across potential habitats addresses this knowledge gap, anything but a blind search. Moreover, only inventories will unravel details such as which bacteria and amoebae engage in predator-prey interactions, and when and where. Unfortunately, these prejudices that undervalue the scientific values of biodiversity inventories pervade contemporary science; this frequently encountered symptom often presents alongside a disregard for taxonomy. We argue these prejudices are proximate symptoms of a more fundamental, widespread problem—a prevalent, pervasive failure to appreciate how natural history underpins all the life sciences. It has serious ramifications on the integrity of knowledge itself, undermining progress and pedagogy throughout science. We term this predicament, *weakening science from within*, the 'Denigration of Natural History'.

Our paper (Cotterill et al. 2008) did not explicate how information from biodiversity inventories underwrites all the life sciences; neither did we review the strategies and tactics of their implementation. This is because we assumed the readership of *Biodiversity and Conservation* to be familiar with developments, over more than two decades in the biodiversity sciences, which have responded to acknowledged deficiencies in knowledge—that our ignorance about biodiversity is stupendous. Beyond a consensus of mere opinion, protracted strategizing has endorsed consummate inventories to discover and characterize species. This familiarity entails an appreciation of how biodiversity knowledge is improved through a sequence of research activities that extend from biotic inventory through alpha taxonomy to systematic revisions (Brooks and McLennan 2002; Cracraft 2002; Wheeler 2008). In partnership with biogeography and ecology, these are core activities in those vibrant museums and herbaria that enjoy the requisite support (Cotterill 2002).

We reiterate that denigration of the scientific values of consummate inventories is diagnostic of a more widespread Denigration of Natural History, which misconstrues the very nature of science. So framed in the Idiographic-Nomothetic Mutualism, we present an epistemological explication for why inventories and taxonomy (so commonly undervalued) hold critical roles in science. Our rebuttal of Baveye (2009) resides in the argument grounded on and structured by these interlinked tenets:

- Scientific generalizations (nomothetic statements) are founded on idiographic data: in a life science these are the natural history facts about individual species (notably autecology, behavior, adaptations, evolutionary affinities);
- A biotic inventory is the inaugural step in knowledge generation because it discovers species (and/or their properties) hitherto unknown to science, simultaneously remedying gaps in our knowledge of described taxa. It follows that biotic inventories constitute core discovery processes; investigators across all the sciences exploit these discoveries for derived and/or synthetic knowledge;
- The credibility of nomothetic knowledge stands or falls on the relative completeness of idiographic sampling of biotic entities (individuals), because the representativeness of any such generalization causally reflects the underlying details of summarized data in all its idiosyncracies. For example, the comprehensiveness of our knowledge of trophic processes (primary productivity for example), hinges on how comprehensively we have characterized the variety of photochemical mechanisms whereby energy is fixed into the biosphere. This in turn is contingent on how comprehensively inventories have described biochemical diversity amongst all autotrophic species, especially microbes;

- These epistemic roles and values of idiographic facts—generated through inventories of previously unexplored biota and landscapes—that establishes natural history as the fundamental, encompassing life science. We reiterate that unprecedented advances in knowledge are set to follow on consummate inventories of biodiversity that include the protists. This argument necessitates unprecedented investment in idiographic natural history.

The idiographic foundations of nomothetic knowledge

Deeper evaluation of the Idiographic–Nomothetic Mutualism qualifies why idiography, and thus natural history, is so crucial and encompassing in its support of science. The crux of this argument builds on a critical linkage; the intrinsic credibility of a generalization about the material world (nomothetic knowledge) stands or falls on the nature and integrity of what we know about individuals (idiographic knowledge). The criterion of classifying the sciences on the criterion of how closely they deal with descriptive facts versus lawlike generalizations can be traced back to 1894, when Wilhelm Windelband articulated the nature of this mutualistic dichotomy. Idiographic and nomothetic science are set apart yet firmly alloyed by their complementary activities (Windelband 1894). In the broader research context, all the empirical sciences integrate idiographic and nomothetic data and associated truth-seeking processes. We recommend reading Ghiselin (1997, 2005); Jenner (2008) and Jenner and Wills (2007) for further details about how the complementarity of these idiographic and nomothetic components is integral to the integrity and progress of all science.

Tentelic specimens

Idiographic data are the grist for nomothetic mills that decipher law-like generalizations about organisms, and the ecological complexes in which constituent species interact and evolve. Yet beyond fueling enquiries across the sciences, it is important to single out other key epistemic processes, intrinsic to idiographic science, especially because these hold a critical role in undergirding the integrity of knowledge. They entail the critical, so poorly recognized, epistemic function of preserved natural science specimens (vouchers collected in inventories, Cotterill and Dangerfield 1997). Each specimen constitutes a source of tentelic[3] information; a specimen's preservation enables the veracity of its identity, affinities and provenance to be verified by independent researchers today and into the future. This tentelic function of specimens, preserved in natural science collections, so critical to the integrity of idiographic facets of knowledge, logically underpins the credibility of any nomothetic generalizations generated from these idiographic data (Cotterill 2002). Although a nomothetic generalization might be conventionally viewed as published and/or archived knowledge, one needs to acknowledge how each is undergirded by collated natural history data, structured by taxonomy. Ultimately, the epistemic integrity of any such compendium of systematic understanding is causally emplaced on the tentelic quality of preserved specimens.

[3] 'Tentelic' means "to hold together a web". A most critical epistemological contribution of preserved specimens is their existence as tentelic tokens of verifiable information; the veracity of particular knowledge causally relates to a specimen's existence and provenance, and its other affinities with the real world (Cotterill 2002).

Idiography and unique individuals: how serendipitous discoveries often redraft knowledge

Each idiographic discovery of an individual possesses a unique epistemic status, which as tokens of obtained knowledge, are associated with elucidating at least some detail of an individual's particulars. This ontological uniqueness inherent to individuals, which prescribes the nature of idiographic findings, explains why idiographic information exhibits an integral variety when grouped into a collective context. Our ability to gauge the unique status of an idiographic discovery, of a new species for example, follows from established scientific methods whereby new facts are incorporated into existing datasets. As a function of their intrinsic uniqueness, idiographic facts amass value through incorporation—as discoveries of novel data accrue increasing epistemic context through time. Precisely how a particular idiographic discovery relates to existing data reflects where it sits on the dataset's respective 'axis of uniqueness' or 'gradation of novelty'. To a large extent, the epistemic status of an idiographic discovery reflects this rank. This revelation of their contingent distinctiveness is an intrinsic part of the processes that incorporate idiographic data into existing knowledge—quantifying how they modify existing information.

This situation highlights an operant question in idiography—how does a particular idiographic fact change prevailing knowledge? The position assumed by an idiographic discovery (along its gradation of novelty) trends from the mundane (logging of yet another fact) to the serendipitous (bizarre and unexpected finds that recast hypotheses and theories). Why single out this property that is a function of integral differences, and thus variety amongst unique entities? By providing a proxy of where and when particular parts of knowledge advance, the degree of "idiographic serendipity" (framed along an axis of novelty) relates directly to this contingent impact of a particular discovery—how its incorporation complements or redrafts existing knowledge. In biology, this degree of "idiographic serendipity" is contingent on what unique entities are encountered in our explorations of biodiversity.

Monitoring programs exemplify how this process of incorporation augments existing datasets, and such data complement, rather than reconfigure what we know. This is demonstrated where data from new inventories enrich established time series (e.g. as rarefaction curves reach asymptotes); analogously, the real species richness of clades is revealed as incremental discoveries of taxa reach the respective asymptote in each clade. Incorporation of the evolutionary affinities of new species (utilising molecular or organismal characters) also augment idiographic datasets, here the more novel discoveries can cause a redrafting of of phylogenetic relationships. Here, phylogenetic distinctiveness is the key proxy of a taxon's degree of idiographic uniqueness, and perceived novelty.

Then there are those idiographic discoveries that exercise more extreme impacts, because they recast nomothetic knowledge. Vivifying T H Huxley's infamous quip—"The great tragedy of Science—the slaying of a beautiful hypothesis by an ugly fact"—reflects how the unforeseen detection of an idiographic entity can modify a nomothetic generalization with irrevocable starkness. Consider how inventories discover those bizarre species, organismal adaptations, or biochemicals. Or monitored data departs from its time-honoured trajectory; now a novel topology reveals a hitherto unsuspected trend. Exemplified by new phyla (Conway Morris 1995; Huber et al. 2002) such startling discoveries trend to the one extreme, along the gradation of novelty, in how they alter prevailing scientific wisdom. This contrast amongst discoveries modifies our operant question in idiography—does a discovery perpetuate a trend, padding out an envelope of sampled variation within familiar boundaries; or does it constitute an unanticipated sample from an arena of hitherto unknown variety?

It is intriguing to acknowledge how these ingredients of novelty and serendipity—inherent characters of idiographic uniqueness—inexorably govern salient aspects of the state of science. Judged against more tangible benchmarks (constituted of the more commonplace data collated during routine, incremental monitoring), more unique discoveries often expand scientific knowledge, suddenly, by leaps and bounds. Akin to one of Huxley's ugly facts, precisely because they have unforeseen impacts on prevailing knowledge, such discoveries tend to incite prominent attention. While the inexorable logging of datum upon datum paints revealing patterns along extending data curves, so gradually pushing back the frontiers on our ignorance, it is most challenging to ascertain where and when we will encounter the serendipitous; those discoveries of bizarrely different entities, which require what science has made known to be redrafted into new, unanticipated configurations, invariably changing the nomothetic status quo. Nevertheless, the more mundane of idiographic discoveries not only modify established knowledge more adroitly, but with equal irrevocability. Above all, they provide the very foundations of robust knowledge that we can return to, again and again, to question and reanalyze using multifarious methods. This is why data assimilated through consummate inventories provide both the framework and benchmarks to classify unfamiliar discoveries. The nature of idiography conveys a critical message. Uniqueness rules! Within the context of the variety of the existing knowledge in which they are evaluated (determining their position along respective axes of novelty), the uniqueness of discoveries varies along a continuum. Nevertheless, each idiographic discovery holds a unique role in structuring the integrity and progress of science. Perhaps the most sobering lesson is that idiographic shortcuts to nomothetic insights simply do not exist. This situation is most instructive for how we plan, support, teach, and above all, do science.

Denigration of natural history: diagnostic symptoms

The Taxonomic Impediment and the Second Alexandrian Tragedy

A synopsis of two examples reveals pervasive impacts of the Denigration of Natural History. The Taxonomic Impediment (Hoagland 1996; Wheeler 2008) is one acute problem weakening the integrity of the life sciences; the core of this crisis is that "…Taxonomy, already weakened by decades of neglect, now suffers the loss of positions and funding…." (Wheeler 2004, p. 571), and too many in the dwindling taxonomic workforce only do real taxonomy in their spare time (Janzen 1993). Moreover, the Second Alexandrian Tragedy that entails extinctions of irreplaceable information represented in established expertise and natural science collections (Cotterill 1995, 1997) undermines idiographic research.

Clearly a major bottleneck on research output, the scarcity of taxonomic resources will indeed render a consummate protist inventory "quite an undertaking". These constraints on taxonomic productivity (as exemplified in the case of protists, which likely explains Baveye's frustration in his local research experience) require urgent solutions, in line with challenges to study other hyperdiverse taxa. This demise of taxonomy reflects the failure by nearly all biologists and policy makers to support taxonomic resources with much more than mere lip service. Towards its remedy, priority training of specialists is a key tactic toward completing biodiversity inventories—with radical increases in the number of taxonomists (Gonzalez-Oreja 2008). A significant increase in the rate of characterization of the protists will require at least 284 protist specialists to describe five new species/year, if 35,500 species are to be described within 25 years!

Scientiometrics fails to quantify the temporal eminence of idiographic knowledge

Our second example is an equally trenchant symptom of the Denigration of Natural History. This is the incapacity of contemporary scientiometrics to quantify the scientific worthiness of taxonomic publications. Impact factors of scientific periodicals attract controversy (Wilson 2007; Brischoux and Cook 2009), especially as publications of pure taxonomic content fare poorly in these ranks; yet contingent on date of publication, half lives of taxonomic descriptions often straddle decades and even centuries (Krell 2002). Widely accepted as succinct benchmarks on the state of scientific knowledge (and indeed a researcher's credibility), scientiometric statistics were proffered as abstractions of the complex trends in communicating new knowledge, which manifest through publications of research findings. So it is most unfortunate that these statistics fail to characterize how taxonomic publications both sustain and improve knowledge. The singular challenge is to accommodate their temporal eminence. Above and beyond how taxonomies structure universal communications of knowledge (Cotterill 1995), published idiographic facts (irrespective of their vintage) continue to accrue relevance in contemporary science. This is because they persist in structuring derived scientific statements, findings and/or conclusions; each product in such a succession of papers constitutes a nomothetic publication. By virtue of their very structure, repeatedly improved upon as a function of incremental attempts to explicate expanding idiographic datasets, nearly all nomothetic publications are relatively shorter-lived affairs.

Given their deficiencies, it is indeed remarkable that bureaucratic assessments employ these scientiometric statistics to guide how science is prioritized and supported. A wide subscription by so many researchers is equaly ironic! It follows that the real value of taxonomic outputs is undermined by biases that follow on infatuations with short term returns on published knowledge. Such prioritizing of myopic successes in science is symptomatic of attempts to turn academic and scientific research into a cost-recovery exercise (Ghiselin 1989; Cotterill 2002; Nesbit 2007). Beyond bureaucrats' uncritical judgments of the relative value of scientists' publications, a statistically-grounded folly leaps into crisp focus when scrutinized under the framework of the Idiographic–Nomothetic Mutualism. Underwriting their remarkably long half lives, the intrinsic scientific values of taxonomic publications, as collations of idiographic facts, not only sustain but often fuel the growth of new knowledge. When judged against the Idiographic–Nomothetic Mutualism, these weaknesses reveal scientiometric statistics to be misguided at best and pseudoscientific at worst. This opens a window of opportunity for scientiometrics; its investigators are challenged to embrace critical realities in how science works—especially to quantify a stark disparity in temporal eminence, where the scientific worthiness of so much idiographic knowledge far outlives that in most nomothetic papers!

What is natural history? why is it science?

Invariably, the conjugated questions—'What is Natural History?" and "Why is it Science?' engender unclear answers; not uncommonly, derisive reposts perpetuate the myth that natural history is mere stamp-collecting—anything but science! These rejoinders add up to another strident symptom, diagnostic of the pervasiveness of the Denigration of Natural History. Although our surveys are admittedly local, none of the professional biologists, we have challenged, could furnish correct, let alone succinct answers to either question. It is equally intriguing that recent defenses of natural history (e.g. Bates 1990; Dayton and Sala 2001;

Greene 2005) lack the epistemologically lucid exposition explicated here, which identifies precisely how natural history research interfaces with other sciences.

In the context of the life sciences, we characterize natural history as the arena of scientific enquiry that encompasses the discovery, elucidation and classification of the idiographic details of extinct and extant biodiversity. Thus, embracing comparative biology, natural history embraces the spectrum of idiographic research that discovers and describes particular facts: evolutionary affinities and distributions of biota, detailing the nuances of the behavior, biochemistry, physiology and autecology of individual species. This is exemplified by how idiographic details about individuals, collated in a consummate inventory, structure and fuel nomothetic research; all these processes entailed in integrating knowledge are framed by the Idiographic–Nomothetic Mutualism.

Unprecedented knowledge from consummate inventories

Idiographic discoveries and interdisciplinary opportunities

To reiterate the core argument (Cotterill et al. 2008)—unprecedented inventories of protist diversity will open new windows of understanding on the ecology and evolution of the microbosphere. And we singled out several criteria why the protists constitute one priority for consummate inventories of their constituent species. Justifications include: the keystone roles of protists in ecosystems, especially as predators, and applied benefits including environmental monitoring and new opportunities in biotechnology.

We can only guess, at present, how discoveries that follow on a consummate inventory of protists will inform science to benefit society. These opportunities highlight the forecast by Hockfield (2009) that emerging opportunities in interdisciplinary discoveries and applications will link the life sciences increasingly with the physical and engineering sciences. We argue that especially in such cross-disciplinary arenas (for example, biomimicry http://www.biomimicryguild.com/) the quality and scope of available idiographic facts about species will constrain the rate and quality of new discoveries and solutions. These opportunities require major investments into the idiographic characterization of organismal diversity.

Arguments for unprecedented investment in taxonomy (Wheeler 2008, 2009) that intrinsically entail consummate inventories, run up against myopic priorities that undermine support for real progress to groundbreaking discoveries in science, where "Funding agencies are seduced either by 'pure' notions of basic science as hypothesis-testing, or by the satanic mills of commercial reward……modern research has become a planned journey through set 'milestones' to deliverable destinations." (Nesbit 2007, p. 798). This pervasive dilemma reveals that natural history is one prominent victim, within the broader dominion of idiographic research silenced under the guise of ranking scientific disciplines, and research projects, on defective credentials, where a perceived superiority of nomothetic science passes over priorities of idiographic research (Jenner 2008). It is this syncretism, this perpetuation of what amounts to a mythological classification that raises stark questions about the state of science.

The prevailing mindset, which has come to direct research priorities, might consider how, time and again, unforeseen discoveries in science have literally leapt out of idiographic datasets. A sobering lesson of history is how serendipitous discoveries have enriched scientific progress (Dyson 2009). These remind us why Society is eternally grateful to those scientists, who recognize the undisguised values of short term rewards as so much parochialism. Exemplified by how the Mauna Loa Curve—charting atmospheric concentrations of CO_2—irrevocably changed humanity's view of a changing earth, scientists of the ilk of Charles Keeling overcome adversities of local political climates to successfully perpetuate longer term quests (Nesbit 2007); exemplified by inventories, these researchers explore the frontiers of the unknown.

Idiographic discoveries of organisms and genomes are interlinked

So we reiterate that "This constraint on generation of idiographic knowledge [inadequate inventories] is an especially acute example of a pervasive hindrance to scientific progress. Stated bluntly, it is impossible to derive nomothetic generalizations when one has too few idiographic facts." (Cotterill et al 2008, p. 438); our ignorance of unexplored domains of the natural world weakens nomothetic knowledge intrinsically. Nevertheless, what discoveries confirm that biotic inventories are a core research priority in the life sciences? What unequivocal evidence vindicates unprecedented investments in consummate inventories of biodiversity? Disease control has benefited time and again from inventories of invertebrate vectors, with obvious benefits to human society. In avoiding peripheral habitats and obscure biodiversity, medical research exemplifies a weakness where research is applied to problem solving, and tends to focus on "problem taxa", thus overlooking species peripheral to epidemiological concerns. To the contrary, "venomics" presents unprecedented opportunities to explore the natural world for evolution's immense arsenal of animal venoms. Guesstimates of this diversity total hundreds of millions of proteins, yet the structures of less than 200 of these venoms have been elucidated. The idiosyncratic properties of species-specific venoms endorse descriptive "mining" of their diversity (Escoubas and King 2009). In important respects this is idiographic research founded on blind inventories!

Recent discoveries in the microbosphere provide fascinating examples that justify consummate inventories; as " ... we live in the Age of Bacteria (as it was in the beginning, is now and ever shall be, until the world ends) ...." (Gould 1993, p. 312). This is precisely why inventories of the microbial world (embracing protists) are research priorities to remedy our shockingly poor knowledge of protist diversity: in space, time and form. One need look no further then genomics, where descriptive outputs of genome sequencing realize idiographic returns on costly investments into primary, descriptive research. It is challenging to distinguish how a consummate inventory of organismal biodiversity really differs from the burgeoning genome sequencing initiatives that characterize selected species. Based on epistemological criteria, genomics is an idiographic—or "neontographic"—science (Ghiselin 1997). Genome sequencing constitutes the inventory of an extant individual. It necessarily entails "blind" inventories of unexplored realms.

For example, Venter et al. (2004) demonstrated how remarkable advances in knowledge can flow from surveys of the unknown: this inventory of marine microbes revealed a hitherto unsuspected diversity of marine phototrophes (Eisen 2007). This example imparts several lessons; one is how these idiographic discoveries across the microbosphere redefine the comprehensiveness, and thus robustness, of our ecological knowledge of trophic processes. The trendy technology of genomics aside, these marine phototrophes exemplify how natural history studies obtain revolutionary idiographic insights. Future research is challenged to obtain verifiable identifications of these unknown organisms that appear to sequester such significant amounts of energy into the biosphere. Such finds and challenges endorse why organismal biology should flourish—as envisaged by Wilson (1989)—burgeoning idiographic databases will consolidate comparative biology as the fulcrum integrating biological research, in tandem with genomic explorations.

Concluding remarks: a brochure of life or the encyclopedia of life?

It is only through the study of idiographic details that nomothetic insights become epistemologically accessible (Jenner 2008). Unfortunately, appreciation of this principle is most poorly incorporated, if at all, in the teaching and practice of contemporary science, and is markedly lacking from evaluations of how the support, accredited by society, is channeled to research.

As the encompassing arena of scientific enquiry that discovers, deciphers and classifies idiographic details of extinct and extant biodiversity, natural history holds multifarious roles in expanding and consolidating the foundations of scientific knowledge and research. Thus, inadequate investment in idiographic research undermines the prerogative to improve our poor knowledge of biodiversity and the biosphere; the prevailing poor support follows from perspectives that either misrepresent, or fail to appreciate, how science obtains and consolidates knowledge of the natural world. We have argued that diagnostic symptoms reveal how the Denigration of Natural History weakens contemporary science:

- the dismissal that exhaustive biotic inventories are of inconsequential scientific value;
- poor support for taxonomy, and taxonomic resources;
- failures to appreciate the critical—tentelic—role of preserved specimens in sustaining the integrity of scientific knowledge, and to support natural science collections;
- the inability of scientiometrics to quantify the temporal eminence, and thus persisting scientific worthiness of idiographic knowledge, exemplified in taxonomic publications;
- a pervasive inability amongst professional biologists to define and articulate, unequivocally, the critical, epistemological roles of natural history research.

We conclude that these predicaments reflect an inadequate understanding of the metaphysics that structures the Idiographic–Nomothetic Mutualism. How then can one remedy this Denigration of Natural History, whose ramifications impact on science, pedagogy and policy? It hinges on recognizing that an integral interdependency alloys the idiographic and nomothetic sciences; this integral structure of the sciences not only complements, but empowers endeavours in the scientific enterprise to explore and understand the natural world.

We reiterate that the Denigration of Natural History fails to appreciate how inventories constitute inaugural epistemic activities in biodiversity science and geobiology; thus endeavours exemplified by "Characterizing all protist species" are vital research priorities that encompass the broader strategy of consummate biodiversity inventories. Most critically, cast in the context of our argument that natural history is the encompassing idiographic science, attitudes that dismiss "blind inventories … as a stamp collector's dream of characterizing all protist species" (Baveye 2009, p. 505) raise serious questions about how the pervasiveness of this attitude undermines the integrity of pedagogy and research across all biology.

To expand on the profound analogy drawn by Gonzalez-Oreja (2008), the biodiversity sciences face an unambiguous choice. Should research objectives target a Brochure of Life or the Encyclopedia of Life? Even if its scope extends beyond the Megafaunal Bias (Cotterill 1995), can a Brochure of Life deliver robust, representative scientific knowledge? This is no trite question. No matter how glossy the marketing of a Brochure of Life, its catalogue of so relatively few charismatic species can never match the scientific integrity of the Encyclopedia of Life that aims to detail biodiversity representatively. To justify their decision to society, those who abrogate the Encyclopedia of Life are challenged to present a metaphysics whose credibility supersedes that of the Individuality

Thesis. This is no small task. The Individuality Thesis, the fundamental ontology distinguishing classes from individuals, is the very foundation of natural science.

A critical weakness in modern biology is in urgent need of remedy. What we think we know about biodiversity is based on fragmentary sampling of genomes, species and landscapes. So we should not be surprised to encounter situations where this inadequate spatial and phylogenetic representativeness manifests in unsound nomothetic knowledge: consequences of parochial, patchy inventories.

An inaugural step will be to remedy inadequacies in science education at all levels. The scientific community has a critical responsibility, not only to inform society why robust science really does matter, but to teach the credentials of how natural history structures the key facets that underpin the epistemic robustness of science; how progress in knowledge generation hinges on credible discoveries of idiographic details about individuals, with these processes encompassed by natural history. We are challenged to reconcile with a disquieting but equally remarkable situation. Ultimately, scientific progress is determined by our success in mapping the idiographic idiosyncracies of the natural world—completing charts of the partly explored, discovering its unsuspected complexities. It is indeed ironic that the state of our idiographic knowledge of these arenas exercises overbearing supremacy over what science does and does not know.

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