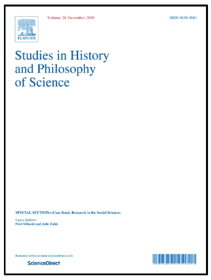
Journal Pre-proof



Genera and Species vs. Laws of Nature Two Epistemic Frameworks and their Respective Ideal Worlds

Oded Balaban

PII:	S0039-3681(18)30074-8
DOI:	https://doi.org/10.1016/j.shpsa.2020.01.007
Reference:	SHPS 1494
To appear in:	*Studies in History and Philosophy of Science*
Received Date:	13 March 2018
Accepted Date:	19 January 2020

Please cite this article as: Oded Balaban, Genera and Species vs. Laws of Nature Two Epistemic Frameworks and their Respective Ideal Worlds, *Studies in History and Philosophy of Science* (2020), https://doi.org/10.1016/j.shpsa.2020.01.007

Title for Law and Order:

Genera and Species vs. Laws of Nature—Two Epistemic Frameworks and their Respective Ideal Worlds

Oded Balaban
Dept. of Philosophy
University of Haifa
Haifa 31905
Israel
Phone 972-526741130
Email balaban@research.haifa.ac.il

Genera and Species vs. Laws of Nature
Two Epistemic Frameworks and their Respective Ideal Worlds

Keywords

Aristotelian Science, Modern science, Common sense, Substance, Function.

Abstract

This paper seeks to exhibit and explain, by way of comparison, two ideal kinds of knowledge: knowledge based on classifications according to genera and species, as in Aristotelianism and common sense, and scientific knowledge based on the application of laws of nature. I will proceed by attempting (1) to determine the role that presuppositions play in knowledge in general by means of the distinction between content and form; (2) to describe and explain the main features of both ideal forms of knowledge; and, finally, (3) to analyze the relation between these two forms of knowledge as it is presented in Eddington's celebrated discussion of the "two tables". I will be critical of the widespread view that modern science is the correct form of knowledge, and that common sense is merely an illusion.

1. Content and Form
    1. Neither true nor false presuppositions
2. Two Ideal Epistemic Frameworks
    2.1. Common sense presuppositions vs. scientific presuppositions
        2.1.1. Rest and motion
    2.2. General abstractions and their criticism
    2.3 Exceptions to the rule, and Newton's universality
    2.4. General things vs. concrete universals
    2.5. Description, explanation, and valuation in the two ideal worlds
    2.6. Genera and species as affirmative judgments vs. laws of nature as hypothetical judgments.
3. Weighing Eddington's two tables
    3.1. Sitting around two tables
4. Conclusions

1. Content and Form

1.1. Neither true nor false presuppositions

I begin by considering thinking in general. For the sake of discussion, I consider the process of thinking and the process of knowledge or cognition as if they were one and the same. Thinking or knowledge has two meanings derived from two necessary conditions:

1) Knowledge or cognition is first of all intentional; knowledge is *about* something other than itself, so that the "other than itself" constitutes its *content*.
2) In addition to its being *about* something, knowledge or thinking is at the same time something in itself; it has what Descartes called "formal reality," which is distinct from content. The content was

> called by Descartes "objective reality." Formal reality is what thinking has *qua* thinking. I call this formal reality the "form of thinking," which is a carrier of contents. I am thinking about something (or knowing something), namely the content of knowledge, in a certain way, as a process in itself, namely the form, that is not derived from the content.

This is a distinction between the process of knowledge and its content. The content of knowledge is the result of the process of knowledge. This is also the difference between the process by which we know something, that depends exclusively on the subject, and the result of knowledge—the known-object. The word "knowledge" has two meanings, and this could cause confusion. In German the distinction is much clearer. *Kennen* means to know or to recognize. The prefix *er* (*er-kenntnis*) puts emphasis on the active nature of knowledge, it captures the dynamic active process of knowledge or cognition. *Erkenntnis* (knowledge) is the process of acquiring *Wissen* (also knowledge, in English). The first to draw the distinction between knowledge as a process and knowledge as its final result, was Aristotle with his development of syllogism. Today the distinction is generally disregarded by analytic philosophy but is in use by Kantians and phenomenologists, though there are many exceptions on both sides of the divide.

Content and form are thus two aspects without which there is no thinking or knowledge. The content of knowledge can be true or false, while the form of knowledge bears no truth value. *Presuppositions* are forms of knowledge. They are not part of the content of knowledge. However, they are the content of *reflective knowledge,* of knowledge of the form of knowledge. They play a decisive role in the formation of the contents of thought. They are neither true nor false, since they cannot be deduced from prior suppositions—they are *pre*-suppositions.

Ordinary thinking is *transitive*, as it is about something else that is not in itself thinking. Thinking about thinking is, in contrast, an act of reflection. Reflection focuses on form and reveals the way of thinking: what is presupposed, focusing on the question *how* content is thought about.

Two examples of presuppositions are Kant's synthetic a priori judgments and Cassirer's symbolic forms. They contribute to knowledge without being acquired by experience. As such, although they are not analytical, for they add information, they are neither refutable nor justifiable—unlike propositions, they are neither true nor false.

Neither science nor any other way of thinking can avoid presuppositions. This means that "though Nature must of course be left to answer to our interrogations for herself, it is always *we* who frame the questions. And the questions we ask inevitably depend on prior theoretical considerations" (Toulmin, 1961, 101, emphasis in the original). By "theoretical considerations" Toulmin means preformed concepts, or preconceptions, which are "inevitable and proper", that is, presuppositions.

Knowledge, implying presuppositions, is relational; it is neither relative nor absolute. Properly understood, knowledge is defined by its relation to the presuppositions each determining *a kind of truthfulness,* namely, a *kind* of pretension of validity. I am arguing for a distinction in cognitive statements, between truth and validity or truth and truthfulness. Truth, without further specifications, means absolute truth, which means that there are no assumptions in knowledge and, therefore, truth is not a relational reference to content. Validity or truthfulness means, on the contrary, a truth that is dependent on presuppositions. We can speak about scientific truthfulness (or validity), Aristotelian truthfulness, even mythical truthfulness. For instance, the eternity of genera and species is valid in relation to Aristotelian presuppositions (*Met*. Bk. III, Ch. 1, 995b-1003a); that physical events can be caused only by physical events is valid under the modern scientific presuppositions, and so on. For this reason, truths under different presuppositions may not be incompatible—there is only need to specify under which presuppositions each statement is made.

Thus, the presupposition of Darwinism, that evolution is a "natural" process of formation of new organic forms underlying natural selection of species (cf. Darwin, 1859, 61), does not oppose the Aristotelian presupposition that species are eternal. Both can perfectly be regarded as true explanations of the same object, though under different presuppositions. The controversy, in this case, can be avoided if we take Aristotle as if he stated his presupposition in a hypothetical style, something like "let's assume that genera and species are eternal. Then the question arises, which kind of natural species world can be constructed?" The world that we get so described, will be a world that has "Aristotelian truthfulness" or validity. Moreover, under Aristotle's assumptions, to say, for instance, that birds are an evolutionary result originated in dinosaurs, will be false (Aristotelian falsehood). And this case is also valid regarding any other presupposition.

This can be explained by means of the analogy of cartography. Let us consider the Mercator projection, based on the neither true nor false presupposition that parallels and meridians are straight and perpendicular to each other. As a side effect, the Mercator map inflates the size of objects insofar as they are more distant from the equator. This inflation starts infinitesimally, but accelerates with latitude to become infinite at the poles. So, for example, "Greenland is larger than Australia" will be a valid statement only if we add that it is true under Mercator's method of projection.

However, there is a cardinal difference between the analogy of cartography and human knowledge in general. In cartography, we not only have methods of projection, but we also know the real size of the original "globe", our planet, so that we are able to know exactly how much each method of projection distorts the original globe. By contrast, human knowledge lacks knowledge of an original reality that is not mediated by our cognitive capacities. To assume that we have it, means to leap beyond the frame of presuppositions involving a reference to something to which we have not cognitive access, like Kant's thing-in-itself.[1] According to Kant, we cannot indeed compare phenomena with "things-in-themselves." Just as Mercator maps, in virtue of distorting the globe, have the advantage of facilitating maritime navigation, so Aristotle's and scientific way of thinking have their own advantages, each one in its field of application. Just as Aristotelian thought is useful for the formation of non-scientific classifications, so is scientific thought useful for explaining, predicting and controlling physical events.

2. Two Ideal Epistemic Frameworks

2.1. Common sense presuppositions vs. scientific presuppositions

What is the resulting world-image of the presuppositions of modern science and those of common sense? Common sense's presuppositions will be analyzed by means of a critical analysis of Aristotle's philosophy. This analysis is justified because a large part of his philosophy is an effort to justify the common sense's perceptions of the world by giving them philosophical coherence. Accordingly, when referring to Aristotle, I do not mean strictly his philosophy, but rather his world-image. I will take it as an ideal of knowledge different from, or even opposed, to the ideal of modern science.

My thesis runs against the view of Crombie's *Augustine to Galileo*. Crombie maintains that there is a progressive continuity from the science of the Middle Ages to modern science (Crombie, 1953, 117–130). According to Crombie there is a tight link between the science of the scholars of Merton College at Oxford (like the "doctor profundus" Archbishop of Canterbury Thomas Bradwardine) and the "Parisian physicists" (such as Nicole Oresme and Jean Buridan) of the 14th century, on the one hand, and, the science of Galileo, Descartes and Newton, on the other.[2] I agree, however, with Paolo Rossi that "there is a strong

---

[1] The answer to the question, why Aristotle did not use hypothetical instead of categorical judgments lies, perhaps, on the fact that he did not see plausible alternatives to the eternity of genera and species. This is the case even when he dedicates entire introductory chapters of his main works to surveying the "opinions" of his predecessors and some contemporaries on the same subject matter. Not even one of them argued that genera and species imply some kind of change and evolution.

[2] For example, see Pierre Duhem's treatment of the laws of physics, where the difference between these laws and what common sense calls "laws" is blurred. See Duhem, 1906, Ch. V, "La Loi Physique," 269–293.

discontinuity between the medieval scientific tradition and modern science that makes room for the legitimate usage of the expression 'scientific revolution'" (Rossi, 1997, xvi, my translation). I claim that *modern science* amounts to a radically new way of thinking. Whitehead, being more precise, draws a distinction between what he calls the "new mentality" and its achievements, or rather, between the new form of knowledge and the contents it produces. He adds that the new *mentality* is more important than the new scientific and technological achievements. This new mindset "has altered the metaphysical presuppositions and the imaginative contents of our minds; so that now the old stimuli provoke a new response" (Whitehead, 1925, 2).

Ideally stated, modern science asks a new kind of question: "*How* does nature behave?" rather than the old, Aristotelian question, "*What* is nature?" Science asks about movements, occurrences, or events, not about things. In common sense, we refer to events as if they were qualities of things. Our language fits Aristotelian categories. An electron, for instance, is not a thing but something in relation to something else, it cannot be recognized in isolation: "…you cannot wipe out the whole structure of events and yet retain the electron in existence (Whitehead, 1920, 171)." Science however, replaces the primacy of the concept of substance with the primacy of the concept of function (Cassirer, 1923, 3-26). Science interprets the same sense data differently from Aristotle. Science explains phenomena by means of their (dynamic) connections: "The description of a phenomenon does not stand alone but is involved in the explanation of the 'how' of phenomena" (Rotenstreich, 1972, 191). The law of gravity tells us *how* the force exerted on an object depends on its mass and the mass of other objects; Kirchhoff's laws tell us *how* the current, electromotive force, and impedance in electrical circuits are related, where these quantities are properties of the circuit or its parts. The laws of thermodynamics tell us *how* thermal properties, such as heat and entropy are associated with the temperature of systems. Kepler's second law tells us *how* a planet moves around the sun for example, that the body moves most slowly at the aphelion, and most quickly at the perihelion.

In a world totally at rest, laws of nature are altogether irrelevant. On the contrary, in a world in which everything is in motion, everything is under change and nothing is at rest, there is no place for substances ordered by genera and species—laws of nature can explain a world in motion without Aristotelian categories.

Modern science means the introduction of a radical way of knowing, including the way in which perceptual data are interpreted. For this reason, I believe that the historical development of knowledge is not a continuous, gradual process. It is not the case that our knowledge allows us to understand exactly the same thing, the same world, since in each period of knowledge the world is understood, as it were, more deeply than before. I argue, on the contrary, that the known world, as it is *conceptually* known, is not exactly the same world in each period; that is, any form of knowledge refers to a different *conceptual world* at different historical stages. Thomas Kuhn, for instance, contends that in the history of knowledge, one conceptual world is replaced by another, though without being the result of the previous paradigm (see Kuhn, 1962, 124-6). Moreover, even the same person lives in two different conceptual worlds, namely, his daily conceptual world and the conceptual world he adopts in the laboratory. At home, he sees colors, in the laboratory he refers to wavelengths that, as everyone knows, do not have colors. In fact, there are not different worlds, but different conceptual interpretations of the same world. If we do not assume that we live in the same world in which Aristotle lived, each interpretation would refer to a different world, and then, the very notion of interpretation and interpretative alternatives could not be sustained.

Both science and common sense, gain knowledge through two radically different ways: (1) They know the perceived world through *sense-perceptions*; and (2) they get a knowledge of the world through their *concepts*.[3] Knowledge is nothing but an interpretation of our perceived world. According to Kant, our

---

[3] About the dichotomy between seeing and thinking, see Kanizsa 1991, Ch. II, and Kanizsa 1979, 14–24. Nowadays there is a general tendency to reduce all meanings to thinking by making a distinction

knowledge starts with experience (or sense-perception) but, conceptually, it is not derived from experience (cf. Kant, 1787, 136, B1).

In any case, as Kant claimed, a world without relation to our senses and categories is unavailable to us. We know that there is such a world, but we know it only as mediated by our knowing faculties — namely, we know only its responses to our senses, categories, and practical (and experimental) interventions; it is the world that we perceive and that "answers" our questions.

Our concepts define the boundary of the world as it is known in each historical period and even regarding each singular research. They define the connections between its components, the nature of generalizations, the line dividing the essential from the unessential, what should be explained for certain purposes and what should remain unexplained due to its particular irrelevance in each case. In this sense, the alternative forms of knowledge construct alternative world images or, rather, alternative interpretations of nature. The choice of one of the alternatives as the valid one is a matter of perspective and pragmatic considerations.

The different forms of knowledge are alternatives rather than different degrees of understanding of the same continuum. Against the argument that all forms of knowledge can be reduced to one progressive explanation of one and the same reality, I claim that each form of knowledge at each historical period provides us with an understanding of nature from a different point of view. These different forms can also be present side-by-side during the same period in different cultures or even in the same culture out of different pragmatic needs (Lewis, 1956, 230–273). This is also the case with the categories of common sense. They exist side-by-side with scientific categories even for the same individual when she adopts different perspectives. The same scientist may employ common sense categories in everyday life but use scientific categories consciously and purposefully when engaged in research. As I explain later, Eddington's example of the two-tables clearly shows the difference between the two worlds: that of common sense and that of science (Eddington, 1935, 5–12).

In short, Aristotle *perceived* with his senses quite the same world that we perceive with ours. However, when we rise to the level of conceptual knowledge and try to *interpret* the shared world of sense-perception, that is, explain it in conceptual terms, Aristotle explains a world that looks quite similar to the picture we construct today when guided by our common sense concepts. Aristotle used a conceptual hierarchical system of genera and species and tried to organize it logically, aiming to avoid contradictions. Modern science, in contrast, has very little in common with common sense. Aristotle, to be sure, constructed his concepts about the world much more strictly than do laymen, namely, individuals lacking philosophical rigor.

2.1.1. Rest and motion

The most convenient way of pointing out the difference between the Aristotelian explanation of *things* by hierarchical constructions of genera and species and modern science that explains *events* occurring under the rigor of laws, is by presenting the distinct "ideal" world that is appropriate for each of them. In the Aristotelian ideal world, any motion or change is a defective state that has to be explained by what is extrinsic to motion and change—rest. Motion is regarded as something that advances toward rest as its final and ultimate state. Rest is the key to understanding motion. Rest is the *explanans* of motion.

Moreover, it is symptomatic of Aristotle's way of thinking, that he finds motion either paradoxical or difficult to explain. Consider, for instance, his definitions: Motion is "the actuality of what is potential qua

---

between sensation and perception. In this view, sensation is devoid of meaning and perception is a meaningful interpretation of our sensations. For a critical analysis of sense-perception dualism, see Strauss & Ben-Zeev, 1984.

potential" (Aristotle, *Physics*, Bk. III, Ch. 1. 201b5) or it is "the actuality of what is potential, as such" (Aristotle, *Physics*, Bk. III, Ch. 1. 201a11). According to these definitions, his kernel actual–potential distinction loses its meaning, because actuality is the opposite of potentiality so that they cannot become one and the same (see Balaban, 1995). In any case, "motion is an incomplete fulfillment of the movable" (Aristotle, *Physics,* Bk. VIII, Ch. 3. 257b7). Guthrie rightly asserts that "the problems of change and becoming had proved the greatest crux in Greek philosophy. Few had had the courage to deny them, none had succeeded in explaining them" (Guthrie, 1981, 125).

By contrast, the ideal world of modern science is that of motion and change. In such a world there is no rest, and if there is any apparent rest, it can be explained by motion or be reduced to motion. Such is, for example, the definition of rest as a balance of forces; that is, rest is explained in terms of motion, as being a special kind of motion. In a world that is entirely at rest, including the observer, there is no room for applying laws, while in a world which is entirely at motion, there is no room for constructing systems of genera and species. Aristotle investigates *things*—modern science investigates *events*. Or, to put it differently, modern science investigates things insofar as they can be regarded as events or processes.

The question may be asked, if the science of statics and strength of materials do not run against my thesis. I do not think so. Statics considers rest as the result of the condition of equilibrium, a rest that has, ideally, to be the result of forces neutralizing each other (a system is in static equilibrium if the applied forces and moments add to zero). Statics is concerned with the way of *stopping* motion (something essential when designing buildings, bridges, dams, etc.). For this purpose, engineers need first and foremost to determine the *forces* acting on the interconnected parts of buildings, etc. The final result, say, a bridge, is the result of the application of the mutual annulment, or rather, the equilibrium that must be achieved in order to keep the result immovable as much as possible. Balance laws are key notions in statics. Thus, statics can be regarded as an expansion of dynamics. Rest is not a *terminus a quo* but a *terminus ad quem*.

Interesting to note, for the sake of comparison, that the idea of inertia, in the sense of the property of matter by virtue of which it continues in its existing state of uniform motion in a straight line, unless it is altered by an external force, is regarded by Aristotle as *absurd* and even as an argument against vacuum or empty space. Aristotle states that "no one could say why a thing once set in motion should stop anywhere; for why should it stop here rather than there? So that a thing will either be at rest or must be moved *ad infinitum* unless something more powerful gets in its way" (Aristotle, *Physics,* Bk. IV, Ch. 8. 215a22-23). He finds this *absurd* – namely, that something is moved *ad infinitum* by something else or that something moves without being moved by an external force. When discussing projectile motion, inertia is not a plausible answer. There must be a mover extrinsic to the thing moved, exercising its moving capacity at every moment of the projectile's flight (See *Physics*, Bk. VII, Ch. 10. 266b29–267a11). Aristotle's account of motion can be explained *a posteriori* as the result of not being capable of eliminating the resistance of the medium, the source of friction, and his incapacity to analyze separately a complex set of forces. Notwithstanding, Aristotle was close to establishing inertia as an inner force, but his presupposition of the end of motion as a final state at rest that explains it, prevented him from accepting this conclusion. Here Aristotle is at his best — he is completely consistent and meets thereby the limits of his own thought.

2.2. General abstractions and their criticism

Aristotle constructed his classification of genera and species through the intellectual procedure of *generalization*. His reference point is the world as it appears at the end of its real, natural processes. These processes, in general, are known by means of their final result, that is the well-defined world at rest. However, the very notion of the final result is but the product of conceptual generalizations.

The process of generalization seems so clear as to deserve little or no consideration — there seems to be no need to describe and explain it. This is generally accepted, since common sense, shared by all of us, as much as we know, from the beginning of civilization, takes it for granted. It is easy for common sense to understand this logic and even to agree with it. This presupposition is so strong and rooted so deeply in our minds that it seems we do not need any previous assumptions. This type of thinking appears, at first glance, as having no organizing categories. According to the Aristotelian theory of knowledge, however, we actually make two basic assumptions based on the distinction between things and their qualities:

1) That we live in a world made up of an endless multiplicity of things.

2) That our minds can sort them by those qualities of the things that we regard as essential, excluding those we regard as unessential.

We use the essential qualities (for instance, having four legs) to construct sets of objects possessing them (such as certain animals). And when we apply the same method of generalization to the groups we have formed according to these qualities, we rise to higher levels of entities, namely, entities that are increasingly abstract (such as living things, subsuming animals and plants). The mind operates here by comparing and distinguishing things by means of their qualities, where the starting point is a given sense-perceived multiplicity. All mental activity, in this Aristotelian method, is a process of extraction and elimination of features that we do not need for the construction of our general concepts while keeping in mind others. Some features are selected—others are omitted. This is how humans produce abstract concepts.

Since the process begins with sense-given perceptual data, the illusion arises that the concepts are inferred from these data, so that they do not seem to be external or foreign to perceived things. The process of thinking apparently consists of selecting qualities from the multiplicity of sense-data, and then extracting and separating them from the whole—for instance, we distinguish boughs from the tree that they are part of.

Reality is constructed according to what seems to be shared and common features given in perception, so that all that remains for us to do is to remember them and classify them. And we do not only apply this method to sense data but also to exact sciences, mainly to geometry. According to Aristotle, just as we construct the concept of tree, we also construct concepts in geometry. For example, a quadrilateral is defined by shared properties that define it: as a "closed shape" with "four straight sides" and "four angles." If we add specifications, we get its multiple species; for instance, if we add "four right angles," we get the species "rectangle," which is less abstract than the genus "quadrilateral." It is important to emphasize that here I am adopting *the point of view* of the Aristotelian presuppositions and the *perspective* of common sense alone.

Accordingly, the concept "tree" is constructed by keeping in mind the properties common to apple trees, pear trees, olive trees, etc., and disregarding the specific characteristics belonging to only one of these types. This construction creates higher concepts that are subordinate to even higher ones, which are generalized by eliminating or disregarding, at each stage, those characteristics that are not shared by all the genera. And when we descend the abstraction ladder, we go the opposite way, adding qualities that were disregarded when we ascended the ladder.

Thus, if we call the number of attributes of a concept its *connotative richness* or *intension*, and the number of species in the genera defined by these attributes its *scope* or *extension*, we get an inverse ratio between intension and extension: the greater the intension of a concept, the less its extension.[4]

This is so because genera are indifferent to the differences between their species and species are indifferent to the differences between its individuals. That means that the singular case is not included in the species. The species is rather thought of as a generalization that preserves only what the singular cases have in common. To put it otherwise, a singular case is annulled insofar as it is different from any other

[4] Intension is sometimes regarded as a *concept, meaning* or *definition*, and extension as *reference*, namely, the range of its applicability (see, for instance, Putnam, 1973).

singular case. Genera and species are indifferent to differences. When genera and species become a well-ordered hierarchical system under its principle of division, each individual has to belong to one species alone. Its belonging to a species becomes a classification of individuals under genera and species. However, the individual enters the classification but only as an *exemplar*, identical to all the other exemplars of the same genera or species. That is, it does not enter the classification as an individual, but as sharing the same properties of all the others, that is, insofar as it is not an individual.

Modern science's criticism of the logic underlying this procedure is, mainly, that under the Aristotelian presuppositions, the highest, and therefore the most general, concept that can be reached no longer has any content, namely, it is indifferent to the lower levels of genera and species. This is the inspiration of Hegel's criticism to the supreme abstract Being, which "is in fact *nothing*, and neither more nor less than nothing" (Hegel, 1812, 59). Hegel, unlike Aristotle, regards abstract concepts as having a low degree of reality, something inferior precisely for being less complex. This being *is* nothingness since it lacks a specific meaning — it has an infinite extension and *therefore* zero intension or definition.

At this level of awareness, doubts arise about the whole method, that is, about its validity and the possibility of applying the results of this intellectual exercise to anything real (see Cassirer, 1923, 6). In the Aristotelian abstractions the species annuls the differences between particulars and the genus annuls the differences between species.

Thus, the goal of this way of constructing concepts, when achieved, appears to be something completely devoid of content, pure nothingness. At this stage, the entire process becomes suspect of being pointless. Though less radical than Hegel, the first to see this point was Spinoza. He explained the general concepts called *Transcendental* (such as "Being," and "Thing") by their origin in the limitations of our mind, mainly in its poor capacity to remember individual differences (see Spinoza, [1677] 1994, *Ethics*, II, prop. 40, school. 1).

If we were able to remember all the images of things that we perceive from any possible perspective under which we approach them, then we would not need to construct general concepts. General concepts are substitutes for the richness of the individuals, consisting of a pale, general image which is a union of elements that were originally different from each other. Instead of the present sense-perceived things, we get a generalization that is an incomplete substitute for the source and it is also a vague hint recalling the source, although indistinctly.

Spinoza's criticism states that *the limitation of our mind cannot be the model for the formation of scientific concepts*. What one would expect from a scientific concept is determinateness, sharpness, and distinctness rather than the products of generalizations, that is, general indeterminateness.

Adopting a similar point of view, Whitehead calls the classical abstract view the "fallacy of displaced concreteness". It consists in "neglecting the degree of abstraction involved when an actual entity is considered merely so far as it exemplifies certain categories of thought" (Whitehead, 1929, 11). The fallacy is "the error of mistaking the abstract for the concrete" (Whitehead, 1925, 59). It is what William James called "the philosopher's fallacy" and John Dewey "the intellectualist fallacy" (cf. Auxier & Herstein, 2017, 42). It is also critically called "reification" (hypostatization) (Coulter 2001, 83). All these expressions mean the tendency to abstract, to isolate a part ascribing to it the sort of reality that belongs to the whole. It means, according to Whitehead's scientific criticism of genera and species, confusing the part with the whole.

According to the scientific criticism of the Aristotelian way of formation of concepts, if a concept is constructed by abstraction, namely, by disregarding singular features, it lacks cognitive value. From the viewpoint of the content of knowledge, classical thinking starts from the contents of the singular cases in order to finally exclude all content whatsoever. Therefore, from the concept of tree, you cannot deduce the concept of apple tree. This is the strictly logical output of the method. In contrast to the classical approach, the process of exclusion or negation in the formation of scientific concepts should retain what was excluded under the Aristotelian perspective. The result, the final concept, is not supposed to be merely the result of arbitrarily chosen features but it means the integration of different features (now regarded as articulated “members”) into the whole. This systematic integration, first gained in mathematics, is the ideal of the scientific approach. The general concept should include its articulated singular features.

In the spirit of modern science, and highly critical of Aristotelian logic, Herman Lotze argues that Aristotle is wrong about the inverse ratio between content and the extension of concepts. However, he also reveals something fundamental in the Greek and medieval approach. Lotze argues that the number of properties or attributes used to construct genera-concepts is not infinite (Lotze, 1912, § 31, 50). Similarly, the number of words in a language is great but not innumerable (*doch nicht zahllosen Worten*). These words suffice to indicate the many qualities of things. Thus, a group of qualities is said to apply to certain general terms, A, B, C. This way we can invent innumerable nonsensical combinations. For instance, cherries and meat can be collected in our imagination into the same genus according to the general qualities of red, juicy and edible, without there being any general notion that actually describes a genus with these general qualities. Lotze claims that this is an absurd case. I think that actually it is not absurd but simply not the way our culture habitually classifies meat and cherries. Inspired by Lotze, and with a great sense of humor, Jorge Luis Borges proposed other classifications. One of them, taken from an imaginary Chinese encyclopedia, divides animals into:

> (a) those that belong to the emperor; (b) embalmed ones; (c) those that are trained; (d) suckling pigs; (e) mermaids; (f) fabulous ones; (g) stray dogs; (h) those that are included in this classification; (i) those that tremble as if they were mad; (j) innumerable ones; (k) those drawn with a very fine camel's-hair brush; (l) etcetera; (m) those that have just broken the flower vase; (n) those that at a distance resemble flies (Borges, 2000, 231).

However, it is precisely Lotze’s idiosyncratic example and that of Borges that show us how the generally accepted classification into genera and species is based on our habits and ways of thinking rather than on any given natural reality, even in cases where we think that this is clearly the case. Lotze tries to show that the formal method of creating genera and species is not sufficient, but that one should pay attention to the implicit presuppositions of any thought, be it scientific or other. Being aware of the presuppositions of a certain categorization, of a certain method of generalization, does not necessarily mean supporting anti-realism, it does not mean that everything depends on the subject, but it depends in the way that the given is reflected within certain presuppositions. In any case no data can be accessed without assuming presuppositions. You cannot think without presuppositions, there is no thought without categorization.

2.3. Exceptions to the rule, and Newton’s universality

The case of how exceptions are explained in both ways of thinking, provides a deeper understanding of the differences between them.

Like rules in general, genera and species accept the existence of exceptions that even confirm them. Aristotle sustains the view that there are even natural exceptions. Even nature commits errors, and those errors are the exceptions to the rule, namely, the species (Aristotle, *Physics*, Bk. II, Ch. 8. 199b).

This is not the case under the presuppositions of laws of nature, at least those that are mathematically formulable, which are the ideal and the model for scientific propositions as a whole.[5] Contrary to genera and species, laws of nature do not have exceptions. Or, to state it somehow paradoxically, each case is an exception, a deviation from the homogeneous character of the individuals in the genera. The law explains the individual by pointing at its typical deviation, its singular nature. A singular case is one that differs from others. For example, the law of a series states that each member differs from the previous one and

[5] Kemeny (1959, 37) sustains the view that physical laws are to be found only among those propositions that are expressed in mathematical language.

from the subsequent one without providing a place for exceptions since each one is itself an exception. For example, in a series {a, ar, ar^2, ar^3, ... }, where a, the first term = 1, and r = 2 (meaning that the "common ratio" between terms is a doubling), each member, for instance 8 (in the series 2, 4, 8, 16…,) differs from all the others. 8 is the only one that stays after 4 and before 16, so that each member of the series is unique, different, exceptional in respect to each other. And all the members have still something in common—their relation, the "law" of the series, which is the same for all the members that are rigorously deduced, each one as different from each other, from the same principle. There is nothing similar between this "general" law and the general character of a genus.

This is the meaning of the *universality* of Newton's law of gravitation as opposed to Aristotelian *generalizations*. Universality is not gained by such generalization. It is what the mathematic formula says about the constitutive members of the series. And this is at the same time the origin of the utopian ideal of many philosophers of science: the illusive attainment of a single law from which the whole universe could be deduced.

Newton's first law of motion, for instance, is determined by two characteristics: 1) It states only that if there is a body, in motion or in rest, it will behave according to the law. It is not a deduction out of empirically given bodies.[6] 2) It states that laws do not refer to isolated bodies but to dynamic relations between bodies.

That there are no exceptions to laws, can be understood from the relations between law and fact under the presuppositions of natural science (the cases to which the law refers as its content) in the case of Newton's theory of gravitation. The law is a general (universal) concept that includes in itself all the singular cases, real and possible, and even those impossible cases. Newton's law of gravity, $F=GM_1M_2/r^2$, applies to all possible and all impossible cases. This is the reason for the lack of exceptions—it includes them within itself. Each case is an exception, in the sense that each case is different from any other. Thus, the law includes a systematic reference to all possible bodies of all possible masses, constitution, shape, relative velocity, distance, at all times and places.

This achievement, namely, the conception of a universal notion that denotes explicitly the exclusion of exceptions, and the inclusion in itself of the singular cases, is an achievement that has its price, namely, the distance between law and fact or the discrepancy between observation and theory. Laws do not refer directly to facts, in the sense that facts cannot be derived from the law. Whoever has in mind the laws ruling the universe, does not have yet the real universe. Facts are not derived from laws but occur according to laws. Laws always contain a hypothetical element. The validity of laws does not come from experience and experience is not a product of laws.

The first law of motion (the law of inertia) states, that a body, real or not, perseveres in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by external forces. But the main point for the purpose of comparison with the Aristotelian view, is the alteration of motion is between a body and another body, namely, an external force. The existence of a motion is expressed by the way it affects another body. It is a definition of *relational* motion, inspired by the idea of function (a function expressing the variation of the mutual relation between two bodies in motion one in relation to

---

[6] It can be argued that the starting point of Newton are natural phenomena as he explicitly contends in his preface to the second edition of the *Principles*. However, from his examples of what are *phenomena*, it is quite clear that they are the most remote from phenomena as described by common sense. They are those that can be reduced, and explained and even observed, by science, not by common sense. They are the result of physico-mathematical observations. One example should be sufficient: "Phaenomenon I: The circumjovial planets [or satellites of Jupiter], by radii drawn to the center of Jupiter, describe areas proportional to the times, and their periodic times—the fixed stars being at rest—are as the $^3/_2$ powers of their distances from that center" (Newton, 1687, 797). And he immediately adds: "This is established from *astronomical* (my emphasis, OB) observations."

the other). Moreover, Newton's laws of motion do not link force with motion *per se* but with *change* of state. This entails a dynamic view of nature against its static ancient view, allowed by a new kind of generality, one that, since it is the expression of change itself, has no exceptions. Indeed, this is the deep reason why there are not exceptions to laws.

The general concepts in the ideal of science are not the *relata* but the relations. Newton's theory of gravitation states the hypothesis that *each body* (actual or possible body) attracts each other bodies with a force *varying* directly as the product of their masses and inversely as the square of their distance. The law expresses a varying force, valid for all individual cases. This is clearly not the same generalization as stated by Aristotle.

Moreover, the truth of the first law of motion becomes clearer when considering what is involved in its denial, what is involved when it is not acted on by any force: in this (negative) case, so states the law, it will persevere in moving uniformly in a straight line, namely, its velocity will remain constant both in direction and magnitude.

2.4. General things vs. concrete universals

Aristotle's ideal ontology is based on the concept of *thing*, whereas the ideal of modern science is based on the concept of *relation*. The concept of thing is based on the idea of *substance*. For Aristotle, relations are not conceived as subsisting between two (related) things, the way they are now when they are symbolized by *R* standing between *a* and *b* in aRb (see Cornford, 1957, 283).[7]

The alternative ideal is the mathematical concept of *relation*, from which the concept of *concrete universality* is derived. Here the universal is not isolated from its individual cases, nor does it transcend them. It inheres, rather, in the individuals as their essential determiner. The universal, in short, is not indifferent to the individuals. This is an achievement of the 18th century. As I will show, the concrete universal does not have an independent existence side-by-side with its instances, and the instances are not independent of the universals. The instances are, rather, its constitutive factors.

The first to clearly articulate the difference between Aristotelian and scientific thought by the use of the mathematical concrete universal as a paradigm was Lambert (1728-1777), who argued that general mathematical concepts do not eliminate the determinations of the individual cases but rather the opposite— they retain them with rigor (Lambert, 1771, §193). The intention of a mathematician in creating a general formula is to include the individual cases (the members of a series, for instance), namely, to derive them from the formula. This possibility of deduction does not exist in scholastic and classic concepts, since in their generalizations the individuals are not considered but as if they were identical to each other.

We can articulate the difference between the two kinds of general concepts, following Hegel, as a difference between *abstract* generalizations producing abstract universals (those that disregard the singular cases), and *concrete* generalizations producing concrete universals (those where the singulars, the members of a series, are included as derived from the formula). Genera and species are general and abstract, while mathematical formulas are concrete laws (see Drobisch, 1887, 23).

Modern scientific thought arose from the criticism of, and dissatisfaction with, Aristotelian generalizations. An expression of the new way of thinking is Hermann Lotze's skepticism about the traditional theory of abstraction. He criticizes the notion of advancing towards general concepts by ignoring the singular cases. Instead of disregarding and abandoning them, he says, we need to keep them by searching for an equivalent. Why reject the old way of abstraction? Because when we construct the

[7] Armstrong contends that "it is not until the late nineteenth and twentieth century with C. S. Peirce, William James, and Bertrand Russell that relations begin (no more than begin) to come into focus" (Armstrong, 1989, 29).

concept of metal, for instance, by classifying gold with silver, copper, and lead, we cannot attribute to the product of abstraction, the abstract concept of "metal," the specific color of gold, the specific brilliance of silver, or the specific weights of copper and lead. However, disregarding all these specific determinations is clearly not useful, because it means having a concept of metal as neither green nor red, without any specific weight or hardness, or any specific resisting power. It means describing metal by disregarding the characteristics of the various members of the group (see Lotze, 1888, ch. I, § 23, 41–43). It is important to consider the positive aspects of these group members. The idea of metal must indicate that it has a color in each case, that it has some degree of density or luster. Similarly, we cannot maintain the concept of an animal without preserving the way the reproductive capacity functions in each case, the different respiratory and blood circulatory of each case, and the like, so that what is common to all animals is just the different ways in which the general feature is realized in each specific case.

Lotze's idea is not focused on disregarding the properties that are different in each species, as is the case with abstraction, but it is grounded in preserving common properties, taking into account the different *modus operandi* of each case. For instance, each kind of respiratory capacity in each species should be regarded as a variation, and the rule should be nothing more or less than a rule of variation.

The process of creating genera and species, in contrast, leads at the end to the nullification of specificity, so that our thinking cannot find its way back from this empty logical nothingness. Scientific (general) concepts emerge from this criticism, demanding a new kind of general concept, one that is able to include the variations of the changing properties. Moreover, this is the purpose of the scientific concept: to provide an account of changing properties. The basic question is now how to annul the opposition between content, *intension* or definition, and *extension* that was typical of thinking by genera and species. To put it otherwise, *modern scientific thinking annuls the character of things as substances in order to preserve them as functions.* Though firstly an achievement of modern physics, it became the ideal of other fields, such as chemistry. Cassirer contends that though "chemistry seems to begin with purely empirical description of the particular substances" it advances towards the same new physical principles and laws. (see Cassirer, 1923, 203ff).

2.5. Description, explanation, and valuation in the two ideal worlds

Another significant difference between both ideal forms of thought, concerns the *idea of value and valuation* in the sense of taking stands for or against the object of knowledge.

From the Aristotelian point of view, understanding, description, explanation, and valuation are part of one and the same process. Reading Plato, one never knows if he is referring to things as they are or as they ought to be, or if one is only describing or also explaining them. In the Platonic theory of Ideas, Truth and Goodness are indistinguishable (just as their opposites, Evil and Falsehood). Science, by contrast, while still distinguishing between description and explanation, leaves values out of the field of scientific investigation—it is value neutral.

Aristotle's approach contended that species and individuals are oriented towards perfection, that is to say, the norm of a perfect species and perfect individual is assumed. The τέλος of things, their purposefulness, their final-cause, is to reach perfection (*Met.* Bk. IX, Ch. 8. 1050 a 9, 21; *Eth. Eud.* Bk. II, Ch. 1. 1219a8). Aristotle tries to prove the purposiveness of nature (*Physics*, Bk. II, Ch. 8). In order to know genera and individuals, there is a need to know the normative ideal of a perfect being. By nature, things tend to arrive at their *proper*, natural, place (contrary to violent motion).

For this very reason, he also contends that sometimes things go wrong—nature incidentally makes mistakes (*Physics*, Bk. VII, Ch. 2, 243b10). And what is a mistake if not a mismatch between the normatively established ideal state and the actual state of an individual or a genus? Moreover, the very idea of an end is itself a valuative criterion without which nothing can be known. In short, error, or excess and defect in nature, is not merely a question of the more and the less but implies a normative ideal that determines what things ought to be.

Contrary to the Aristotelian approach, science refers to events as they are, never as how they ought to be. Values and valuations themselves remain outside the object of investigation. Science neither takes stands for nor against it. It does not ask what the world should be like. It does not judge, in the sense that it neither approves nor disapproves of its object of investigation, it neither condemns nor praises it. This does not mean that science is value-free. Values have a role in the use of knowledge as a means for practical decisions, such as the decision about what to search for, or about how many resources should be invested in a given search, or about the motives for searching certain issues rather than others. All these *practical* questions involve a synthesis between knowledge of facts and the application of values, and in this sense knowledge and values cannot be separated. In short, the ideal of science, though science is not value-free, is value-neutral.

The value/fact distinction refers to the ideal *attitude* of scientists towards their object of research. Modern scientists, at least in principle, do not consider their values, their wishes or what ought to be the results of their investigations, so as to determine what their empirical findings will be. On the contrary, they can be aware of their values and still decide to neutralize them consciously when trying to learn about matters as they understand them to be. They understand the meaning of the distinction between what something is and what it ought to be and can thus maintain the is/ought distinction (and therefore their value neutrality) in their research. If they try to change their results to accommodate them to external interests, such as producing results requested by a financial donor, or hiding findings that might have a negative influence on their chances of academic promotion, then they are not committed to the search for truth but motivated or misguided by extrinsic interests that go far beyond scientific commitment under the guide of an impartial *sine ira et studio* attitude. Although it is difficult to decide in advance if a theory is value-biased or if it is guided only by the claim to truth, the distinction is clearly understandable. This difficulty is not a reason to erase the difference between a value neutral and a value-biased research.

The first to make a clear-cut distinction between knowing and valuating, was Spinoza. Under the guide of the value neutral scientific approach, he warns against "those who prefer to curse or laugh at the affects and actions of men, rather than understand them. To them it will doubtless seem strange that I should undertake to treat men's vices and absurdities in the geometric style" (Spinoza, 1677, Part 3, Preface). No geometrician says, indeed, "what a pity that the sum of the angles of the triangle amounts only to 180 degrees!" or "how lucky that they only add up to 180!"

2.6. Genera and species as affirmative judgments vs. laws of nature as hypothetical judgments.

Genera and species pretend to refer to what is or ought to be. They are, as it were, generalizations of single cases. Such generalizations cannot include all the cases, but can only assert something like "most of the cases are x." In particular, Aristotelian generalizations are restricted to what is known, and the way it is known, beforehand by common sense.

Laws of nature, by contrast, are universal hypothetical judgments (Lotze, [1874] 1912, 333), namely, they apply only to hypothetical cases, not to what is or what ought to be. Scientists use sentences like "Given such-and-such conditions, then we will necessarily get such-and-such results." Or they state that if A and B, then C, where it is possible that A and B might never occur at all, or at least not in a pure state and yet it is a scientific statement. Laws in themselves are but possibilities. They are actual only in real cases. To put it sharply, "all that we can be certain of [about laws] is this, that they are *not* what we know, namely, given phenomena" (Bradley, [1897] 1916, 125).

If laws are hypothetical judgments, there is no reason to demand empirical verification. Let me stress: events occur *according* to laws, not derived from laws. The universality of laws is gained precisely by going beyond experience—they are universal only because they are hypothetical, they are not based on empirical inductions and not derived from facts.

Scientific laws are never meant to be mere enumerations of events. Their function is not the reduction of the multiplicity of phenomena to generic vacuous concepts, but to understand each particular phenomenon as particular, namely, when it is designed to each phenomenon its univocal place within the total net of the relevant phenomena.

By not being derived from real events, and because of their hypothetical character, laws do not refer directly to real existent events but rather to the way humans understand events. Laws are, primarily, the result of trying to find an order of concepts and only then to find an order of events applying to them the order of concepts. Descartes reduction of all the physical realm to geometrical determinations, makes clear that he is not looking for the inner structure of events, but for the meaning of concepts. The universality and necessity of the events which laws describe are not demonstrable. The function of laws is only to determine what will happen under certain given conditions. The first law of motion, first stated by Descartes and adopted by Spinoza, asserts that a body "will have to persevere in its state of resting or of moving uniformly straight forward" (Newton, 1999, 428). It is interesting to remark that Newton uses the word force in relation to inertia (*vis inertiae*). Inertia is the inherent force of matter (Newton, 1999, 404) even when the body is at rest.

This obviously cannot be a generalization out of given bodies, since experience does not provide us with even a single body moving (persevering) in a straight line (see Cassirer, [1936] 1956, 83). Bolotin words about Newton's first law of motion are illuminating in this regard: The law of inertia

> requires us first to imagine a body that is always at rest or else moving aimlessly in a straight line at a constant speed, even though we never see such a body, and even though according to his own theory of universal gravitation it is impossible that there can be one. … it begins with a claim about what would happen in a situation that never exists (Bolotin, 1998, 33)

3. Weighing Eddington's Two Tables

3.1. Sitting around two tables

The achievements of modern science as described above, come with a price: the scientific outlook is no longer linked with the daily "common sense" experience of reality. The question arises, whether they are different interpretations of the same world, or does each one offer a different world? Alternatively, is one of them a true, faithful copy of the world and the other a distortion?

I think that none of these alternatives are plausible. For the sake of the discussion, let me consider one possible answer: the one proposed by Sir Arthur Eddington in his famous description of the "two tables":

> One of them has been familiar to me from earliest years. It is a commonplace object … It has extension; it is … permanent; it is coloured; above all it is *substantial*. By substantial I do not merely mean that it does not collapse when I lean upon it; I mean that it is constituted of "substance" and by that word I am trying to convey to you some conception of its intrinsic nature. It is a *thing* … It is the distinctive characteristic of a 'thing' to have this substantiality, and I do not think substantiality can be described better than by saying that it is the kind of nature exemplified by an ordinary table. … My scientific table is mostly emptiness. Sparsely scattered in that emptiness are numerous electric charges rushing about with great speed; but their combined bulk amounts to less than a billionth of the bulk of the

> table itself. Notwithstanding its strange construction it turns out to be an entirely efficient table. It supports my writing paper as satisfactorily as table No. 1; for when I lay the paper on it the little electric particles with their headlong speed keep on hitting the underside, so that the paper is maintained in shuttlecock fashion at a nearly steady level. If I lean upon this table I shall not go through; or, to be strictly accurate, the chance of my scientific elbow going through my scientific table is so excessively small that it can be neglected in practical life (Eddington, 1935, 5-6).

Eddington responds to the question of whether these are two interpretations of one and the same world by saying that they are "ultimately to be identified after some fashion" (for all the quotations in this paragraph, see Eddington, 1935, 8). However, he does not explain this claim, but declares that "the process by which the external world of physics is transformed into a world of familiar acquaintance in human consciousness is outside the scope of physics." And he adds, "so the world studied according to the methods of physics remains detached from the world familiar to consciousness, until after the physicist has finished his labours upon it". The physicist works in a "foreign territory." Since the only real one is the physical (scientific) table, he asks about the process by which the external world of physics is transformed into the familiar world. Eddington does not have any idea about how to go from one world to the other. The first table is a "strange compound of external nature, mental imagery, and inherited prejudice," whereas the scientific table is, according to modern physics, "the only one which is really there." Eddington promises to unify the familiar world with the world of physics, where the world of physics becomes the real one, while the familiar world becomes subjective, but under the illusion of being real. He accuses "the man in the street" (Eddington, 1935, 9) of asking for concrete explanations that science cannot offer. Instead, he offers analogies that fail to explain both worlds, since one of them becomes an illusory one. The very world that has been the point of departure of the whole scientific journey becomes, in the end, an illusion contrary to the real world that is but a construct of physics! It is worth showing how Eddington inverts the order of things since this inversion is typical of modern philosophy of science in general. Eddington hints that the scientific table exists whereas the familiar one does not.

According to Eddington, "in the scientific world the conception of substance is wholly lacking, and that which most nearly replaces it" is electric charge (Eddington, 1935, 265). Ayer explains Eddington's perspective by saying that the two tables cannot co-exist:

> If the electric charges are what there really is, then the coloured substantial object is no more than an appearance, the effect on the observer's mind of a series of physical processes which starts with the electrical charges, continues through the intervening medium and ends in the observer's nervous system (Ayer, 1973, 83).

Eddington is making two mistakes here. The first is treating an *interpretation* of reality as if it were reality itself. The second is claiming that colors (and other sense-data) are a part of the nervous system of the individual. Assuming that colors are part of the nervous system is again supposing that what really exists is the scientific interpretation while the immediate experience of color (the nervous system has no color) becomes an illusion or appearance.[8] According to Eddington, science becomes the authority for common sense and experience. Its purpose is to correct the image of reality. I claim, however, that science cannot deny the given perceptual data of common sense, which it merely interprets. Eddington's inversion is indeed very useful for the manipulation of reality, but it remains only an interpretation of the phenomena. To suppose that the table is not brown and that this is a fact of everyday experience is to suppose that we

---

[8] There are, in addition, those who consider this the origin of the mind-body problem, believing that colors, for instance, are perceived by the mind, whereas the translation or interpretation of color belongs to the field of neurophysiology, which offers the real event. See, e.g., McGinn, 1989, 349-366. See also Broad, 1929, ch. 2.

do not see what we actually see. But we do actually see the table as brown, and this is not an illusion but a real fact of our visual perception.

Scientists, in the spirit of Eddington, try to distinguish between things as they are in themselves and things as they appear to us. And it is science that tells us how they are in themselves. This implies that we can look at things from no one's viewpoint, from the perspective of an infinite mind, independently of our perceptions and thoughts—that we can refer to things as they are independently of our own contribution to knowledge. This is not the case, since any sense-data, whether directly perceived or indirectly interpreted, include the human hallmark; all perceived qualities and all conceptual thinking entail the human contribution to our knowledge of the world. We thus have no alternative to finding out about the world in general through the immediate data of perception. But here it should be borne in mind that a table is already an interpretation of the visual data. We see in effect a meaningful percept, not necessarily a table, which implies the *concept* of table, not only our visual perception of it. That we see a table implies an understanding not only of the meaningful visual sense-data as described by Gestalt psychology, that is, according to certain laws of immediate perception. The conceptual aspect should be added, namely, what we understand under the concept of table at the discursive level of thinking. Both cases, the case of a substantial world constructed by genera and species, and that of the scientific world explained by laws, have sense-perceptions as their primary data. The given, not as interpreted by science but as it appears to consciousness, without any further mediation, is meaningful prior to being the product of interpretation. An interpretation leans on something meaningful in itself. Otherwise, how can the meaning of interpretation become attached to something if all knowledge originates only in the field of interpretation? It is my conviction that conceptual elaborations are, ultimately, interpretations of our sense-data, which are meaningful prior to being interpreted. Sense perception contents are translated into concepts, be these substantial or scientific concepts.

An additional issue, a fundamental one for my criticism of Eddington's approach, is the way Eddington, in accordance with the general approach of modern science, adopts the controversial distinction between primary and secondary qualities. Eddington refers to the distinction between the "familiar" perception of color and its "scientific equivalent electromagnetic wave-length" (Eddington, 1935, 88). There is here a physical cause and a "mental sensation which arises" (*ibid*). Although he does not refer explicitly to primary and secondary qualities, Eddington refers to physical causes, traditionally regarded as primary qualities, whereas "mental sensations" are regarded as secondary qualities. Naïve knowledge regards secondary qualities as fundamental qualities of things, whereas reflective criticism regards them as dependent of sensory organs. It translates them into the language of physical quantities.

Those who draw a distinction between primary and secondary qualities typically regard only the former as resemblances of the things carrying those qualities. Kepler draws a similar distinction, saying that "Just as the eye was made to see colors, and the ear to hear sounds, so the human mind was made to understand, not whatever you like, but quantity." (my translation, Kepler, 1858, I, 31). Quantity is the fundamental feature of things, their "*primarium accidents substantiae*" (Kepler, 1858, VIII, 150). And why things are real? because they are measurable, which makes them independent of the observer, unlike colors, sounds, etc., whose existence depends on the subject.

Galilei was much clearer on this issue. He distinguished between what is absolute, objective, and mathematic, from what is relative, subjective, fluctuant and sensible. The first is the field of human knowledge, the second the field of illusion and opinion alone (see Galilei, [1623] 1968, 347-348).

The difference between primary and secondary qualities lies in the fact that the primary qualities are measurable, namely, they can be quantitatively considered, whereas the secondary qualities are qualitative and therefore cannot be reduced to quantities or degrees.

This distinction implies an attempt to banish man from the mathematical world of measurable things into a secondary and subjective realm. However, the very mathematical criteria are no less human than the former. Moreover, primary qualities are but interpretations and conceptual elaborations established by the intellect but based on the world of senses.

Boyle, in an attempt to making room for humans in the cosmos, contends that primary qualities are not more real than secondary qualities. Not only their senses are real, but also their mind (See Boyle, 1772, III, 22ff, 35). However, we may conclude that both secondary and primary qualities, are not fundamental qualities in things but relational. Both bear in themselves the seal of humanity. Hence, what is regarded under scientific interpretation as secondary qualities, is rather the very primary qualities. What we perceive by our senses as something meaningful is, in my view, the starting point of knowledge.[9]

Eddington, faithful to his commitment to the presuppositions of modern science, inverts the relationship between the two worlds. However, we can reinvert the relation by asking how the world of common sense, the one that imposes itself on our senses and thoughts, existed before the rise of scientific thinking. The question now is how science regards it. Science is an interpretation of what common sense regards as its sense-data. The difference between the two interpretations is that common sense is much closer to what is perceived by the senses than the scientific interpretation.

Eddington recognizes that "modern physics will never succeed in exorcizing" our "inherited prejudice", namely what is "visible to my eyes and tangible to my grasp" (Eddington, 1935, 8). He fails to explain two things, however: why these "prejudices" exist and why they cannot be overcome. Be that as it may, since they are prejudices, Edington holds that only physics reveals a scientific world that is not an interpretation of it!

Yet, he promises to overcome common sense by means of science. But this will happen only after physicists finish their work. This promise has not yet been fulfilled. What remains is to deal with physics as if the other world did not exist, as if it were "altogether separated from the familiar table". Eddington says that the familiar world is the point of departure for science and that science has to return to it in the end. Physics works in a foreign territory. Its "raw materials are aether, electrons, quanta, potentials, Hamiltonian functions, etc." (Eddington, 1935, 9) Nothing of all this is taken from common sense. Indeed, there are no parallels in common sense for much of the subject matter of science. There are no familiar electrons, etc. parallel to the scientific electrons, but we do not need such parallels to understand and explain electrons.

Instead of considering itself as an interpretation of those contents, science becomes a substitute for the original. Scientific thought regards itself, in its self-consciousness, as dealing with the real original thing, whereas the original becomes a subjective illusion. However, if indeed it is an illusion, why do we need to return to this world at the end of our scientific labor, as requested by Eddington? This question is left unanswered.

4. Conclusions

Briefly stated, I made the following distinctions:

(1) I have made a distinction between content and form of knowledge in order to establish that philosophically, different kinds of knowledge can be distinguished by means of an analysis of their form.

(2) Accordingly, I made a distinction between what can be called broadly "Aristotelian form of knowledge" and "scientific form of knowledge". The whole paper was devoted to the analysis of these

[9] Cf. Bergson's remark: "Philosophy made a great step forward on the day when Berkeley proved, as against the 'mechanical philosophers,' that the secondary qualities of matter have at least as much reality as the primary qualities. His mistake lay in believing that, for this, it was necessary to place matter within the mind, and make it into a pure idea" ([1939] Bergson, 1991, 10-11). In my opinion, however, what is regarded as secondary qualities are those that we directly perceive by our senses and that is the basis for our further intellectual interpretation. In contrast, the primary qualities are only the result of an interpretation of sense-data.

forms of knowledge.

Science, ideally considered, asks neither *what* the world is nor *why* it is the way it is. Its ideal is to ask *how* the world is—to formulate laws of nature. It has no conceptual instruments for "what" and "why" questions. Aristotelian knowledge, on the contrary, lacks conceptual means for explaining motion, but is capable of answering "what" questions.

(3) Genera and species are supposed to be affirmative, while laws of nature are hypothetical. Pre-scientific thinking tried to explain the world from the viewpoint of final fixed states. Science, on the contrary, explains events by means of their changing relationships, that is, through their relative movements.

(4) Aristotelian type of thinking claims that there are final causes in nature, while science claims that the only "causes" are the actual behavior of events as expressed by laws.

(5) Under common sense form of knowledge, general rules have exceptions, while under scientific form of knowledge there are not exceptions to laws.

(6) Classical thinking does not draw a clear distinction between knowledge of facts and taking stands for or against the object of research; in science, values remain extrinsic to the research, as science only describes and explains, but does not take stands.

In view of this contrast between the two systems of knowledge, I criticized the generally accepted way of addressing these two forms of thinking, namely, the claim that the scientific form of knowledge is the correct one, and that common sense thinking is merely an illusion or even a prejudice (as stated by Eddington) and therefore an incorrect explanation of the world.

The comparisons between Aristotelian and modern scientific presuppositions consolidates the claim that no object can be known beyond the frame of presuppositions. For this reason, we should renounce the claim for Truth, keeping only a deflated *conditional truthfulness*: That Genera and Species are eternal is truthful under Aristotelian presuppositions, and that a physical event can be caused only by a physical event is true under the presuppositions of modern science. Something is true or false only under its corresponding set of presuppositions.

Acknowledgments

I would like to sincerely thank Yael Kedar, Giora Hon and an anonymous reader for their advices and constructive comments.

References

Aristotle. (1984). *The Complete Works of Aristotle,* Princeton: Princeton University Press, Vol. II, 1552–1728.

Armstrong, David M. (1989). *Universals: An Opinionated Introduction*, Boulder, CO: Westview Press.

Auxier, Randall E. & Gary L. Herstein. (2017). *The Quantum of Explanation: Whitehead's Radical Empiricism,* New York: Routledge.

Ayer, Alfred J. (1973). *The Central Questions of Philosophy,* London: Weidenfeld & Nicolson.

Balaban, Oded. (1995). The Modern Misunderstanding of Aristotle's Theory of Motion. *Journal for General Philosophy of Science,* 26, 1–10.

Bergson, Henri. ([1939] 1991). *Matter and Memory,* New York: Zone Bk. s.

Bolotin, David. 1998. *An Approach to Aristotle's physics,* New York: State University of New York Press.

Borges, Jorge Luis. (2000). *John Wilkins' Analytical Language*, in Weinberger 2000.
Boyle, Robert (1772). *The Works in Six Volumes,* vol. III, London: Thomas Birch.
Bradley, F. H. ([1897] 1916). *Appearance and Reality: A Metaphysical Essay,* London: George Allen & Unwin.
Broad, C. D. (1929). The Mind and Its Place in Nature, New York: Harcourt, Brace and Company.
Cassirer, Ernst. (1923). *Substance and Function,* New York: Dover.
Cassirer, Ernst. (1956 [1936]). *Determinism and Indeterminism in Modern Physics: Historical and Systematic Studies of the Problem of Causality,* New Haven: Yale University Press.
Cornford, F. (1957). *Plato's Theory of Knowledge: The Theaetetus and the Sophist*. New York: McMillan Publishing.
Coulter, Jeff. (2001). Ian Hacking on Constructionism. *Science, Technology, & Human Values,* 26, 82–86.
Crombie, Alstair C. (1953). *Augustine to Galileo: The History of Science A.D. 400–1650,* Cambridge, MA: Harvard University Press.
Darwin, Charles. 1859. *On the Origin of Species by Means of Natural Selection,* London: John Murray.
Drobisch, Moritz Wilhelm. (1887). *Neue Darstellung der Logik,* Hamburg: Leopold Voss.
Duhem, Pierre. (1906). *La théorie physique: Son objet et sa structure,* Paris: Chevalier & Riviere.
Eddington, Arthur. (1935). *The Nature of the Physical World,* London: J. M. Dent.
Galilei, Galileo ([1623] 1968). "Il Saggiatore," in *Opere di Galileo Galilei,* Vol. 6, Firenze: Giunti Barbera.
Guthrie, W. K. C. (1981). *A History of Greek Philosophy,* Vol. VI, Cambridge: Cambridge University Press.
Hegel, Georg Wilhelm Friedrich. ([1812] 2010). *The Science of Logic,* transl. George di Giovanni. Cambridge: Cambridge University Press.
Kanizsa, Gaetano. (1979). *Organization in Vision,* New York: Praeger.
Kanizsa, Gaetano. (1991). *Vedere e pensare,* Bologna: Il Mulino.
Kant, Immanuel. (1998 [1787]). *Critique of Pure Reason,* Camridge: Cambridge University Press.
Kepler, Joannes. (1858). *Astronomi Opera Omnia,* 8 volumes, edited by Christian Frisch, Frankfurt: Frisch.
Kuhn, Thomas S. (1962). *The Structure of Scientific Revolutions,* Chicago: The University of Chicago Press.
Lambert, Johann Heinrich (1771). *Anlage zur Architectonic*, Vol. I, Riga: Hartknoch.
Lewis, Clarence Irving. ([1929] 1956). *Mind and the World-Order,* New York: Charles Scribner's Sons.
Lotze, Hermann. (1888). *Logic*, Second Edition in Two Volumes, London: Clarendon.
Lotze, Hermann. ([1874] 1912). Logik. In *Logik: Drei Bücher von Denken, vom Untersuchen und vom Erkennen*, Vol. I, Leipzig: Felix Meiner.
McGinn, Colin. (1989). Can We Solve the Mind-Body Problem? *Mind,* vol. xcviii, no. 391, 349-366.
Newton, Isaac. ([1687] 1999). *The Principia: Mathematical Principles of Natural Philosophy,* Berkeley: University of California Press.
Putnam, Hilary. (1973). Meaning and reference. *The Journal of Philosophy,* 70, 699–711.
Rossi, Paolo. (1997). *La nascita della scienza moderna in Europa,* Roma: Laterza.
Rotenstreich, Nathan. 1972. *Philosophy: The Concept and its Manifestations.* Dordrecht: D. Reidel.
Spinoza, Baruch. ([1677] 1994). The Ethics. In Curley, Edwin, ed., *A Spinoza Reader,* Princeton: Princeton University Press, 85–244.
Strauss, Michael & Aaron Ben-Zeev. (1984). The Dualistic Approach to Perception. *Man and World,* 17, 3–18.
Toulmin, Stephen. (1961). *Foresight and Understanding: An Enquiry into the Aims of Science,* London: Hutchinson.
Weinberger, Eliot (ed.). (2000). *Borges: Selected Non-Fiction.* London: Penguin.

Whitehead, Alfred Norton. (1925). *Science and the Modern World,* New York: Macmillan.
Whitehead, Alfred Norton. ([1929] 1978). *Process and Reality: An Essay in Cosmology*, New York: Free Press.
Whitehead, Alfred Norton. (1920). *The Concept of Nature,* Cambridge: Cambridge University Press.

Laws of nature highlights

Oded Balaban

- — Science neither asks *what* the world is nor *why* it is the way it is. It asks only *how* it is.
- — Genera and species are categorical—laws of nature are hypothetical.
- — For classical thinking general rules accept exceptions to the rules—for science there are not 'exceptions to the laws'.
- — The world insofar as it is understood depends on our mind's contribution to its knowledge.