THE NATURE OF BIOLOGICAL SPECIES: RETHINKING DAVID HULL'S CONCEPT OF 'SPECIES-AS-INDIVIDUALS'

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Abstract. One of the most puzzling conundrums in contemporary evolutionary biology concerns the ontological status of species. The debate developed gradually after the publication of Darwin's most famous work, *The Origin of Species*, and it is not restricted to taxonomy, but has profound implications for all branches of biological science and equally for our understanding of the natural world. One of the most spectacular proposals regarding this issue belongs to David Hull who argued that species are individuals, not natural kinds as they were traditionally considered. Consequently, according to Hull, individual organisms studied by naturalists are just parts of species as individual entities. Although Hull's definition has been praised by many philosophers of biology, it was not very well-received by biologists themselves for obvious reasons: it is profoundly counter-intuitive and doesn't seem to fit well with our empirical observations. In the present paper I will argue that Hull's idea could still be a promising hypothesis and I will try to respond to the main objections which have been formulated against it.

Keywords: biological species; species concept; philosophy of biology; biological taxonomy; ontology; individuation.

INTRODUCTION

Before Darwin, the general philosophical background of biological systematics was metaphysical realism: the view that all things in Nature possess some defining and essential properties. This metaphysical belief urged naturalists and biologists to search for those morphological properties which separate species from one another according to their nature or essence, in the hope of discovering the true natural order of all species of plants and animals. Nonetheless, this metaphysical view of the organic world was accompanied, inevitably, by a presupposition which is incompatible with any theory of evolution, namely that the organic world is a static realm (as any realm of essences), a world formed by entities created once and for all and which cannot change significantly through time.

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After the publication of Darwin's theory, which explicitly states that all species evolve, essentialism was gradually eliminated from biological sciences, and taxonomists started to abandon morphology as the main criterion for the individuation and identity of species. This major shift triggered a feverish and passionate search for a proper definition of biological species. Although biologists and philosophers advanced many proposals, some of which being already considered classical, the search for *the* one correct definition of species continue to this day.

CLASSICAL DEFINITIONS OF SPECIES AND THEIR DIFFICULTIES

Maybe the most successful and popular definition regarding species is that formulated by the German biologist Ernst Mayr, one of the founding fathers of the so-called 'synthetic theory of evolution'. According to Mayr, "species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups."[1] The specific reproductive features of these organisms isolate them from other organisms in nature, and thus separate them in what we usually call species. A distinctive feature of this definition is that it does not use morphological features of biological organisms, but only a constitutive feature given by their reproductive characteristics, and this feature is considered to be both necessary and sufficient for an adequate and precise demarcation of species. In short, according to Mayr, reproduction is the main criterion for the individuation of species, not their morphology.

However, despite its solid biological background and its usefulness, the biological species concept (BSC) is not able to offer a coherent and precise description of the mechanism which divide nature into particular species of plants and animals for at least two main reasons: the first reason is the existence of asexual species, which could not be covered by the definition; the second is the existence of hybrid species which, according to Mayr's definition, should not exist. Or, to put it differently, sexual reproduction is not universal enough to offer the required criterion for articulating a unique biological taxonomy. In order to eliminate this difficulty, Mayr subsequently added morphological properties as a supplemental criterion, one which would permit us to adequately individuate asexual species. Unfortunately, this refinement of his initial definition could be easily considered a new and different definition for asexual species. As Nathan observes, "proponents of the BSC in its classical guise, who also acknowledge the existence of asexual species will, *ipso facto*, recognize the existence of at least two kinds of species, each with its own concept or definition."[2] Moreover, even if we accept this supplement

[1] Ernst Mayr, *Systematics and the Origin of Species*, New York, Columbia University Press, 1942, p. 120.

[2] Marco J. Nathan, "Pluralism is the Answer! What is the Question?" *Philosophy, Theory and Practice in Biology*, vol. 11, no. 15, 2019, https://doi.org/10.3998/ptpbio.16039257.0011.015, last accessed: May 2023.

to Mayr's initial definition, it does not explain the existence of hybrid species which, sometimes, have an adaptive success bigger than the original species from which they initially originate.[3]

Another definition of species, frequently invoked by taxonomists and biologists was initially formulated by the famous American paleontologist G.G. Simpson. According to Simpson, "an evolutionary species is a lineage (an ancestral-descendant sequence of populations) evolving separately with its own unitary evolutionary role and tendencies."[4] The so-called 'evolutionary species concept' (ESC) manage to overcome the difficulties which affects Mayr's proposal, evolutionary lineage being a more universal feature than reproductive isolation and being able to cover both sexual and asexual species. Moreover, Simpson's definition can also recover the existence of hybrid species, given that the evolutionary history of a certain species and its evolutionary lineage does not impose any *a priori* restriction on such major biological events as hybridization. Nonetheless, even if ESC does not exclude hybridization, it still cannot explain it properly, because the evolutionary lineage of the new species which arise from hybridization will be emergent in relation to the evolutionary lineages of the previous species. More precisely, the evolutionary lineage of the new species cannot be rigorously continuous with any of the evolutionary lineages of the previous species, and it should be treated as a new evolutionary lineage, with no clear evolutionary history. Moreover, beside the impossibility to properly explain hybridization, the evolutionary concept of species also faces difficulties regarding its capacity to explain speciation in the case of asexual species. As Rosenberg notes, "the definition leaves completely indeterminate what counts as speciation in evolution of asexual organisms. For all lines of descent among asexual organisms, intra- and inter-specifically, are evolving in utterly separated ways."[5] Consequently, we should supplement the definition with a series of stipulations that should allow us to formulate a proper explanation for speciation in the case of asexual organisms, or even to draw a radical conclusion and accept, as Rosenberg puts it, "that an asexual species is not a species at all, but only so-called by courtesy or confusion."[6] However, both strategies are undesirable for obvious reasons: in the first case, if we add some stipulation to the original definition, we are in the same situation as with the BSC, we get two definitions instead of one; whereas in the latter case we would be forced to sacrifice solid empirical data for the sake of a clear definition by accepting, despite the evidence, that there are no asexual species.

[3] A good example is the so-called "coywolf", a hybrid species which lives in North America, formed through hybridization between coyotes and wolves. Coywolves have better adaptive features compared to original coyotes and wolves populations.

[4] G.G. Simpson, *The Principles of Animal Taxonomy*, New York, Columbia University Press, 1961, p. 153.

[5] Alexander Rosenberg, *The Structure of Biological Science*, Cambridge, Cambridge University Press, 1985, pp. 197–198.

[6] *Ibidem*, p. 198.

Finally, the third classical definition for species comes from ecology. Initially formulated by Leigh Van Valen and refined later by Edward Wiley (and even by Mayr himself), the ecological definition of species states that a species is "a lineage (or a closely related set of lineages) which occupies an adaptive zone minimally different from that of any other lineage in its range and which evolves separately from all lineages outside its range."[7] This description already shows that the central notion in Van Valen's definition is that of an adaptive area. In his view, an adaptive area would allow us to unequivocally distinguish between those populations of organisms that we usually call species and, at the same time, to offer a proper explanation for their evolutionary path forged during the innumerable interactions with the ecological niche they occupy. An important difference between Van Valen's ecological species concept (EcSC) and the other two definitions previously examined is that the ecological concept of species proposes an external criterion for the demarcation between species, namely the adaptive area. Apparently, such an independent and external criterion could provide a rigorous classification of species. Unfortunately, the notion of adaptive area is burdened by at least two major difficulties. The first one is its inability to precisely individuate species: an adaptive area can be inhabited by an indefinite number of species and is never uniquely tuned for a single set of adaptive parameters corresponding to a single species. The fact that a certain ecological niche is inhabited by a particular species does not tell us anything significant about that species or tells us something about several species at the same time.

The second major difficulty which EcSC needs to tackle with concerns the independence of the demarcation criterion offered by the notion of 'adaptive area'. At first glance, by using the concept of 'ecological niche', the definition seems to give us an independent criterion for the classification of species, a criterion that does not use any internal features of the species, as the two other classical definitions we previously examined. But this is only provided if the notion of "ecological niche" is understood as comprising the total resources available in a certain geographic area *excluding* other living organisms that inhabit it. However, this is the same as saying that an ecological niche is made up of all (and only) the inorganic resources in a certain geographic area, which is utterly inaccurate, since prey-predator and/or host-parasite relations are the ones that often determine the types of resources available in a particular geographic area. More precisely, an adaptive area for a particular population of organisms or species will necessarily contain other populations of organisms, *i.e.*, other species that may be in prey-predator or host-parasite relationships with the original species. In short, the definition of a species using the notion of 'adaptive area' is equivalent to defining it according to its relationships with other species. Therefore, the notion of an 'adaptive area'

[7] Leigh Van Valen, "Ecological Species, Multispecies and Oaks", *Taxon*, vol. 25, no. 2/3, 1976, p. 233.

becomes almost completely dissolved in the relationships between species sharing a certain geographic area. Which means that in defining the adaptive area we already need a certain concept of species that would allow us to identify the relationships and the specific mechanisms that takes place between those populations, and which constitute together the adaptive area in question.

COMMON FEATURES OF CLASSICAL DEFINITIONS AND SOME REMARKS ABOUT PLURALISM

From a methodological point of view, all three definitions discussed above seem to have several common features. For example, they are all partial or incomplete, as we have seen, none of them being able to offer a unique criterion for the individuation of all species. Moreover, each of them sheds light on a single prominent property considered relevant for the biological profile of many species, although not for all. For instance, it is an undeniable fact that the reproductive mechanisms of species and their peculiarities tell us something very important about a significant percentage of the organisms living on our planet. However, beyond these resemblances, all three concepts of species also share a metaphysical foundation, namely the presupposition that all biological species are natural kinds. Even if this metaphysical doctrine regarding the ontological status of species is no longer accompanied, as it was before Darwin, by a straightforward essentialism, it still imposes a series of restrictions on any definition of species formulated on its basis. For example, if species are natural kinds, then any adequate definition has to specify at least one property which is common to all species and also theoretically relevant. As we have seen, BSC fails to offer an adequate definition precisely because the reproductive mechanism, although quite important for many species, does not cover the class of asexual species and leaves a wide area of uncertainty in the case of hybrid species. In addition, those traits or properties considered relevant for an adequate definition of species must also be relevant for the individuation and identity of individual organisms. If the reproductive mechanism provides the criterion of demarcation between species, as Mayr argued, then the species a certain organism belongs to will be decided according to its ability to reproduce with members of that species. In short, if we believe species are natural kinds, and we try to formulate an adequate definition for them, we are automatically looking for some common features, some uniformities imbued with an explanatory role.

At first glance, this metaphysical belief of species as natural kinds looks completely natural because it seems to be in full agreement with our empirical observations and common sense. What we actually see when we observe the members of any species is precisely this: a group of individuals that seem to have several traits in common, therefore a natural kind of organisms. Consequently, it seems equally natural to seek for those common and theoretically relevant properties necessary in order to formulate a definition of that species as a natural kind. The

strange thing is that, as we accumulated more and more information about species, the disagreement regarding the definition of species has deepened, instead of dissipated, as would have been expected. As Nathan remarked, "what makes the species problem puzzling, from a philosophical perspective, is its conceptual trajectory. Instead of gradually converging towards consilience, scientific progress seems to foster the production of dissonance."[8]

Moreover, this disagreement grew so big, that for many authors species pluralism became an unavoidable conclusion, any other methodological trajectory being considered a sort of 'species dogmatism'. As Mishler and Donague argue, "a variety of species concepts are necessary to adequately capture the complexity of variation patterns in nature. To subsume this variation under the rubric of any one concept leads to confusion and tends to obscure important evolutionary questions."[9]

In sum, if we are still far from an adequate and unique definition of species despite the fact that we continue to accumulate more and more relevant information about them, this could mean that the assumption behind the search for a unique species definition as natural kinds might be wrong. But what is that assumption? Well, none other than the old Realist (indeed, with a big "R") tenet that Nature is divided in natural kinds of plants and animals in a single and unique way. If we endorse this metaphysical principle, then scientific progress could mean only one thing: unraveling that unique order of biological natural kinds and formulate a unique taxonomy. And, of course, in order to obtain that, we need a unique concept/definition of species as natural kinds.

However, if we take the other approach and we argue that species pluralism is the only legitimate conclusion regarding the definition of species, we manage to overcome, indeed, the unpleasant consequences of metaphysical realism but, at the same time, we also depart from the ideal of traditional systematics. That is because a unique and correct description of all species seems to be precisely what taxonomists actually search for.[10] Or, to put it differently, by using this strategy and accepting pluralism, we avoid one problem by opening another. If we embrace species pluralism (in any of its versions), we get rid of the thorny problem of finding a unique definition of species, but we have to face the difficulties of an anti-realist position. Some authors argue that species pluralism is not necessarily associated with an anti-realist position, and *vice versa*, monism regarding species is

[8] Marco J. Nathan, "Pluralism is the Answer! What is the Question?" https://doi.org/10.3998/ptpbio.16039257.0011.015

[9] Brent D. Mishler, Michael J. Donoghue, "Species Concepts: A Case for Pluralism", *Systematic Zoology*, vol. 31, no. 4, 1982, p. 500.

[10] Rosenberg captured this taxonomical ideal very neatly. In his words, "the presuppositions of traditional systematics are twofold:

1. There is a single correct description of the basic types of flora and fauna in the world.

2. This single correct description is not merely compatible with the rest of science, but actively coheres with it, as reflected in the conviction that the explanatory power of the uniquely correct taxonomy of terrestrial flora and fauna can be grounded in the rest of biology" (A. Rosenberg, *The Structure of Biological Science*, p. 181).

not necessarily associated with a hard metaphysical realism.[11] That may be true, but traditional systematics is committed precisely to *this* version of hard metaphysical realism. If we argue for species pluralism, we are somehow forced to accept not only the possibility, but also the legitimacy of many biological taxonomies, which will classify species in divergent (or even contradictory) ways, according to the definition they take for granted. But that, in turn, means that 'carving Nature at its joints' is no longer on the table as the only legitimate way of classifying biological species. Unless we are ready to accept that 'Nature in itself has no joints'. But for many biologists this conclusion seems hard to accept.

SPECIES AS INDIVIDUALS

It's time to take stock. As we have seen, from an ontological point of view, classical post-Darwinian definitions of species describe them as natural kinds or classes. This perspective comes with certain restrictions – a proper definition of species would have to identify one or more necessary and universal properties which could offer the basis for species individuation and identification. But precisely because of this condition, all three concepts of species presented above (and many others advanced so far) fail to offer a unique and coherent definition of species, despite their usefulness in particular research contexts and for certain clusters of species. One of the possible escape routes from this conundrum is the so-called "species pluralism", according to which a unique definition of species is not only unachievable, but also unnecessary. However, if we accept species pluralism, we need to abandon the main objective of traditional biological systematics, that of formulating a unique and precise 'periodic table' of all species of plants and animals. If species pluralism is the correct view, then different biological taxonomies are possible and legitimate. These different and even (possibly) contradictory taxonomies could be justified either by the typological variety of species and/or by the diversity of our research interests and theories regarding species. But this conclusion – and its logical foundation, species pluralism – is not easily accepted by naturalists and biologists for obvious reasons.

However, pluralism is not necessarily the only alternative. If we examine again the three definitions of species discussed above, we can observe they are somehow ordered hierarchically regarding their theoretical content. As Rosenberg notes, "the succession of accounts of the species notion thus far canvassed has moved in the direction of greater theoretical content and greater operational distance from the facts with which naturalists and taxonomists grapple. The sequence has reflected a willingness to trade off direct operational applicability in favor of greater generality."[12] In other words, the main definitions advanced so far follow a

[11] See, for example, Nathan's paper cited above.
[12] A. Rosenberg, *The Structure of Biological Science*, p. 198.

bottom-up strategy, starting from empirical properties and advancing gradually toward a more theoretical definition with enough explanatory and predictive force to allow a precise differentiation of species. But this strategy, which would seem rather obvious for a biologist, faces a lot of difficulties, as we have seen, given the variability and diversity of biological organisms. Reflecting on these difficulties makes one wonder if the possibility of using the reverse strategy wouldn't be more fruitful. More precisely, to try and define species starting from the theoretical conditions imposed by the theory of evolution through natural selection and then going down, toward the observable features of those natural entities that we call species.

Here David Hull's definition of species enters the scene because that's precisely what he does, using a *top-down* strategy when discussing about species. Following a proposal made initially by Michael Ghiselin, Hull argued that species are individuals, not natural kinds, or classes. Moreover, according to Hull, this is a rather necessary conclusion regarding the ontological status of species, one imposed by evolution itself: "if they are to perform the function which they do in the evolutionary process, they must be spatiotemporally localized individuals, historical entities. Reinterpreting biological species as historical entities solves several important anomalies in biology, in philosophy of biology, and within philosophy itself."[13]

The main argument for this is straightforward. At the level of genes and organisms, Hull observes, evolution by natural selection works by replicating individuals, imperfect copies of previous exemplars being selected. There is no reason why evolution would work differently at the level of species. On the contrary, we have every reason to expect the same result precisely because species are composed by combinations of different individual genes in individual organisms interacting individually in so many unique ways. So, it seems that, if we take evolution into account, the burden of proof rests on those arguing that species are natural kinds or classes, not individuals. That's because, as Hull puts it, "the relevant genetic units in evolution are not *sets* of genes defined in terms of structural similarity but individual lineages formed by the imperfect copying process of replication.[14] Moreover, Hull continues, "exactly the same observations can be made with respect to organisms […] The relevant organismal units in evolution are not sets of organisms defined in terms of structural similarity but individual lineages formed by the imperfect copying process of reproduction."[15] In sum, species cannot be other than individuals, because evolution through natural selection always results in individuals, not sets, both at genetic and organismal levels. In Hull's words, "species as the results of selection are necessarily lineages, not sets of similar lineages, not sets of similar organisms."[16]

[13] David Hull, "A Matter of Individuality", in Elliott Sober (ed.), *Conceptual Issues in Evolutionary Biology*, Cambridge, MIT Press, 2006, p. 363.

[14] *Ibidem*, p. 367.

[15] D. Hull, "A Matter of Individuality", p. 368.

[16] *Ibidem*, p. 369.

However, if we accept this conclusion, then the criterion for individuation and identity of species should be drastically altered: we should look no more for similarities between individual organisms in the hope of discovering those properties relevant for species differentiation. According to Hull, if species are historical entities, the same sorts of considerations which apply in the individuation of organisms should also apply to them: "the only apparent discrepancy," he notes, "results from the fact that not all biologists have been totally successful in throwing off the old preevolutionary view of species as classes of similar organisms and replacing it with a truly evolutionary view."[17] Although he is not very clear on this point, Hull seems to suggest that, if we see species as natural kinds or classes, historical considerations are not very important, whereas, if we see them as individual entities, history becomes crucial.

We shall return to this point later. For now, let's note some obvious theoretical advantages which seem to follow from this definition of species as individuals. First of all, if species are, indeed, individual entities, the result is a sort of ontological symmetry between genes, organisms, and species. They are all individual entities, driven by evolutionary forces. Therefore, their interactions and behavior are governed by the same pattern which apply to all individuals: symmetry is not a rule, but an exception, variability and uniqueness are the key elements. This is not something new, of course, innumerable observations made by naturalists and biologists before and after Darwin point to the same conclusion regarding species variability and diversity. But now we can reinforce this conclusion on the basis of their ontological status. From an ontological point of view, if species are natural kinds, their variability remains a puzzling feature no matter how many empirically and theoretically relevant observations support it. Whereas, if species are individuals, variability is just a trivial consequence of their ontological profile, and not a mystery anymore.

A second theoretical advantage of Hull's thesis is two-folded. First, it permits us to see more clearly why we cannot formulate nomological statements about particular species, why biology contains no lawlike statements about any particular species or cluster of species. If species are not classes of individuals sharing some relevant properties, but individual systems with parts causally connected, then our search for some universal empirical properties shared by all species (like the atomic number in the case of chemical elements) is in vain. We cannot achieve that simply because there isn't any such property shared by all species. Secondly, if we conceptualize species as individuals, then we could see more clearly where we should actually look for those regularities necessary for nomological statements. Those regularities are not empirical properties, but theoretical ones, like those derived from the theory of evolution by natural selection which cover *all* species. The result is that we are forced to admit, as Rosenberg puts it, "there are in biology at most two bodies of statements that meet reasonable general criteria for being

[17] *Ibidem*, p. 373.

scientific theories. These will be the theory of natural selection and such general principles of molecular biology as are free from any implicit or explicit limitation to any particular species or indeed any higher taxon of organisms restricted to this planet."[18]

OBJECTIONS TO HULL'S THESIS

However, despite its theoretical appeal, species-as-individuals thesis has been confronted with several objections which could be grouped in two main categories. The first group of objections concerns its counter-intuitive character and its apparent lack of corroboration with empirical observations. If we conceptualize species as individuals, then it would be impossible to find any empirical observations which could corroborate this thesis. That's because, when we observe a species, what we actually see is not an individual, but a group of more or less similar individual organisms sharing some properties, interacting, and competing for resources. In other words, Hull's definition of species is a metaphysical theory like Hegel's theory of history: it might be interesting and coherent, but it is empirically irrelevant and useless. The obvious reply to this objection is that the lack of direct empirical corroboration doesn't imply, necessarily, irrefutability or even the lack of empirical content. Hull's thesis offers the possibility to explain evolutionary traits and behavior of genes, organisms, and species, and that is something empirically traceable. The apparent counter-intuitive character of the thesis does not imply a complete lack of corroboration with empirical observation, on the contrary: seeing species as individuals could help us to explain their collective behavior and structural empirical features, even if it won't shed much light on the morphology of individual organisms. Moreover, on the basis of Hull's thesis, even those morphological similarities between individual organisms that we could so easily observe in any species would be seen in a different perspective: they are caused by the fact that those organisms are parts of a certain evolutionary lineage, a certain species *qua* individual, not by them being members of a certain natural kind, or copies of a certain biological pattern.

The second group of objections revolve around the idea that Hull's thesis is insufficient or theoretically lacking. More precisely, it is not a proper definition of species because it offers no adequate criterion for species demarcation and species membership. As we have seen, Hull's suggestion regarding the individuation and identity of species is pretty vague: according to him, we should try to use the same criterion that applies to any other individual entities. But what is that criterion? We can begin to see this by using an analogy. In many ways, species are like nations, individuals persisting through time and developing gradually in unique and unpredictable (or at least difficult to predict) ways. Historians, sociologists, and

[18] A. Rosenberg, *The Structure of Biological Science*, p. 219.

other scientists interested in the history and evolution of nations individuate and identify them using different criteria which comprise both empirical and theoretical properties of nations. But those properties are never considered universal and/or necessary conditions for nations individuation and identity. There is no unique and limited set of empirical properties which could individuate a nation, because all empirical properties of nations are variable and depend on many historical, geopolitical, and even geographical factors. In a similar fashion, there is no unique and limited set of theoretical/conventional properties which could individuate a nation, because, again, those properties are variable and local, not universal. Only a combination of these two types of properties could offer a criterion for individuation in the case of nations. How about species? Well, if species are individuals like nations, then the same rule would apply to them as well. Only a combination of empirical and theoretical properties would be able to offer a criterion for species individuation and identity. In short, for both nations and biological species, history becomes crucial when discussing about individuation and identity. However, as we all know, history is a messy business, it offers no clear-cut demarcation between nations, only an approximate and often conventional one, which is far from what we need and want when discussing about species. So, it seems that treating species as individuals forces as to accept that we would never be able to obtain a precise taxonomy for all species, but only an approximate and ever-changing one.

It is worth noting that this objection merely draws the ultimate consequences from the evolutionary thesis regarding species, no matter what their ontological status really is, and therefore it is not restricted to species-as-individuals thesis. In fact, it is a much bigger challenge for the other perspective regarding the ontology of species, *i.e.*, species as natural kinds. Let's suppose species are natural kinds, and they evolve given a significant amount of time. History would be no less important for understanding their evolution and for ascertaining their identity than it would be if they are individuals. But the relationships between a species as a natural kind and its historical evolution would be much more difficult to ascertain. An individual has a unitary trajectory through history, given its constitution and the relationships between its parts. Whereas the trajectory of a class or a natural kind could be much more difficult to discern. Moreover, if species are natural kinds, we are constrained to specify those properties which function as the criterion for their individuation and identity, and only *after* that we would be able to examine properly their history and to ascertain their evolutionary trajectory. To clarify this aspect further, let's make an analogy with chemistry. For taxonomical and individuation purposes, the history of a chemical element is not very relevant, what is really important is its atomic number. That is the main property which serves as the basis for its individuation and for the position it occupies in the periodic table of elements. If we hadn't discovered that property, it would have been very difficult to formulate a reliable and accurate taxonomy of chemical elements. In the case of biological species, where history is much more relevant because they evolve and change significantly in time, we don't have an equivalent

for the atomic number which could serve as a criterion for individuation. Actually, as we have seen, we don't even have a limited set of such properties: all three classical definitions of species (and many others) accentuate a different feature or property as being the necessary and sufficient condition for species individuation and identity. Therefore, the history of species as natural kinds is very difficult to follow and often yields divergent results and needs to be seriously revised and rewritten in the light of new discoveries regarding species' properties and features. As a consequence, formulating a reliable and accurate taxonomy of species as natural kinds is also a very difficult task.

So, it seems there is a serious tension between the ontological perspective of species as natural kinds, and our taxonomical and epistemological practices regarding species individuation and identity which seem to rest heavily on historical considerations.[19] Species-as-individuals thesis seems to be less problematic in this regard. If we see species as individuals, then historical considerations would play a central role in taxonomy, and we wouldn't be constrained to identify a property or a limited set of properties which could differentiate unequivocally between species. This task could be performed, jointly and legitimately, by a plethora of criteria, the only methodological restriction being that of following the history and unique trajectory of species *as a whole*. Some might argue that although this would result in a unique and coherent taxonomy of species, it would be a very confusing and complicated one. That might be true, but why would we expect it to be otherwise? After all, we are discussing about the history and classification of all species on Earth, it would be rather naïve to hope for a very clear and precise taxonomy akin to the periodic table in chemistry when trying to classify biological species.

Moreover, the same difficulties are to be found in the case of other individuals, beside nations, such as persons. Philosophers have long struggled to find a unique, necessary, and universal criterion for the individuation and identity of persons, and they gloriously failed. I think the reason is the same as in the case of species and nations: persons are not static, but dynamic entities which constantly change in interaction with the environment and with other people, and they possess several relevant properties – physical, psychological, social, cultural, etc. To say that you individuate a person only when you individuate an entity that possesses a single property X is to take a very simplistic (and naïve) view of persons. Perhaps the most reasonable approach on this subject is taken by Parfit, who argues that persons are bundles of properties linked together by causal relations.[20] When these

[19] Despite Boyd's more optimistic view according to which there is no such tension, and we could conceptualize species in both ways (as natural kinds and individuals) with no contradiction whatsoever. In Boyd's words, "even those scientists who are convinced that species are individuals must conclude that they are natural kinds as well." See Richard Boyd, "Homeostasis, Species, and Higher Taxa", in R.A. Wilson (ed.), *Species: New Interdisciplinary Essays*, Cambridge, MIT Press, 1999, p. 141.

[20] Derek Parfit, "Divided Minds and The Nature of Persons", in C. Blakemore, S. Greenfield (eds.), *Mindwaves: Thoughts on Intelligence, Identity and Consciousness*, Oxford, Blackwell, 1987, pp. 19–25.

kinds of causally connected properties are present, we can say that we have a person. And if (approximately) the same properties of each type are present, we can say that we have the same person, hence we have identity and continuity. But there is no necessary and universal property, an indivisible and unchanging core that makes up what we usually call a 'person'. Individuation (and identity) in the case of persons is a matter of historical investigation and interpretation, and cannot be done *a priori*, it cannot be ascertained universally and necessarily. Therefore, if we conceptualize species as individuals, we should draw a similar conclusion: there is no necessary and universal property definitory for all species. Nevertheless, in the case of each species we could always find a combination of empirical and theoretical properties which are sufficient to allow us to individuate it, and to differentiate it from other species.

What follows from this? Well, it seems to follow that we should abandon the ideal of a clear-cut and precise taxonomy in biology. That's because, when it comes to its object of study, biology is a little bit different than physics and chemistry, which study physical and chemical natural kinds. If species are individuals, then biological systematics is a historical science through and through. And, as it is the case with all historical sciences which study individuals, we cannot achieve the same level of precision and clarity as in physics and chemistry or other branches of natural sciences that study natural kinds.

There is still another version of this objection to Hull's ontological perspective regarding species, one which takes a different route to the same conclusion. As we have seen, species-as-individuals thesis does not specify, explicitly, a criterion for the individuation and identity of species. This remains a matter of historical, empirical, and theoretical assessment, starting from the most significant events which mark the evolution of every species, and going down to the less important ones. This is also the case with other individual entities, such as nations and persons, where we proceed in the same way when it comes to individuation and identity. However, this theoretical neutrality regarding the criteria for individuation and identity could be easily misinterpreted as implying the possibility of combining species-as-individuals thesis with any criterion would be theoretically preferable for species individuation and identity, and the consequence would be, again, species pluralism and taxonomical pluralism. For example, Brogaard argued that "unless the species-as-individuals thesis is but a crude claim about the ontological status of species taxa, more is needed. The reason is that mereology yields no uniform segmentation of organisms into species. We are left with the additional task of finding criteria for determining which mereological sums we should label 'species taxa'."[21]

I think there are many possible answers to this objection, so I shall indulge myself in choosing the most straightforward one. No ontological claim about any classes of entities is ever 'crude': it always comes with certain restrictions regarding

[21] Berit Brogaard, "Species as Individuals," *Biology and Philosophy*, 19, 2004, pp. 223–242, https://doi.org/10.1023/B:BIPH.0000024322.46358.61, last accessed: May 2023.

the individuation of those entities, even if it does not rigorously imply a certain precise and clear-cut criterion for that task. As we have seen, according to Hull, if we see species as individuals, when it comes to individuation and species delimitation, we have to use criteria best suited for individuals, not natural kinds, or classes. Those criteria combine a diverse set of historical, empirical, and theoretical properties, but this is just the way it should be, because all those properties are relevant for those individuals. For example, reproductive relationships, genealogical relationships, and even ecological specificity and coevolutionary relationships are all important factors when discussing about the individuation of species. However, they should not be considered in isolation, but in combination with one another. Sometimes, one of those factors might be more important than the others, sometimes all of them might weigh more or less equally in the process of individuation, and sometimes historical events might outweigh all other relevant factors. Individuation is a fine-tuning process, which uses not one, but many different properties, but it is so for any historical entities, not just for biological species. However, this is not the same as species pluralism. Saying that in the process of individuation we have to combine different criteria and different properties is not the same as saying that we could conceptualize species in many different ways. Contrary to Brogaard's conclusion, I think species pluralism is not a consequence of species-as-individuals thesis, but of species as natural kinds thesis. If species are natural kinds, it is a matter of debate which properties are best suited for species individuation and identity. Moreover, given the restrictions implied by the species as natural kinds thesis, we cannot coherently combine all those properties. And so, if all species concepts advanced so far have both empirical and theoretical merits (which are roughly equivalent), and cannot be discarded, the trivial consequence would be species pluralism and taxonomical pluralism.

To sum up, the fact the Hull's thesis could be combined with any empirically and theoretically relevant criterion for species individuation and identity is not a weakness, but rather a trivial corollary for any such ontological, or 'metaphysical' thesis, as Hull calls it.[22] After all, the same could be said of the traditional ontological perspective regarding species: treating species as natural kinds does not imply a certain set of properties as being necessary and sufficient for species membership and/or demarcation. That is something to be discovered by empirical and theoretical research. The ontological status of species has no rigorous implications regarding the epistemological criteria we should use for species membership and species delimitation. For example, the three classical definitions discussed above offer three different criteria for this, despite the fact they all assume species are natural kinds.

However, even though the main objections raised against Hull's thesis regarding species could be easily rejected, most biologists and philosophers of

[22] D. Hull, "A Matter of Individuality", p. 365.

biology still resist to it, preferring to stick with the classical ontological thesis of species as natural kinds. Why is that? I don't intend to dive into a thorough explanation of this curious skepticism, but in my final remarks I would like to make some brief observations about this and to offer another reason for embracing Hull's thesis.

CONCLUSIONS

As we have seen, Hull's thesis regarding species offers a straightforward way to restore the ontological symmetry between genes, organisms, and species and to explain the main evolutionary features present at all three levels. Moreover, it opens the possibility to formulate proper nomological statements in biology, accentuating the need to look for regularities at higher theoretical levels than that of particular species and their respective properties. If species are conceptualized as individuals rather than natural kinds, when searching for biological laws we should look for those properties modelled by evolutionary forces and those properties present at the molecular level, and not for properties relevant for species membership and demarcation. In short, when it comes to formulate an explanation for the evolution of species and the mechanisms responsible for that, it would be better to see species as individuals and to take into consideration only evolutionary forces and constraints that apply to all species, no matter their ecological niche, mechanism of reproduction or genealogical lineage. Treating species as natural kinds no matter what epistemological interests we actually have would be rather misguiding by accentuating confusion regarding the nomological status of biology. And it would also be counter-productive, since a consensus regarding the best definition of species as natural kinds is still lacking, and there are no foreseeable reasons to believe it will be achieved any time soon.

Moreover, there is still another (rather external) reason for taking a more malleable approach regarding species ontology, and for giving species-as-individuals thesis a chance. Recent debates in philosophy of science regarding the status of natural kind concepts aggravate, rather than alleviate the theoretical conundrum of species as natural kinds. For example, according to Hacking, contemporary natural kind debates are confusing and disconcerting because those involved in these debates have different and often incompatible definitions in mind when they use the term 'natural kind,' and they usually "refer to the class of classifications they most admire, as the class of natural kinds."[23] Nonetheless, as Ludwig observed,[24]

[23] Ian Hacking, "Natural kinds: Rosy dawn, scholastic twilight", *Royal Institute of Philosophy Supplement,* vol. 61, 2007, pp. 203–239, https://doi.org/10.1017/S1358246100009802, last accessed: May 2023.

[24] David Ludwig, "Letting go of 'Natural Kind'. Towards a Multidimensional Framework of Non-Arbitrary Classification", *Philosophy of Science,* vol. 85, no. 1, 2018, pp. 31–52, https://doi.org/10.1086/694835, last accessed: May 2023.

despite Hacking's criticism (and others), the debate around the status of natural kind concepts continues, with different proposals being advanced regularly. Clearly, this is not an encouraging tendency if what we are looking for is a sound theoretical explanation of the ontological status of species *as* natural kinds.

Now let's get back to Hull's thesis. As already mentioned, despite its theoretical benefits, species-as-individuals thesis is still regarded with skepticism, and most biologists still prefer to consider species as natural kinds. I think the main reason for this is an ideological one, and it involves a preconception regarding the theoretical status of biology and the nature of biological laws. If we accept that species are individuals, *i.e.*, historical entities, then historical considerations would have to play a central and crucial role in systematics. To be fair, they already play an important role, geological strata and fossils contributing massively to a constant readjustment of the history of life on Earth drawn by naturalists. However, most biologists and taxonomists still hope that a unique and clear-cut definition of species would allow us to go beyond historical considerations, and to offer a more rigorous and not so fluctuating taxonomy, similar to those achieved in other natural sciences, such as physics, or chemistry. If we accept that species are individuals, not natural kinds, it seems we are forced to accept that not only systematics, but biology as a whole is a historical science through and through, one which cannot achieve the rigorousness and the precision of physics and chemistry. Therefore, such an ontological perspective as that of Hull's would imply a seemingly dangerous disunity in the realm of natural sciences, one which we should avoid with any costs.

But that is not necessary so. As we have seen, species-as-individuals thesis does not imply the impossibility of formulating nomological statements or laws in biology. It only implies that those statements are not what we used to expect, generalizations about particular species, or clusters of species, like the statement "All geese migrate," or "All wolves hunt in packs," but of a much higher theoretical level. Accordingly, we are not constrained to draw the conclusion that biology cannot achieve, from a nomological point of view, the status of physics or chemistry. After all, physical laws are statements about all bodies, not about particular bodies, or particular types or cluster of bodies. The same should apply in biology: biological laws should be statements about *all* species, not about any cluster of particular species, no matter how large or historically significant they happen to be.

Nonetheless, even if Hull's thesis does not endanger the theoretical status of biology as a natural science, biological systematics would have to remain, indeed, a historical science. But this is just a trivial consequence of the theory of evolution: species evolve, they are not fixed and unchanging entities, like chemical elements. Therefore, any biological taxonomy which aims to be precise and in strict accordance with nature, needs to follow and mirror as accurately as possible the evolution of species, and thus to be historical.

Unfortunately, this implies we need to abandon the ideal of achieving a precise 'periodic table' of species, because that objective is simply impossible to

reach. Not only because our necessarily incomplete knowledge about species, but also because their intrinsic dynamism and evolution through time, which are typical features for any other individual entities. The organic world, unlike the physical and chemical realms, is much more dynamic and the changes which determine major shifts in the evolution of species and organisms manifest themselves in much shorter periods of time comparing to those in physical universe. In short, the physical universe (and, implicitly, the chemical one) is changing much slower that the organic world. Which means that the universality and necessity of the nomological statements in physics and chemistry are just a consequence of the much higher stability present in the physical and chemical world. When the overall state of the physical universe will change dramatically, the laws of physics will be different than they are now. Even the elegant and precise periodic table of chemical elements might need to be rearranged or changed dramatically someday. But in the organic world, dramatic changes are a constant, not an exception. Therefore, it would be wise to draw the taxonomical tree of life keeping that feature in mind, and not ignoring it. However incomplete and imprecise historical considerations about the trajectory of individual species might be, they are all we have. There is an old saying regarding human affairs which could be accommodated, with a twist, to natural affairs as well: history is written by the victors. Well, in Nature, history is written by survivors. Which means we would (possibly) never get to know the whole story about species and their evolutionary adventure. But it's the most we can do. In science, at least, an incomplete but accurate story is always better than many complete but inaccurate ones.