

# *Stuff versus individuals*

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## **Foundations of Chemistry**

Philosophical, Historical, Educational  
and Interdisciplinary Studies of  
Chemistry

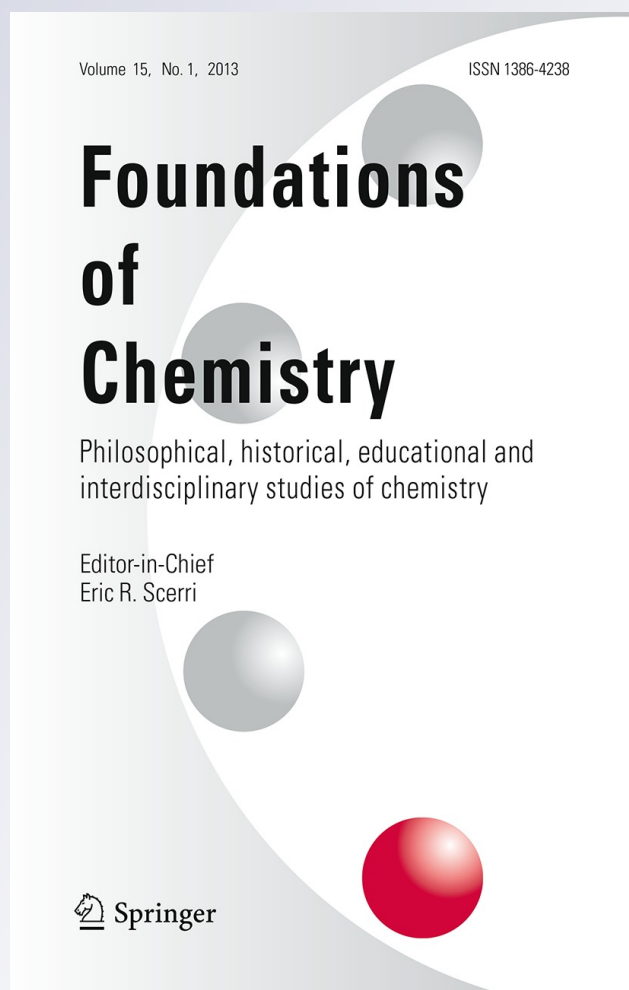
ISSN 1386-4238

Volume 15

Number 1

Found Chem (2013) 15:65-77

DOI 10.1007/s10698-012-9152-2



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# Stuff versus individuals

Lucía Lewowicz · Olimpia Lombardi

Published online: 3 April 2012  
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**Abstract** The general question to be considered in this paper points to the nature of the world described by chemistry: what is macro-chemical ontology like? In particular, we want to identify the ontological categories that underlie chemical discourse and chemical practice. This is not an easy task, because modern Western metaphysics was strongly modeled by theoretical physics. For this reason, we attempt to answer our question by contrasting macro-chemical ontology with the mainstream ontology of physics and of traditional metaphysics. In particular, we introduce the distinction between stuff-ontology, proper of chemistry, and individual-ontology, proper of physics. These two ontologies differ from each other in the basic categories of their own structures. On this basis, we characterize individual-ontology in such a way that the features of stuff-ontology will arise by contrast with it.

**Keywords** Stuff · Individuals · Mass terms

## Introduction

During the most part of the twentieth century, the philosophy of science was deeply influenced by logical-positivism, with its strong aversion to metaphysics. Fortunately, in the last decades and mainly in the context of the particular sciences, many authors have freed themselves from the exaggeratedly rigid constraints imposed by the logical-positivist tradition. Since then, the problems related with the ontology of science began to be addressed from different perspectives. The present work, which focuses on ontological matters, is framed in this trend.

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ontological categories that underlie chemical discourse and chemical practice. This is not an easy task, because modern Western metaphysics was strongly modeled by theoretical physics, in such a way that the practical activity of chemistry remained as a domain of minor relevance from a philosophical viewpoint. Therefore, in this work in progress we will attempt to delineate an answer to our question by contrasting macro-chemical ontology with the mainstream ontology of physics and of traditional metaphysics.

For this purpose, we will begin by recalling a distinction, introduced by Joachim Schummer, between matter-metaphysics, proper of chemistry, and form-metaphysics, proper of physics. In spite of the merits of Schummer's distinction, we will introduce a complementary one, between stuff-ontology and individual-ontology, which differ from each other in the basic categories of their own structures. On this basis, we will characterize individual-ontology in such a way that the features of stuff-ontology will arise by contrast with it. Then, we will argue that the conceptual analysis of mass terms by contemporary philosophy can offer fruitful insights for the understanding of the stuff-ontology specific of macro-chemistry. Finally, we will suggest that the conclusions resulting from the attempt to characterize the stuff-ontology not only shed light on the peculiar features of the world of chemistry, but can also supply conceptual elements to physics in the task of facing the interpretation of the subatomic realm.

## Matter versus form

In his challenging paper, "Matter versus form, and beyond", included in the volume *Stuff. The Nature of Chemical Substances* (2008), Schummer stresses the deep difference between chemical ontology and physical ontology in terms of the opposition between *matter* and *form*. According to the author, matter and form should not be conceived as two opposing and mutually exclusive principles, but as concepts arising from two epistemic perspectives on the world. The form-perspective appeals to geometrical spatial properties to describe bodies. The matter-perspective, on the contrary, is interested in the composition of the bodies, the particular materials each body consists of.

The matter-perspective finds its origin in Ancient Greece, when pre-Socratic philosophers conceived the world as consisting of certain elemental substances that supply unity to diversity. However, the two major philosophers of Antiquity deprived the materiality of substances of its pre-Socratic role. In his *Timaeus*, Plato dematerialized the world by conceiving it as composed of geometrical figures of space. In turn, Aristotle, although considering individuals as composites of matter and form, turned matter into the principle of change, of generation and corruption. In the Aristotelian world, the unchanging form is what makes an individual to be what it is.

During the Middle Ages, the negative connotations of matter increased in the context of Christian thought: matter was associated with evil, darkness, ugliness and falseness. In particular, Augustine concluded that matter is ultimately incomprehensible, and thus cannot be an object of knowledge or science.

Under the influence of the Renaissance and the revival of Platonism, the form-perspective acquired a dominant position with the idea that God wrote the world in mathematical language. As a consequence, since the seventeenth century form-metaphysics has become the mainstream philosophical view: nowadays it is the prevailing perspective in philosophy and in contemporary physics.

As Schummer (2008) remarks, in form-metaphysics, the essential properties of the bodies are intrinsic geometrical properties, such as size and shape; consequently, change is

only motion in space. Conversely, in matter-metaphysics, the properties that describe the world are dispositions, that is, they describe the behavior of an object under certain conditions, but independently of its size and shape; so, change is manifested as reaction and transmutation. The fact that form-metaphysics prevailed in Western thought up to the twentieth century possibly had a bearing on the attempts of analytic philosophy to reduce dispositions, and even other non-dispositional properties, by defining them exclusively in terms of physical form-properties. A case in point is the disposition to walk considered as the property of changing position or, in the scientific domain, the attempt to reduce dispositional properties as solubility or conductivity to the microscopic structure of bodies. Given this philosophical background, it is not surprising that contemporary philosophers of science had paid little attention to chemistry as the science of material substances.

Schummer stresses that matter and form are *complementary epistemic perspectives* that should be combined for a better understanding of reality. Tensions arise only when these perspectives are transformed into ontological principles that exclude each other and become rival metaphysical systems. According to this author, the two perspectives are useful in chemistry even if both have limitations. The form-perspective is what focuses in structural features of molecules, in particular, geometrical properties like angles and distances. However, this kind of description supplies rather poor information about dispositional properties. On the other hand, although the matter-perspective is the specific approach of chemistry in the prediction of dispositional properties and in the production of new substances, that viewpoint finds its limitations at the nanoscale, where materials display properties that may be very different from those shown at the macroscopic level. On this basis, Schummer concludes by emphasizing the need for combining matter and form perspectives in a coherent scientific approach.

### Ontology: categories versus kinds

At the beginning of his paper, Schummer (2008) considers the picture, popular in the nineteenth century, according to which the world is build up in a hierarchical order. In this order, the lower level is populated by subatomic particles, followed at the next levels by atoms, molecules, biological organs and organisms including humans and, eventually, societies. These levels have their correlates in the realm of science: each discipline is assigned to each level, in such a way that our scientific knowledge mirrors the hierarchical structure of the world. It is quite clear that reductionism was nurtured by this hierarchical physicalist view. According to Schummer, one particular problem in the hierarchical picture is “the lack of matter or stuffs in the ontological hierarchy, which actually consists of a series of structures or forms. Correspondingly, the hierarchy of disciplines disregards all our knowledge about stuffs, including chemistry and most of our experimental sciences” (2008, p. 3).

It is clear that the hierarchy is originally conceived as *ontological*, that is, as expressing the structure of the world. It is in this organization that stuff finds no place. However, after considering matter versus form, Schummer concludes that they arise from *epistemic* perspectives. Of course, if they are epistemic, matter and form perspectives may peacefully coexist as complementary approaches. But this is not the case if they are conceived in ontological terms. In which point of the argumentation did an ontological problem turn into an epistemic issue? The fact is that Schummer finally deprives its position from any ontological commitment: in his “Matter versus form, and beyond”, the issue is not what reality is like, but how we describe it. In other words, Schummer remains neutral respect to how the world is.

The difference between a form-perspective and a matter-perspective, as proposed by Schummer, is an interesting tool to conceptualize certain features of chemistry that turn out to be peculiar when compared with that of physics. However, here we are interested in another difference, one which does not point to complementary *epistemic* approaches to scientific knowledge, but to a deep breakdown in the *ontological* categories that underlie each one of the two domains, the chemical and the physical: the physical world is an individual-and-properties ontology, whereas the chemical world is a stuff ontology. *Individual* and *stuff* are different *ontological categories*.

In order to understand the extent of such a breakdown, the first step is to recall what an ontological category is. A category is not a kind defined by a concept, like “red” or “mortal”, which lump together certain objects because they possess a certain property or cluster of properties. A category is not a *taxon*, like “mammal” or “feline”, which classifies preexistent individuals into well-defined kinds. Categories are previous to any classification, since they are what endow an ontology with a certain structure. For this reason, they are conditions for any classification, even for any discourse about the ontological domain (Lewowicz 2005).

In his *Tractatus Logico-Philosophicus*, Ludwig Wittgenstein (1921) makes a distinction between *saying* and *showing*. Something is “sayable” when it is a state of affairs external to language itself: a proposition can only depict what is external to it. Something “sayable” has a content that is fully intelligible to a person without that person’s knowing if it is true or false. However, while propositions can depict all of reality, they cannot depict its logical form, since in order to depict its logical form a proposition would have to do so from a perspective outside of language itself. Rather than depict its logical form, a proposition shows it in its own structure. In other words, the logical structure of language cannot be *said*; it can only be *shown*. As Wittgenstein asserts, “What can be shown, cannot be said” (1921, Proposition 4.1212). These “unsayable things” show themselves in the form of the propositions: they are there, in language, even though they cannot be said.

According to Wittgenstein, our language is not sufficient for expressing its own logical structure, and the philosopher’s task is to discover the structure of language through analysis. But that structure of language, shown by language itself, is also the structure of reality: “Propositions show the logical form of reality. They display it” (Wittgenstein 1921, Proposition 4.121). Therefore, the analysis of the logical structure of language allows us to understand the ontological structure of reality. A proposition as ‘the balloon is red’ can say something, in particular, that the balloon is red, but it cannot *say* that ‘balloon’ is a noun representing an object and ‘red’ is an adjective representing a property: it can only *show* that it is talking about a reality inhabited by objects and properties.

Once these Wittgensteinian considerations are taken into account, it is easier to understand that categories are *said* neither by nouns or predicates nor by any other type of word. *Categories are shown by language*: each language manifests, in its own structure, the categories that inform and organize the ontology referred to by it. For instance, the structure of language will tell us if the ontology is inhabited by individuals, properties and relations, or if there are no individuals *stricto sensu* but only bundles of properties. It will tell us if possibility is an ontologically irreducible feature of reality or it can be reduced to actuality. By analyzing the logical structure of language we will be able to say if there are causal links in the ontology, as well as if ontological items can be categorized as one or multiple. It is the tensed structure of language what tells us that the events belonging to the ontology are temporally arranged according past, present and future.

Summing up, categories are what determine which *kinds of items* inhabit ontology. It is in this sense that individual and stuff are different ontological categories.

## The category of individual

What is an individual? It is something that belongs to an individual-and-properties ontology: an individual exists by itself, whereas properties are applied to the individual. As Steven French and Décio Krause (2006) notice, the category of individual requires some “principle of individuality” that makes an individual to be that individual and not another. The metaphysical question is, then: what confers individuality to individuals? The answers to this question can be broadly divided into two kinds: (a) those that appeal to a “transcendental individuality” (Post 1963), that is, something over and above some set of properties of the individual, like, for instance, a substance as a characterless substratum supporting properties, and (b) those that appeal to some subset of the properties of the individual, together with some further principle which ensures that no other individual must possess that subset. In Western philosophical tradition, the properties of an individual may be either (1) accidental, which are those that can change in time because the individual may or may not possess them, or (2) essential, that is, those that the individual possesses necessarily and that in many cases allow the individual to be reidentified through time. In this sense, spatio-temporal properties always play a central role, either as essential properties of the individual in case (a), or as the properties that confer individuality to the individual in case (b), in both cases under the assumption of impenetrability, which guarantees that two individuals cannot occupy the same spatial location at the same time.

An individual is a *whole unity* in the sense that, as an individual, it is indivisible. This means that either it cannot be divided (*infima species*) or, if it can be divided, the results of the division are individuals or parts different from the original one. In turn, an individual is subject to the Kantian category of quantity (unity-plurality): individuals are either one (each one of them) or many, that is, a plurality. In the plural case, individuals form aggregates, where they can be counted. Even though he calls the category ‘object’ instead of ‘individual’, Henry Laycock says that the key to the character of the general category of object “evidently rests in the notions of unity and singularity—and thereby perhaps, more generally, in the concepts of number and countability” (Laycock 2010, p. 8). Moreover, when individuals are sorted according to their properties, that is, when they are classified, the resulting aggregates are kinds, some of which are considered as “natural”.

The ontology of individuals and properties is what underlies Western ordinary languages and most systems of logic. In fact, in the traditional proposition ‘Socrates is mortal’, of the form ‘S is P’, the linguistic distinction between the subject S and the predicate P expresses the ontological distinction between individual and property. The same can be said in propositions with non-copular verb, as in the case ‘The baby cries’: here there is also a subject, ‘the baby’, representing an individual, and a predicate ‘to be crying’, representing a property. But the predicate does not need to be monadic; in a relational proposition as ‘Aristotle was the teacher of Alexander’, the names ‘Aristotle’ and ‘Alexander’ refer to individuals, and the dyadic predicate ‘to be the teacher of’ denotes a relation.

The way that the ontological category of individual is mirrored in language by the linguistic category of subject is noticed by Peter Strawson in his already classical book, *Individuals*, where he states that an individual is “[a]nything whatever can be introduced into discussion by means of a singular, definitely identifying substantival expression” (1959, 137), “anything whatever can appear as a logical subject” (1959, 227). Ernst Tugendhat expresses the same idea in other terms: “There is a class of linguistic expressions which are used to stand for an object; and here we can only say: to stand for something. These are the expressions which can function as the sentence-subject in



so-called singular predicative statements and which in logic have also been called singular terms” (1982, 23). This means that the category of individual has its linguistic correlate in the so-called singular terms, which play the role of logical subjects of propositions and have singular references.

In turn, most of the systems of logic include individual constants and individual variables to represent those items belonging to the category of individual. For instance, in first order logic, a sentence ‘ $Pa$ ’ says that the property referred to by the predicate ‘ $P$ ’ applies to the individual denoted by the individual constant ‘ $a$ ’; in turn, in the expressions ‘ $\forall xPx$ ’ and ‘ $\exists xPx$ ’ the range of the individual variable  $x$  is a domain of individuals. In Wittgenstein’s words: “the variable name ‘ $x$ ’ is the proper sign of the pseudo-concept object. Wherever the word ‘object’ (‘thing’, ‘entity’, etc.) is rightly used, it is expressed in logical symbolism by the variable name. For example in the proposition ‘there are two objects which...’ by ‘ $\exists x,y$ ’” (1921, Proposition 4. 1272). Here Wittgenstein is clear: “object” is not a concept, but what is expressed—not said—by an individual variable.

The presence of individual constants and variables is not specific of traditional logic: the vast majority of systems of logic, even extensions of the traditional logic or deviant systems (see Haack 1974, 1978), all include symbols to represent individuals, in such a way that an ontology inhabited by individuals is presupposed. In turn, in set theory, the elements of a set are also individuals: when we say that ‘ $a \in A$ ’, we mean that the element denoted by ‘ $a$ ’ belongs to the set represented by ‘ $A$ ’, and this holds even in the case that the element denoted by ‘ $a$ ’ is itself a set, since in this case the set behaves as an individual.

Summing up, even if it may be difficult to define what an individual is, it seems quite clear that the ontology we use to talk about includes individuals, since the symbols used to denote them are ubiquitous in all our ordinary and formal languages. Perhaps for this reason the idea of an ontology of individuals and properties has been the dominant view in Western philosophical thought. Moreover, this kind of ontological structure has modeled physics since modern times, with the corpuscular philosophy of Galileo and Boyle, up to present-day physics, with the standard model of fundamental particles. On the contrary, the answer of the question ‘What stuff is?’ is not easy at all since, as Schummer points out, there is not a strong tradition to help us. The challenge is, therefore, to elucidate this new ontological category.

## The category of stuff

Laycock introduces the issue with an everyday example: “Removing a fly from a bowl of soup inevitably involves removing some soup as well; but it seems grammatically inappropriate to say that in such a case, there is another thing which is removed, alongside the fly. [...] the spatio-temporal isolation of any such soup will be arbitrary or adventitious [...] that, in essence, is why soup must be served in discrete bowls” (Laycock 2010, p. 15). The key difference between both cases is that a fly is an individual, whereas soup is stuff.

The category of stuff has been implicitly present in ancient Greek philosophy. In fact, many of the pre-Socratic philosophers believed that the being of the universe consisted in some kind or kinds of stuff. Thales, for example, thought that everything was essentially *water*, and Anaximenes that everything was a form of *air*; for Anaximander the stuff in question, called *apeiron*, was indeterminate, “the Indefinite” or “the Unlimited”. By contrast, Democritus and the other atomists took *atoms* and *void* as the ultimate constituents of the universe: all things around us are made of atoms as fundamental individuals, in motion through void. For Aristotle, the *primary substances* are individual objects, which,



in turn, can be analyzed in terms of form and matter. The form is what kind of thing the object is, and the matter is what it is made of. In a certain sense, matter can be thought as stuff, since it is whatever, for a given object, meets the role of being that from which the object is constituted: marble in a statue, flesh and blood in a human body. Nevertheless, at the same time, whereas form is the universal in the individual, matter is its principle of individuality, what makes an individual different from another: “Socrates and Callias are different because of their matter [...] but they are the same in form” (*Metaphysics*, 1034a6–8). Therefore, Aristotelian matter loses the universal nature of the stuff that Thales, Anaximenes or Anaximander thought the world was made of. In fact, the fundamental items of the Aristotelian ontology are not stuffs but *primary substances*, that is, individuals, with their essential and accidental *attributes*. Perhaps it is this preeminence of individuals in the very influential Aristotelian philosophy what strongly marked the further development of Western philosophy.

In his interesting paper “Stuff: a phenomenological definition”, Jens Soentgen (2008) points out the analogies and differences of the word in English and German: whereas in German, the term ‘*Stoff*’ is used both in scientific and in everyday language, in English ‘stuff’ is more restricted to everyday use. The word ‘*stoffa*’ in Italian can be also taken into account, whose main meaning is ‘fabric’. The three words have the same root; Soentgen notices that they are related to the Old French term ‘*estoffe*’, which means “material to fill something with”. Let us point out that this derivation exists in English in the word “stuffing” with the same meaning.

Although Soentgen explicitly asks “How can the category of “stuff” be defined” (2008, p. 71), it is clear that he is not searching for a nominal definition like those given in a dictionary. Nevertheless, he is looking for the elemental properties that all stuffs possess. However, from a Wittgensteinian viewpoint, if stuff is a category, it cannot be described by language; so, the meaning of stuff has to be elucidated by analyzing how the category is used in our discourse, be it scientific or ordinary.

As in the case of individuals, a stuff must have an identity principle, that is, a principle that distinguishes a stuff from other stuffs of kinds of stuff. Nevertheless, in this case, such a principle has nothing to do with space and time: what distinguishes water from alcohol has no relation with spatio-temporal properties. In spite of this, portions of stuff do exist in space and time: a portion of water can be spatio-temporally located, for instance, now and here, in my glass.

Unlike individuals, a portion of stuff can be further divided into portions of the same stuff, that is, it can be divided without losing its identity: if a piece of chalk is broken into smaller pieces, the resulting parts are also pieces of chalk. However, a stuff is not each one of its portions: the meaning of ‘chalk’ cannot be established by pointing to one piece of chalk. But a stuff is neither the mere aggregate of its portions: the reference of the word ‘water’ is something beyond all the portions of water that exist in the universe. As Albert Grote clearly states, “[e]ven if I gather all quantities of a certain stuff in front of me, it would become a big amount of the stuff, but would not be the stuff as such” (cited in Soentgen 2008, p. 84). This means that a stuff *embodies unity and multiplicity at the same time*: it is one stuff, but it has multiple manifestations in its portions.

In spite of the fact that portions of stuff are multiple, they do not behave as individuals. In fact, if portions of stuff are put together in an aggregate, they cannot be counted: the aggregate of two portions of water is not “two waters” but “more water”. Moreover, whereas individuals preserve their identity in the aggregate, portions of stuff cannot be reidentified once they are put together: it cannot be said that “this” is one and “that” is the other of the original portions of, for instance, water or iron.

In *Chemistry: the Impure Science*, when commenting Aristotle's account of the dispute about the conceptual differences between the notions of "aggregate" and "mixture", Bernadette Bensaude-Vincent and Jonathan Simon (2008) suggest rethinking Pierre Duhem's concept of "mixture" as the concept that characterizes and specifies chemistry: "A mixture is the product of two or more components that disappear in the process to form a new entity, and yet it is possible to decompose this mixture to recover the original components" (Duhem, cited in Bensaude-Vincent and Simon 2008, p. 127). Indeed, the mixture of two different stuffs seems to have the kind of behavior described by Duhem in *Le Mixte et la Combinaison Chimique* (1902). However, mixture so characterized is a *concept* and, therefore, it is logically posterior to the *category* of stuff we are dealing with here: "mixture" should presuppose the notion of stuff.

Analytic philosophy has faced the problem of understanding the category of stuff from a linguistic perspective, through the discussion of the so-called "problem of mass terms", as Donald Davidson (1967) puts it: the problem is to understand the difference between *count nouns* and mass nouns or *non-count nouns*. Gottlob Frege already noticed the peculiarities of certain "concepts": "Only a concept which isolates what falls under it in a definite manner, and which does not permit any arbitrary division into parts, can be a unit relative to a finite number [...] Not all concepts possess this quality. We can, for example, divide up something falling under the concept 'red' into parts in a variety of ways, without the parts thereby ceasing to fall under the same concept 'red'" (Frege 1884, p. 66). Here Frege is talking of adjectival terms. However, there are other terms whose reference is not a unit that cannot be arbitrarily divided: they are nominal terms as 'soup', 'water' and 'gold', that is, mass terms.

One of the first discussions of mass terms can be found in Francis Pelletier's compilation *Mass Terms: Some Philosophical Problems* (Pelletier 1979), where we can find an in-depth and exhaustive discussion of the complex philosophical problems surrounding the ontology of mass terms. In the field of the philosophy of chemistry, a pioneering work is "The chemistry of substances and the philosophy of mass terms", by Jaap van Brakel (1986), which discusses how to identify the referent of a mass term. In particular, the author argues that, in order to identify the referent of a mass term, we have to look for macroscopic sameness, and not for underlying structure. However, here we are interested in a previous problem, a problem of a logico-ontological nature: how is the ontology presupposed by the use of mass terms? And how is the ontology presupposed by the use of mass terms related with the ontology presupposed by the use of count terms?

The first aspect to notice is that a mass term, precisely because it is not a count noun, refers to something that cannot be counted. It is in this sense that it is said that mass terms have the semantic property of referring cumulatively: "any sum of parts which are water is water" (Quine 1960, p. 91). Water may be distributed all around the world, even in disconnected oceans, lakes and glasses; nevertheless, this fact does not affect its identity; the ways in which water is distributed and the total number of its portions is entirely irrelevant to the identity of water.

Mass terms have in common with plural nouns the distinction of being semantically *non-singular*, a fact reflected in their non-acceptance of singular determiners. In fact, as with plural nouns, we speak of 'all water', 'some water' and 'more water', but not in the singular of 'a water', 'each water' or 'one water'. As Thomas McKay notices: "plural discourse has natural semantic units that are the same as those of singular discourse, but stuff discourse has no natural semantic units, and reference and predication seem to proceed on a different model than that of an individual and a property" (McKay 2008, pp. 316–317). As a consequence, mass terms do not denote individual portions of stuff. However, on the other hand, they have in common with singular nouns the distinction of

being semantically *non-plural*: whereas we may say ‘all oranges are sweet’, where the count noun ‘orange’ appears in plural form, we can only say ‘all water contains impurities’. This means that the reference of mass terms is neither singular nor plural, since they designate neither one nor many *things*: “we should not expect a successful reduction to singular reference and singular predication, something that the application of traditional first-order logic would require [...] when we say that water surrounds our island [...] our discourse is not singular discourse (about an individual) and is not plural discourse (about some individuals); we have no single individual or any identified individuals that we refer to when we use ‘water’” (McKay 2008, pp. 310–311).

These considerations, although confined to the linguistic domain, lead us to the ontological question. If mass terms do not refer to individuals, to what they do refer? McKay answers this question by saying that we must “be talking about some stuff, not a thing or some things, and in that way, mass reference and predication are ontologically more significant than plural reference and predication. We seem to be in new territory ontologically, not just grammatically” (2008, p. 311). In a move unusual in the context of analytic philosophy, McKay acknowledges the ontological commitments of language and, in particular, the new ontological category that underlies mass terms.

### The relationships between individuals and stuff

Once we have admitted the differences between count terms and mass terms, and the different ontological commitments of an individual-discourse and a stuff-discourse, a further question arises: is the ontology presupposed by the use of mass terms related with the ontology presupposed by the use of count terms? And, if the answer is affirmative, how are those two ontologies related?

If we took Schummer’s strategy, we would say that individuals and stuff are complementary *epistemic* approaches that should be combined for a better understanding of reality. From this position, there are no tensions between both perspectives since they have no ontological import. But if we consider individual and stuff as ontological categories that, although mirrored by language, endow reality with its structure, we are forced to explain the coexistence of ontologies so differently structured.

The traditional move regarding this problem has been to dissolve it by confining one of the ontologies to the realm of the mere appearance. As Schummer himself points out, the usual trend in philosophy has been to translate dispositions into intrinsic properties. In fact, whereas the intrinsic properties of individuals, as color, size and shape, are always manifest, dispositional properties are considered mysterious, “ethereal”, as Nelson Goodman (1954) characterizes them. For this reason, the philosophical analysis has searched for the “grounds” or “bases” of dispositions: it is supposed that a glass vase is fragile in virtue of its atomic structure, and in that sense the atomic structure of the vase *grounds* its fragility (Mackie 1977). In other words, dispositions do not exist in themselves, but they are mere macroscopic manifestations of the real non-dispositional nature of the underlying ontology. Some authors claim that not only must every disposition have a causal basis, but moreover the causal bases of dispositions must be non-dispositional properties (Armstrong 1968; Prior et al. 1982). As David Mellor puts it, “Dispositions are as shameful in many eyes as pregnant spinsters used to be—ideally to be explained away, or entitled by a shotgun wedding to take the name of some decently real categorical property” (Mellor 1974, p. 157).

An attempt of reduction analogous to that of dispositions to intrinsic or categorical properties is that of stuff to individuals or individual things: “only things are concrete, not stuffs. We can only gain a concept of stuffs if we ignore the quantitative features (mass, volume,...), conditional features (temperature,...) and form distinguishing features and only take into account the remaining measurements which can be counted as stuff properties” (Dierks and Weninger, cited in Soentgen 2008, p. 74). For instance, Michael Burke (1997) considers that a stuff like copper is a plurality composed from a vast amount of copper atoms and thus not a single thing.

An interesting position is that adopted by Nikos Psarros in his paper “Things, stuffs, and coincidence. A non-ontological point of view” (2001), where we can read: “Obviously the words ‘substance’ and ‘stuff’ mean something. But this fact and the fact that in English ‘stuff’ is grammatically a noun does not imply that the word ‘stuff’ refers to something in the world in the same sense as the word ‘statue’ refers to things of given shape and of definite social and cultural function. It is also undeniable that a concept like ‘stuff’ or ‘bronze’ fulfils the conditions that it is self-identical and distinguishable from the concepts of ‘thing’ or ‘statue’; but these are logical conditions that every concept must fulfil in order to produce meaningful sentences. At no instance does this justify treating the term in question as systematically referring to a thing, even if it has the grammatical form of a substantive” (p. 24). Psarros underscores the difference between stuff and thing: in spite of the fact that both can be represented by substantives, they are different linguistic categories. And he continues by saying that it is not possible to establish the meanings of mass terms ostensively; it is, for example, not possible to introduce the word ‘water’ solely by pointing to a pond and pronouncing ‘water’, since what we point at and what we see are liquid entities called ‘pond’, ‘river’, ‘drop’ or ‘ocean’, but not water. After these claims, one is prepared to read that such a linguistic difference manifests the distinction between two ontological categories, as in McKay’s paper. Nevertheless, this is not the path followed by Psarros. According to him, if stuff and thing are so different, it is because things are effectively existent, whereas stuff is an abstraction: a mass term, as ‘bronze’, is “an abstract substance name that does not refer to a thing, but merely to a specific way of talking about a common substantial aspect of things” (Psarros 2001, p. 28). In other words, stuffs do not inhabit the ontology, but populate the realm of our mind-produced concepts. In a similar vein, Vere Chappell claims that “[m]atter is by nature a kind of abstraction. It can be distinguished in thought—singled out for attention, referred to, identified, and reidentified—but it cannot in fact exist apart from some thing or other whose matter it is” (Chappell 1973, p. 694); the author is adopting the Aristotelian idea that the true and ultimate constituents of the world are primary substances, that is, individual things.

Summing up, according to a widespread view, the fundamental categories of reality are those of individual and of property. Therefore, dispositions are nothing else than intrinsic properties, and stuffs are collections of minute individuals, or the mere result of intellectual abstraction. This reductive viewpoint is in the same line of microstructuralism in the philosophy of chemistry, that is, the thesis that chemical substances can be individuated solely in terms of their microstructural properties: the structure of the molecules is what explains the chemical behavior of the substance. And this position is, in turn, in resonance with a well-known tradition of ontological reductionism in chemistry, according to which chemical phenomena and chemical entities are, when considered in depth, nothing else than microscopic entities and processes described by an underlying “fundamental” theory.

This traditional reductionist stance in chemistry can be challenged from a pluralistic viewpoint according to which, if different theories—or even different disciplines—are accepted at the same historical time and in the context of a single paradigm, we must also

admit that different ontologies may coexist since each one of them is constituted by its corresponding theory. Since the privileged viewpoint of God's Eye does not exist, there is not a single 'true' ontology: all ontologies have the same status to the extent that all of them are constituted by equally objective descriptions, whose objectivity derives from the pragmatic success of the corresponding theories (Lombardi 2002; Lombardi and Pérez Ransanz 2012).

In the philosophy of chemistry, ontological pluralism has been appealed to in rejecting the idea that the world of molecular chemistry can be reduced to the quantum–mechanical ontology (Lombardi and Labarca 2005, 2006; Labarca and Lombardi 2007, 2010). In particular, it has been argued against ontological reduction and for the ontological autonomy of both worlds, on the basis of the deep categorical breakdown between both theoretical frameworks: whereas molecules are semi-classical individuals with their shape and spatial position, quantum entities cannot be subsumed under the category of individual due to the contextual and non-local nature of quantum mechanics. This theoretical discontinuity mirrors the sharp difference between the two ontologies. But once we have given up God's Eye, we have to admit that any claim of fundamentality is based on an ungrounded metaphysical presupposition: the astonishing practical success of molecular chemistry calls into question the privilege of quantum mechanics for becoming the clue witness about what exists and does not exist in the world.

The case analyzed in the present work, namely, the difference between the categories of stuff and individual, leads us to reflect on the relation between macro-chemistry, that is, chemistry as “the science of the transformation of substances” (van Brakel 1997), and molecular chemistry, whose “alpha and omega [...] is the doctrine that molecules exist as individual objects and that every molecule has a shape” (Primas 1994, p. 216). This means that, whereas the ontology of molecular chemistry is populated by individuals with their properties, the world of macro-chemistry is structured according to the ontological category of stuff. Therefore, the assumption of ontological reduction, according to which the macro-chemical discourse in terms of substances is nothing else than a coarse and merely approximate description of the really true molecular ontology, has to be revised in the light of the categorical breakdown between the two realms. In other words, the specificity of the category of stuff poses a serious challenge to the attempts to reduce the complex and very articulated world that macro-chemists face in their laboratories to the much more stylized ontology of molecules with their geometrical properties.

## Conclusions

The main aim of this article has been to argue that the ontological category that underlies the discourse and the practice of macro-chemistry is the category of stuff. Our effort has been directed to stress the deep breakdown between the ontology of macro-chemistry, inhabited by stuffs, and the ontology that prevailed in Western philosophy and physics, populated by individuals and properties. We have also argued that the conceptual analysis of mass terms by contemporary philosophy can offer fruitful insights for the understanding of the stuff-ontology specific of macro-chemistry. On this basis, finally we have stressed the need of reconsidering the relationships between macro-chemistry and molecular chemistry in the light of the deep breakdown between the category of stuff and the category of individual.

In an article of 1998, Paul Teller tells us the following story. Let us suppose that in Monday one puts a silver dollar into his piggy bank, and on Tuesday he puts a second,

qualitatively identical one. On Wednesday he pulls one of the silver dollars out. The question ‘Is this the dollar that he deposited yesterday?’ makes sense. Let us now suppose that on Monday he makes a deposit of one dollar in his checking account, and on Tuesday he makes a second one dollar deposit. On Wednesday he appears at the bank wanting to withdraw one dollar. Can he ask for the dollar he deposited on Monday? Of course not. The difference between both situations lies in the fact that a silver dollar is a coin and, as such, it is an individual, whereas money is stuff. On this basis, Teller concludes: “There are only amounts, or “heaps” of stuff, coming in discrete units, though of in analogy to dollars in a bank account, with no this one or that one about ones with the same properties” (Teller 1998, p. 128). What is Teller analyzing with this analogy? He is not talking about chemical substances as oxygen or water, but about quantum “particles”. In fact, several authors have noticed that quantum indistinguishability has to be understood as the consequence of the non-individual, stuff nature of the items that populate the quantum ontology (Lavine 1991; Teller 1983, 1998). If these interpreters of quantum mechanics are right, the philosophy of chemistry, with its familiarity with the category of stuff, may fruitfully contribute to clarify one of the traditional problems of the philosophy of physics.

## References

- Armstrong, D.M.: A materialist theory of the mind. Routledge, London (1968)
- Bensaude-Vincent, B., Simon, J.: Chemistry: the impure science. Imperial College Press, Singapore (2008)
- Burke, M.E.: Coinciding objects: reply to Lowe and Denkel. *Analysis* **57**, 11–18 (1997)
- Chappell, V.: Matter. *J. Philos.* **70**, 679–696 (1973)
- Davidson, D.: Truth and meaning. *Synthese* **17**, 304–323 (1967)
- Duhem, P.: *Le Mixte et la Combinaison Chimique*. Mixture and Chemical Combination and Related Essays (trans: P. Needham), Dordrecht: Kluwer, 2002 (1902)
- Frege, G.: *Die Grundlagen der Arithmetik: eine logisch-mathematische Untersuchung über den Begriff der Zahl*. The Foundations of Arithmetic. A logic-mathematical enquiry into the concept of number (trans: J.L. Austin), Oxford: Blackwell, 1950 (1884)
- French, S., Krause, D.: Identity in physics: a historical, philosophical and formal analysis. Oxford University Press, Oxford (2006)
- Goodman, N.: Fact, fiction and forecast. Harvard University Press, Cambridge, MA (1954)
- Haack, S.: Deviant logic. Cambridge University Press, Cambridge (1974)
- Haack, S.: Philosophy of logics. Cambridge University Press, Cambridge (1978)
- Labarca, M., Lombardi, O.: Irreversibilidad y pluralismo ontológico. *Scientiae Studia* **5**, 139–167 (2007)
- Labarca, M., Lombardi, O.: Why orbitals do not exist? *Found. Chem.* **12**, 149–157 (2010)
- Lavine, S.: Is quantum mechanics an atomistic theory? *Synthese* **89**, 253–271 (1991)
- Laycock, H.: “Object”, Stanford encyclopedia of philosophy, <http://plato.stanford.edu/archives/fall2010/entries/object/> from the Fall 2010 Edition (2010)
- Lewowicz, L.: *Del Relativismo Lingüístico al Relativismo Ontológico en el Último Kuhn*, Montevideo: Departamento de Publicaciones de la Facultad de Humanidades y Ciencias de la Educación, Universidad de la República (2005)
- Lombardi, O.: Determinism, internalism and objectivity. In: Atmanspachery, H., Bishop, R. (eds.) *Between chance and choice: interdisciplinary perspectives on determinism*, pp. 75–87. Imprint-Academic, Thorverton (2002)
- Lombardi, O., Labarca, M.: The ontological autonomy of the chemical world. *Found. Chem.* **7**, 125–148 (2005)
- Lombardi, O., Labarca, M.: The ontological autonomy of the chemical world: a response to Needham. *Found. Chem.* **8**, 81–92 (2006)
- Lombardi, O., Pérez Ransanz, A.R.: Los Múltiples Mundos de la Ciencia. Un Realismo Pluralista y su Aplicación a la Filosofía de la Física. UNAM-Siglo XXI, México (2012)
- Mackie, J.L.: Dispositions, grounds and causes. *Synthese* **34**, 361–370 (1977)
- McKay, T.: “Critical notice” of *Words without Objects*, *Canadian. J. Philos.* **38**, 301–323 (2008)
- Mellor, D.H.: In defense of dispositions. *Philos. Rev.* **83**, 157–181 (1974)

- Pelletier, F.J. (ed.): Mass terms: some philosophical problems. Reidel Publishing Company, Dordrecht (1979)
- Post, H.: Individuality and physics. *Listener* **70**, 534–537 (1963)
- Primas, H.: Hierarchic quantum descriptions and their associated ontologies. In: Laurikainen, K.V., Montonen, C., Sunnarborg, K. (eds.) *Symposium on the foundations of modern physics 1994*, pp. 201–220. Editions Frontières, Gif-sur-Yvette (1994)
- Prior, E., Pargetter, R., Jackson, F.: Three theses about dispositions. *Am. Philos. Q.* **19**, 251–257 (1982)
- Psarros, N.: Things, stuffs, and coincidence. A non-ontological point of view. *Hyle–Int. J. Philos. Chem.* **7**, 23–29 (2001)
- Quine, W.V.: *Word and object*. MIT Press, Cambridge, MA (1960)
- Ruthenberg, K., van Brakel, J. (eds.): *Stuff. The nature of chemical substances*. Königshauen & Neumann, Würzburg (2008)
- Schummer, J.: Matter versus form, and beyond. In: Ruthenberg, K., van Brakel, J. (eds.) *Stuff. The nature of chemical substances*, pp. 3–18. Würzburg, Königshauen & Neumann (2008)
- Soentgen, J.: Stuff: a phenomenological definition. In: Ruthenberg, K., van Brakel, J. (eds.) *Stuff. The nature of chemical substances*, pp. 71–91. Würzburg, Königshauen & Neumann (2008)
- Strawson, P.: *Individuals. An essay in descriptive metaphysics*. Methuen, London (1959)
- Teller, P.: Quantum physics, the identity of indiscernibles and some unanswered questions. *Philos. Sci.* **50**, 309–319 (1983)
- Teller, P.: Quantum mechanics and haecceities. In: Castellani, E. (ed.) *Classical and quantum objects in modern physics*, pp. 114–141. Princeton University Press, Princeton (1998)
- Tugendhat, E.: *Traditional and analytical philosophy: lectures on the philosophy of language*. Cambridge University Press, Cambridge (1982)
- van Brakel, J.: The chemistry of substances and the philosophy of mass terms. *Synthese* **69**, 291–324 (1986)
- van Brakel, J.: Chemistry as the science of the transformation of substances. *Synthese* **111**, 253–282 (1997)
- Wittgenstein, L.: *Logisch-Philosophische Abhandlung*, *Annalen der Naturphilosophische*, **XIV** (3/4). *Tractatus Logico-Philosophicus* (trans: C.K.Ogden), London: Routledge & Kegan Paul, (1921)