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The world as interpretation:

Philosophical Reflections on the History of the Discovery of Water.

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Introduction

A tale is two tales: Method as Success and Method as Distress

1. The marvel of modern science

"If worldviews interact with Being in a mutually creating fashion, we do affect and shape "reality". We can choose to live in a world that makes sense to us."[1]

One of the many marvels of the modern man[2] it has been argued, is his conquest of Nature. In a different time, and in a different place, Nature's whims were attributed to a world full of deities, of powerful and vengeful Gods, commanding the respect and obedience of the people. A world in which Nature was a mysterious and fearful entity; a world where the "unknown" produced tales of the marvels of demi-gods, a world filled with oracles and prophets, a world of witchcraft. The world before the "advent of science"[3] was one filled with a plethora of entities and concepts, most of which are deemed fictional, mythological, "unreal" even, by the creatures of modernity. But still, to those people in those eras, surely, the world which they inhibited was as "real" as our modern-day world is to us.

In the course of many centuries, and with a myriad of changes and transformations, Nature, and by extension our image of the world, has been transformed into something "familiar", something "oikeion".[4] Nature isn't unknown to us anymore, it isn't something we are afraid of anymore; Nature has yielded to the modern man. We now believe that we have "rational" and "true" explanations for why thunderbolts occur, why the stars collide, we now know that they are not a product of Zeus' anger, or a product of a quarrel between the Gods. Today we can even have a rational, "approximately true" prediction, or forecast, of when the next rainfall is going to occur, and we have dismissed prophecies as acceptable ways of

[1] Feyerabend, *Conquest of Abundance*, p. xi.

[2] I am employing the terms "modern" and "modernity" to refer to the time period between the 17th-century up-to and including today.

[3] By "the advent of science" I mean from the 17th century onwards.

[4] I am employing the ancient greek term "oikeion" with the intended usage of H. G. Gadamer: "that in which one feels at home and which pertains to one...", Gadamer, *Dialogue and Dialectic*, p. xi.

acquiring that prediction. What has changed? How did we come to acquire this certainty about our knowledge? How do we know that we today know the “true”, the “approximately true”, the “real”, whereas our ancestors didn’t?

The answer lies in the methodology we have endorsed. The method of acquiring true or approximately true belief, of predicting, of knowing. Our method of inquiring about the world changed. We have invented the “scientific method of inquiry”. By that we mean the method which has characterized the natural sciences since the 17th century onwards and which consists in conducting observations, measurements, experiments, and the formulation, testing, and modification of hypotheses.[5]The scientific method has been the “go-to” method to acquire “true”, and “real” knowledge, and has established itself as the only acceptable way of conducting scientific inquiry. And who can doubt its effectiveness, its success? After all, with the advent of the scientific method we were able to demolish chimeras, dethrone Gods, get rid of the fantasies of prophets and oracles alike. We were able to do that because the scientific method did deliver us something which we didn’t have before, or rather something we didn’t find acceptable before: criteria of “truthfulness”, criteria of “reality”, criteria of choosing between theories, world -views, entities.

The scientific method did deliver to us an acceptable way of making choices,of demarcating; did deliver acceptable criteria of choice. We are now able to choose between systems of thought and hypotheses based on their simplicity, their accuracy, their consistency, their scope, and their ability to be bearers of future research.[6]We paved the way to knowledge, to understanding, to capturing the essence of Nature. We came to know the “real” as opposed to mere “appearances”. We came to the realization that the actions of Zeus, of Athena, and of other “divine entities”, which were treated by the ancient Greeks as “real”, were as “real” as dreams are when they are opposed to waking events.[7] In short: we were able to to choose which entities and world-views were real and which fictitious, and replaced the fiction with the real. We were able to establish a new way of looking at the world, a new way of interpreting the world, a new way of reducing the Being of the world. Could it be possible though, that we jumped on that ship a bit too hastily?

[5] I am using the definition of the scientific method as provided by the Oxford Dictionary. https://en.oxforddictionaries.com/definition/scientific_method
[6] Kuhn, “Objectivity, Value Judgment, and Theory Choice”, pp. 320-22.
[7] Feyerabend, *Conquest of Abundance*, p.9

1.1. A scientific realist's guide to the way the world is (or the way the galaxy is).[8]

According to many firm believers in the scientific method, scientists and philosophers alike, the *only way the world is*, is the world described by the scientific method. The firm believers in this "reality" are identified, by today's nomenclature, as scientific realists. Briefly, scientific realism "is the positive epistemic attitude towards the content of our best theories and models recommending belief in both observable and non-observable aspects of the world described by the sciences."[9]More comprehensively, a scientific realist could subscribe to one, or a combination of, the following dimensions of scientific realism:[10]

i) metaphysical realism, the belief that there is, exists, a mind-independent world best described by the sciences,

ii) semantic realism, which entails the belief that scientific claims about the world should be taken at face - value, should be interpreted literally, and

iii) epistemological realism, the belief that theoretical claims, taken literally, constitute knowledge of the world.

At first glance, the dimensions of scientific realism, appear to be innocent enough. But upon careful reflection, an inescapable observation is being made, and a disturbing question emerges. At the heart of the web of beliefs of the scientific realist lies one thing and one thing only: Reality. Reality as opposed to appearance. Reality as opposed to fiction. That's the observation. And now the question: Does the notion of "reality" which the scientific realists hold onto so dearly, settle the issue of what's real and what's not? Again, did we jump on this ship too hastily?

One of the most prominent supporters of scientific realism, Max Planck observed:

> "The two statements, "There exists a real external world which is independent of us" and "This world cannot be known immediately" together form the basis of all physics. However, they are in conflict to a certain extent and thereby reveal the irrational element

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[8] This is a word-play on the radio comedy series *The Hitchhiker's Guide to the Galaxy (1978)* created by Douglas Adams.

[9] Chakravartty, Anjan, http://plato.stanford.edu/archives/fall2015/entries/scientific-realism/

[10] Feyerabend, *Conquest of Abundance*, p. 62.

> inherent in physics and in every other science, which is responsible for the fact that a science can never solve its task completely."[11]

Planck's observation has a very disturbing element in it. It seems that there is something more to the scientific realist's notion of reality than meets the eye. It seems as if the scientific realist is on a quest, on a search for reality. As Feyerabend notes, in our modern day notion of "reality" there lies a hidden assumption, a prejudice if you may, shared by physicists and philosophers alike. The assumption is that what is "real", is assumed to be something hidden, something not manifest in what we experience.[12] It's as if there's something in the way of "truth". As if we have established a grand dichotomy between a solid, trustworthy and genuine reality on the one hand, and the deceiving appearances on the other.[13]

We, the author, have a quarrel, if you may call it that, with scientific realism, and not with the scientific method *per se.* Our falling-out does not simply rest on the notion of reality which it embraces, although that is an enormous concern of ours. Our disagreement rather rests on a deeper and more profound problem which scientific realism potentially presents us with. That problem is none other than the problem of theoretical monism. In our view, the notion of reality which the scientific realist embraces, runs the risk of leading to theoretical monism. But before we proceed with providing an argument for why that is the case, a few words on our definition of theoretical monism are due. Our definition of theoretical monism runs as follows: Theoretical monism is the belief that there is such a thing as Truth[14], and a theory, or a set of theories, can attain or encapsulate this Truth. In addition, according to our definition of theoretical monism, theoretical monism is the belief that some theories are closer to being true, closer to attaining this Truth, than others, therefore, we should narrow down the set of theories which we are working with, discard those further removed from this Truth, and keep working only on those deemed closer to attaining this Truth.[15]

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[11] Ibid, p. 62.
[12] Ibid. p. 10.
[13] Ibid, pp. 9-10.
[14] The capitalization is purposeful. We use it to denote "Truth" as in one single, objective and unobjectionable Truth, in contradistinction to "truth", which we will use to employ as a subjective, contingent truth. Similarly we will use "Real" to denote "objectively and unquestionably "Real" from "real" which we use to employ a subjective, human dependent, real fact.
[15] Feyerabend, *Knowledge, Science and Relativism,* pp. 4-5.

1.2. The problems with theoretical monism: The metaphysical problem.

A pair of problems presents itself; the first one is of a metaphysical nature, the second is methodological in kind. Let's examine the metaphysical problem. It appears that a theoretical monist believes in a single, coherent, unified picture of the world. He believes in a "correct", or "real" picture of the world, as opposed to a "false" or a "manifested" one. This is troublesome for the single fact that the belief that there is a distinction between the "Real" from the "subjectively real" is, we will argue, an assumption. It's not something which has, or possibly can, be proven by empirical observation, unless in such cases as a "dream state" and in a lucid state. That there is a distinction between something "objectively Real" and something "merely real" and the consequent classification of something as "True" as opposed to "false" or "true" holds true only if we accept the *assumption that there is such a thing as an "objective reality" which can be distinguished from a "subjective" one*. This assumption we, the author, denote as the "*staged dichotomy of the real*".

The "*staged dichotomy of the real*" is the assumption that there are objective, real, facts about the world, which we can hold onto and label as "Real" or "True", and discern them from "subjectively true" or "merely real". But why is this an assumption? To show why this is an assumption we employ Feyerabend's "concept of the stage".[16]The "concept of the stage" denotes the following: In any scientific experiment, the human subject relies on a set of rules, processes, methodologies, which he or she employs to bring to the fore the desired or intended result. The intended result is, possibly, the discovery of a "new objective fact" about nature, the demarcation or testing of a theory against the backdrop of nature. Here is the problem however: whatever the result, that result is not, and cannot be, an "objectively Real" or "True" result or fact of or about nature. This is the case for the simple reason that nature, is not faced "directly". Rather, what is faced and tested is a set of theories, measuring devices, and methodologies compared with *projected images* of nature, which in turn produce another or other *image(s) of nature*. In short, depending on the way we choose to approach nature, which set of theories and/or methodologies we endorse, we have the ability to make nature fit to our "projected image" of it. Human beings are endowed after all, with the unique ability of "world-making".[17]What this means is that the "reality" which we choose to believe in, or the

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[16] Feyerabend, *The Conquest of Abundance*, pp. 89-128.
[17] Goodman, *Ways of Worldmaking*, pp. 2-3.

"truthfulness" of a fact, depends on the methodologies, stages, theories, and systems of thought, we embrace. Does this make the result of an experiment "less real", or "less true"? Does this fact invalidate our most well-corroborated scientific theories? It does, only if we still hold on to the ideal of the "Real" or the "True" in the sense in which some scientific realists, and most scientific monists employ the term.

With what we've been discussing so far it seems that the existence of the "Real" depends upon its assumption. And that's the metaphysical problem with theoretical monism. That there is something "Real" is something which can be proven only if we assume that it exists. It's this assumption which causes the problem: Essentially the theoretical monist's way of holding onto his notion of the "Real" as something which can be distinguished from the "real", is another version of "the myth the given". "The myth of the given", a familiar episode in the literature of the philosophy of mind serves to highlight our point about the worrying aspects involved into the monist's conception of the "Real". According to Sellars, the originator of "the doctrine" or "the myth of the given", the doctrine of the given is that any empirical knowledge *that p* requires some (or is itself) basic, that is, epistemically independent knowledge (*that g, h, i,...)* which is epistemically efficacious with respect to *p.*[18,19] With respect to Sellas' observation, a question arises: how can we can verify that the statement "There is a dark-red vase in the ledge of my window containing dried flowers" is a **T**rue and **R**eal statement about the world? If we follow the monist's line of thought the idea seems to be that this statement about an object of our experience can be verified simply by pointing out to what is given to us in perception. But this "pointing-out" already implies the assumption from which we started, namely, that there is a "fixed" notion of "Reality" already in place when making this judgment. And it's at this point that this "Real" becomes a metaphysical idea: when the monist "imposes on the real". It does not take into consideration that the judgement itself is a product of a world-view, of an interpretation, of one amongst a myriad of ways of approaching Being. Different stages, world-views, ways of Being, will produce different images of nature and therefore different "truths" and different "reals". The "reality" of these images of nature, depends upon the given framework we have chosen to embrace.

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[18] deVries, Willem, "Wilfrid Sellars", *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), Edward N. Zalta (ed.)

[19] For more details on Sellar's "doctrine of the Given" see: Sellars, "Empiricism and the Philosophy of Mind", pp. 127-196.

The question of “Reality” cannot be settled by its very assumption. And assuming that there is something “Real” which can be readily distinguished from something “real”, is a metaphysical notion, one which cannot be sustained because its very apodicticity relies on its assumption. Our proposal is to treat questions and issues pertaining to “reality” as framework-dependent; realities and images of nature are construed out of the ways in which we have chosen to embrace nature.

1.3. Intermission I: The conceptual framework of “Being”.

It has been brought to our attention that the concept of “Being” which we employed earlier, and we have been employing throughout this paper, could be understood as something “mystical”; as if we are “conjuring up” a metaphysical concept with excess conceptual and ontological baggage.[20] Because the employment of the concept of “Being” is crucial in the broader context of this present discussion, we intend to specify exactly what we mean with that; we shall try to “demystify” it and make clear to the reader the intended usage of the concept. We employ the word “Being”, in the intended usage of the word by P. K. Feyerabend throughout his *The Conquest of Abundance* to denote nature; but this conception has deeper philosophical underpinnings. The nature we speak of, and is encapsulated by the concept we have chosen to employ, following Feyerabend, is of a nature which reacts to different ways of being approached. As Preston argues, nature, or Being, reacts to different enquiries in different ways.[21] According to Feyerabend, scientific realists assume that the reactions observed depend only on “Being”, and *not* on the way it is approached; which is an objectionable assumption as Feyerabend’s body of philosophical work tried to show. As Preston put it:

> “...Feyerabend suggests, we ought to consider the possibility that Being is more yielding, more multi-faceted, more responsive and altogether more cuddly than contemporary materialists concede. Perhaps the things prescientific people found were the way in which Being “received” their approach, so that these things are as real, relative to their approach, as electrons are “for us”? Instead of thinking that the procedures of a research

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[20] I would like to thank my supervisor Guido Bacciagaluppi for bringing this matter to my attention; I hope that my treatment of the issue here is satisfactory, and makes things on the part of the reader, clear.
[21] Preston, “Feyerabend’s Retreat from Realism”, p. 427.

programme reveal how nature is independently of the interference, we are to think of them as revealing how nature responds to them."[22]

Despite the language, which might seem a bit poetic at times, we would like to make clear that our employment of the word Being, and our conception of it, is not of a metaphysical entity, of a mystical entity. It is *not* a conception of Being with a special ontological status; we are not talking about a "substance" here. We are *still* talking about nature. The reason why we prefer to employ the term Being is because it highlights the dynamic character of our interaction with nature; a nature which reacts to the ways we approach it, a nature which reveals its aspects through the stage(s) we have chosen to project it. Being is meant to highlight just this dynamic character of our interference with nature, not a "sterilized" objective nature as some theoretical monists have chosen to treat it, a nature which "is there" without interference, but rather a nature in which the interference itself, the ways it is projected, the stage upon which our approaches are set-up, is embraced. We think that this is the reasoning for which Feyerabend himself chose to employ the term Being interchangeably with nature, and this is the reason for which we have elected to do so as well. The concept of Being will be discussed extensively in the following sections as it is of paramount importance in understand Feyerabend's philosophical positions which largely inform our own.

1.4. The problems with theoretical monism: The methodological problem.

The "imposition on the real" brings us to the second problem with theoretical monism, which is methodological in kind. The insistence on a single, uniform Truth, or Reality, becomes an ideal to be attained. This by itself is not a problem. It becomes a problem however, when the belief in the existence of a single Truth overwhelms the theorist and excludes the possibility of entertaining other alternatives. Following Kant's observation that the theories we subscribe to influence our language, our thought, our perception, it becomes evident that if we follow only one theory in the way we approach Being, no matter how empirically adequate that theory may be, we will end up with only one way of interpreting reality, interpreting the world, approaching and reducing Being, to the exclusion of any other alternative. **T**ruth runs the risk of becoming a dogma. Again, following the line of reasoning produced so far, it's hard to see how something can be labeled as "True" in direct opposition with something "merely, or subjectively true". The

[22] Ibid. p. 428.

fact that I am now counting three objects contained in my office as I am typing this paper, my notebook, my desk and my chair, might be a true fact for me, but according to a mereologist who follows Lezniwski's work, the truth of the matter would be that my office contains seven objects. [23]Is one version of the "reality" and the "truthfulness" of the world in this particular instance more or less "real" or "true" than the other? Or maybe the very reality of the situation, the "truth of the matter", depends on the framework we choose, on the way we approach and reduce Being? We believe that the latter is indeed the case and a look at different research traditions and scientific practices, supports our view. Take "the Aristotelian tradition" for example. The scientists embracing this way of reducing Being try to be as close to experience as possible, they try to avoid big cosmological questions, and favor predictions which are strongly supported by clear-cut experiments. On the other hand however, lies "the Platonic tradition" which advises to follow every plausible idea, follow every truth to its utmost, and which informs us that experience could be illusory and even superficial.[24]Aren't the findings, theories, versions of the world, or worlds, of the scientists of the Aristotelian traditions equally real, or equally true, compared to those in the Platonic camp and vice-versa? We think that they are.

Let's take a step back and review our progress. It seems that the the scientific monist's conceptions of "Truth" and the "Real" have some disturbing metaphysical underpinnings. It's as if the "Truth" and the "Real" are metaphysical ideas, which have to be assumed in order to be "proven"; this we coined as the "staged dichotomy of the real", and demonstrated the circular reasoning involved in that line of thought. The situation is only worsened if we add to the equation the fact that theories which are after this attainment of Truth or Reality run the risk of becoming metaphysical systems. Finally, as we saw in our mereological example, it's hard to see how we can still insist on a single Truth, on a single way the world is. It seems that nature is multi-faceted, and the more alternative viewpoints, interpretations, world-views, we allow, the more interesting nature becomes and more images of nature are produced. But that's the case only *if we allow* for alternatives. If we don't grant alternatives then Truth becomes a dogma, and at that point, the whole idea of Truth becomes a myth.[25]This is the problem with theoretical monism, and these are the dangers which scientific realism potentially faces. Scientific realists need to be cautious to avoid the dogmatism inherent in theoretical monism. They need to avoid

[23] Putnam, ed. McCormick, "Is There Still Anything to Say about Reality and Truth", pp. 24-25.
[24] Preston, "Feyerabend's Retreat from Realism", p. 5.
[25] Ibid. pp.3-4.

the pitfall of reducing the abundance of Being, its richness, and its plurality to one single way. That's our quarrel with theoretical monism: How can the science envisioned by the theoretical monist differ from a myth, when it imposes a dogmatism based on a metaphysical system, on a metaphysics of Reality and Truth? The scientific method, a tale of success, becomes a tale of great distress in the face of theoretical monism. A tale, after all , can be two tales.

1.5. Reality: Fake Sparkle or Golden Dust?[26]

The present paper attempts to tell a different tale. A tale in which Being isn't reduced to a single uniform thing. A tale in which there is no "right" or "wrong" way of looking at the world. A tale in which the richness of Being, and the ways of reducing it, is embraced. Our thesis is that there is no singular way the world is, nor is there any singular world to begin with. Rather, the world is many worlds. The way the world is, its reality, is directly related to the way we choose to approach it, to interpret, to understand it, but most importantly of all, experience it and live it. The world is our interpretation of it. This is as much an epistemological thesis as a meta-theoretical one. A plurality of interpretations of the world generates a plurality of worlds. A plurality of ways of living in the world embraces the richness of Being. This is the thesis we want to advocate:

the way the world is, is the way we choose to live in it. A plurality of alternatives presents us with different ways of how to live in the world and therefore it presents us with different ways the world is; the world is our interpretation of it.

If science, and the scientific method, is to be of any value to the growth of knowledge, and by that we mean to provide us with a plethora of ways and of systems to embrace the richness of Being, then science should work in a pluralistic way. Knowledge is best attained by working with a plethora of hypotheses, a plethora of systems. And contrary to the theoretical monist's grand vision of science, science has worked in this exact manner, and scientific progress has been achieved in this precise way.

The tale we are going to tell starts with our examination of the history of the discovery of water, and the ways in which water came to be known as H_2O. Our aim with examining this

[26] After Peter Murphy's song "Fake Sparkle or Golden Dust", from his album *Dust* (2002).

history is to show the ways in which a plurality of systems of thought, of competing hypotheses, of competing metaphysical ideas, can be achieved. In short, we want to show that science can, and has, worked in a pluralistic fashion. In addition, we want to show how a pluralistic framework can produce knowledge and expand our knowledge. By "expansion of knowledge" we mean the production of alternative ways of seeing, of conceiving, of thinking, and fundamentally, of Being in the world. More precisely in the next section, we will follow Hasok Chang's historiography on the issue as it appeared in his *Is Water H_2O?* We will examine the different systems of thought, and scientific standards, operating at the time the discovery took place, and how this discovery was achieved. In the subsequent sections, we will offer our reflections on the issue, and showcase the benefits of pluralism in opposition to scientific monism. We will further develop and advance our thesis, which is heavily influenced and informed by the philosophy of P. K. Feyerabend, to the kind of pluralism we advocate, a pluralism of the normative kind but with an existential component; an ontological pluralist position or as Brown put it an "abundant realist" position, and present what this position entails. [27]

As Boris Yellnikoff put it:

"That's why I can't say enough times, whatever love you can get and give, whatever happiness you can filch or provide, every temporary measure of grace, whatever works".[28]

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[27] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 142.
[28] Boris Yellnikoff is a fictional character created by Woody Allen and appears in his film *Whatever Works* (2009).

The History of the Discovery of Water

2. The discovery of Oxygen (or Dephlogisticated air)

The statement: “water is a compound, consisting of two atoms of hydrogen and one of oxygen” seems to be a an objectively True and Real fact of nature today. However, up to the first half of the eighteenth century, people held to the notion, that water was an element. This True and Real fact about nature dated back to the ancient Greeks and the early atomists, in this case Aristotle, who held that water was one of the four elements, along with fire, earth and air, which constituted the world. That water is a compound, consisting of hydrogen and oxygen, came to be a Real and True fact *about* nature only with the advent of the Chemical Revolution. The present section attempts to tell the story of how water came to be universally known as a compound with the constitution H_2O, and what this discovery means for our discussion of issues pertaining to Truth, Reality, and the ways we project or approach nature. In this section we will attempt to tell the story of this discovery, only briefly mentioning or commenting on the philosophical implications of the history of the discovery of water. A more extensive treatment of those implications will be offered on the subsequent sections.

Our inquiry into the history of the discovery of water begins with Joseph Priestley (1733-1804) and his work in “pneumatic chemistry”, the chemistry that is of gases and airs.[29] Priestley’s work is fundamental in our discussion for two reasons: one, because he is the “father” of the theory of phlogiston, which we will examine shortly, and two, because his work on pneumatic chemistry changed the Reality and Truth of how we consider air and through this work oxygen was born. Air, like water, was believed to be a pure element before Priestley. Priestley however showed that air wasn’t a pure element, that it in fact had at least two components, and that different types of air could be produced as a result of different chemical reactions. It was Priestley’s work on the chemistry of gases and airs that the world came to learn

[29] Chang, *Is Water H_2O?*, pp. 2-3.

of oxygen, and Priestley to be credited for its discovery.[30] Funnily enough, Priestley did not name his new element oxygen, and according to Chang his element being given the name "oxygen" would have been something which would have annoyed him.[31]

Priestley's annoyance at the nomenclature "oxygen" would not have stemmed from his whims or quirks. He would in fact have had very important metaphysical and methodological reasons for why his element being called "oxygen" wouldn't have satisfied him. Priestley in fact called his new element "dephlogisticated air". Phlogiston was a fundamental substance which combined with other substances and gave them its characteristic properties. In addition, phlogiston was the substance which bestowed the ability to a substance to become combustible; to those (substances) that could be combustible at all. A combustible substance was a substance which was rich in phlogiston, and when it burned out, it released its phlogiston, the phlogiston then manifesting itself in the flame which ensued.[32]The discovery of oxygen took place while Priestley was working with mercury calx. Priestley thought that mercury calx could be revived into its metallic form by absorbing phlogiston from air. That air would have been dephlogisticated, and it would be a prime candidate for combustion since it could readily re-absorb phlogiston.[33] And so, Priestley's "dephlogisticated air", or Oxygen for the rest of the world, came to be. Phlogiston, a "bogus" notion, a scientific chimera, by today's standards, led to the discovery of oxygen.

The name oxygen to the element which Priestley discovered was given by another important scientific figure in our story, Antoine-Laurent Lavoisier (1743-1794). Lavoisier gave Priestley's element the name oxygen because he had a different way of reducing Being, he had a different interpretation of the world, he held different metaphysical and methodological convictions. The name oxygen stems from Lavoisier's interpretation of Priestley's experiments. According to Lavoisier's interpretation, combustion was combination with oxygen (Priestley's dephlogisticated air), and the same held true for calcination. According to Priestley's interpretation, dephlogistication occurred, according to Lavoisier, oxidation. Eventually, the scientific community agreed with the latter, and hence, Priestley's "dephlogisticated air" became known as oxygen.

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[30] Ibid. p.3.
[31] Ibid.
[32] Ibid.
[33] Ibid. pp. 4-5.

2.1. Two images of water: Water as an element and water as a compound

The reasons which led to the the "victory" of the oxidation theory are very important in our discussion of the history of the discovery of water.[34] So far, we've seen two competing world-views, two images of nature, two ways of reducing Being, two scientists trying to give their interpretation of the occurrence of a certain phenomenon. Since the name oxygen is used to refer to Priestley's element, it's safe to assume that Lavoisier's oxidation theory prevailed over Priestley's, but why is this the case?

The decisive moment which led to the dominance of Lavoisier's "oxygen" and his oxidation world-view as opposed to Priestley's "dephlogisticated air" and phlogiston theory, was Lavoisier's argument that water was not an element, but was in fact a compound.[35]Priestley, along with his fellow countryman and natural philosopher Henry Cavendish (1731-1810), who is known as the "discoverer" of hydrogen (inflammable air) which took place in 1766 while he was also working on pneumatic chemistry, had formulated their own hypothesis on the formation of water. According to the Cavendish-Priestley hypothesis (henceforth "CP hypothesis" for reasons of economy and ease on the part of the reader), hydrogen, or "inflammable air" as they called it, was phlogiston which was driven off metals via acidation. Based on the theory of calcination developed by Georg Stahl (1659-1734) this meant that the metal turned into calx and dissolved into the acid which led to the formation of some kind of salt-based chemical substances. If a calx was put into the acid, it dissolved without producing "inflammable air" since the calx did not contain any phlogiston. This "pneumo-chemical" observation, served as the basis upon which Priestley and Cavendish formulated their hypothesis on the formation of water. According to the "CP Hypothesis" inflammable air was "phlogisticated water", which meant water in excess of

[34] The debate between phlogiston and oxygen based viewpoints and its importance for the discovery of water is also at the forefront of a recent paper by Blumenthal. J., Ladyman. J. "T*heory comparison and choice in chemistry, 1766–1791*". The authors highlight how the debate between the two viewpoints accorded a plurality of interpretations and theory choice which led to the consensus of 1860. For more see: Blumenthal. J., Ladyman. J. "Theory comparison and choice in chemistry, 1766–1791" in *Foundations of Chemistry*: pp. 1-21 (forthcoming)

[35] Chang, *Is Water H_2O?* p.6.

phlogiston. Oxygen, or dephlogisticated air, was "dephlogisticated water", which made sense given Priestley's views on oxygen. Cavendish and Priestley's observation was that when phlogisticated water, hydrogen, and dephlogisticated water, oxygen, were combined with one another, they canceled each other out; the excessive phlogiston of inflammable air, canceled with the deficit of phlogiston in dephlogisticated air, and this led to the production of "pure"[36] water. [37]

So far we've seen the "pneumo-chemical" account on how water is produced. According to the CP hypothesis, water is an *element* which is produced by the combination of phlogisticated water and dephlogisticated water, one is in excess of phlogiston, the other in deficit, and via their combination they cancel each other out and "pure" water is produced. As we've been discussing however, this world-view did not prevail. In fact, the dominant interpretation on the nature and composition of water was the Lavoisierian one. As we briefly mentioned, according to Lavoisier, water was not an element after all, but was in fact a *compound*, and it was brought about by the combination of hydrogen and oxygen. Lavoisier's interpretation was based on three fundamental pillars of his system, his theory of acids, his theory of combustion, and his caloric theory, which had their own metaphysical implications. While Priestley named the element we now know of as Oxygen "dephlogisticated air" because of his phlogistonist based image of the world, Lavoisier named it Oxygen based on his theory of acids. According to Lavoisier, all acids contained Oxygen and the name Oxygen was employed to denote "acid-generator".[38] According to Lavoisier's theory of combustion, combustion is combination with Oxygen, which causes the emission of heat and light. Lavoisier's theory of combustion brings us to the third pillar of his system and that's none other than his caloric theory. This is the case because according to Lavoisier, the production of heat in combustion stems from the release of caloric fluid from oxygen gas, and it's the caloric which is responsible for oxygen's gaseous state.[39]In fact, Lavoisier's views on caloric, similar to Priestley's on phlogiston, could be considered as the "the building blocks" upon which their entire systems were built. Caloric was not just an explanatory vehicle for Lavoisier's theory of heat, it was well embedded in his cosmology as his list of chemical element testifies.[40]Of course, the caloric, just

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[36] Pure is employed here to denote "plain", "simple" water; water as we commonly refer to it.
[37] Ibid. pp. 6-7.
[38] Ibid. pp.8-9.
[39] Ibid. pp. 9-10.
[40] Ibid. p. 10.

like the phlogiston, is deemed a scientific chimera today, a mythological concept, but Lavoisier's oxidation theory still prevailed.

While there are important reasons for why one world-view prevailed over another, which we will discuss in the next sections, it's important to make the following two observations: one, both world-views had different images of nature which contained different *entities*. Metaphysics, according to our interpretation of the literature,informed those systems of scientific practice and the ways in which their hypotheses were formulated. The history of the discovery of water has afforded us with the opportunity to see two different worlds, one with phlogiston in it, the other with caloric. A world in which water is an element, one in which water is a compound. And while both entities, (caloric and phlogiston), are deemed as non-existent today, for both Lavoisier and Priestley they were as real as the acknowledgment of their non-existence is for us today. This is even more interesting if we add to that the fact that the name Oxygen prevailed, whose discovery and name stems from working on what a theoretical monist would today classify as a chimeric, false, "unreal", scientific system of practice. The same holds true for water's classification as a compound substance, which brings us to our second observation. The issue on whether or not water was a compound, was not settled. And while the scientific community was heavily in favor of the Lavoisierian world-view, the question still remained open. In the next sub-section we will examine how that issue was eventually settled, and we will see a plethora of different systems of practice, methodologies, and world-views colliding.

2.2. Electrolysis: Every cure is someone else's disease[41]

The issue on whether water was a compound substance or an element was not entirely settled during the Chemical Revolution. And while most granted Lavoisier's hypothesis its truthfulness, unequivocal agreement had not yet been reached. The situation started to change during the year 1800; the time had come to test Lavoisier's account on the composition of water. This year was marked by the invention of the "Voltaic Pile" named after its inventor, the italian physicist Alessandro Volta (1745-1827), and it's partly due to this invention and the ongoing, at the time, research on the growing field of electro-chemistry that the testing of Lavoisier's hypothesis in a

[41] Part of the title pays homage to IAMX's song "White Suburb Impressionism", from the album *Kiss + Shallow* (2004).

more extensive manner was possible. Lavoisier had already “demonstrated the truth of his decomposition of water hypothesis” by conducting an experiment in which he passed steam through a hot gun-barrel and “showed” that hydrogen gas, inflammable air for the phlogistonists, was produced while the metal in the gun-barrel was oxidized.[42]However, Lavoisier’s experiment, suffered from a major problem, similar in kind with the theoretical monist’s “proof of the real”; Lavoisier’s proof required the assumption of a substance whose very constitution was that which he tried to prove. Similar to the monist’s proof therefore, Lavoisier’s experiment employed circular reasoning, and for that very reason the issue was not settled.

Lavoisier’s hypothesis of the compound nature of water was put to the test by William Nicholson (1753-1815) and Anthony Carlisle (1769-1840).[43] They employed Volta’s device with the intended goal of decomposing water into hydrogen and oxygen gases. This process hitherto became known to the world to as electrolysis, and gave birth to a new and exciting scientific field. Returning to our story, the findings of the experiment conducted by Nicholson and Carlisle, did not settle the truth of the Lavoisierian hypothesis. In fact, the results of the experiment produced a major problem for his hypothesis. If, based on electro-chemical theories, the action of electricity is to decompose each molecule of water into one particle of oxygen and one of hydrogen[44], why were the two gases released from different places at visible distance from each other, instead of being released from the same place as one would expect given the theoretical framework of the time? And why was oxygen released from the wire which was connected to the positive pole of the battery, while hydrogen from the negative one?[45]This gave rise to what Chang denotes as the “distance problem”.[46]

The “distance problem” became a “universal sensation”. Most scientists invested in the field tried to replicate the results of Nicholson and Carlisle, which they did, and tried to find a solution out of the problem. A solution to the problem was not found for more than fourteen years, and the nature and composition of water still remained elusive. George Singer (1768-1817), the tutor of Michael Faraday, observed:

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[42] Ibid. 74.
[43] Ibid. 73.
[44] Please note that the truth of the statement “Water is H_2O” has not yet been established, and water was considered to be HO. An extensive treatment on this will be provided on **2.3.**
[45] Ibid. 74.
[46] Ibid. 75.

> “The most difficult feature of all the voltaic decompositions, is the invisible form, in which the separated elements of various compounds appear to traverse the fluid, and arrange themselves at the opposite wires….without any apparent alteration of the interposed fluid. On the hypothesis of electric energy, the hydrogen is said to be attracted by the negative wire, because it is naturally positive; and the oxygen by the positive wire, because it is naturally negative; this does not explain how the same particle of water can have its elements liberated at so great distance from each other….”[47]

The “distance problem” started to threaten the entirety of Lavoisier’s chemical system, and electrolysis, which was supposed to confirm it, started to become its most cunning adversary. It was on the basis of the “distance problem” produced by the electrolysis of water that Johann Wilhelm Ritter (1776-1810) challenged the Lavoisierians’ views on the decomposition of water when electricity ran through it. According to Ritter, whose own metaphysical and ontological commitments informed his world-view, when electricity ran through water there was no decomposition occurring. Rather, it was *synthesis* taking place. At the positive pole of the battery, positive electricity was combined with water to create oxygen and similarly, at the negative pole, negative electricity was combined with water and created hydrogen. That the two gases were released into different places under Ritter’s account, was only logical, since the two places were the locations for the different types of electricity. Water, under Ritter’s account, is seen once again as an *element*, while hydrogen and oxygen this time, are seen as *compounds,* and electrolysis instead of decomposing water, is seen as *synthesis*![48]

The *synthesis view* of electrolysis had a very appealing part to it; that of being aligned with the ontological conceptions of the time, a fact which made it somewhat intuitive to grasp. At the time of Ritter’s writings, electricity was considered to be matter, and the outcomes of its contact with water were considered to be *electrical compounds*. Another appealing aspect which the *synthesis view* had in its favor was that it also aligned with the CP hypothesis pertaining to the constitution of water.[49]As was natural therefore, the synthesists and the phlogistonists marched closely together in their attempts to overthrow the Lavoiserian “orthodoxy” of the time,

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[47] Singer, *Elements of Electricity and Electro-Chemistry*, pp. 378-379.
[48] Chang, *Is Water H20?*, p. 79.
[49] Ibid. pp.79-80.

by highlighting the problems it faced, and by presenting their own respective accounts as potential candidates for the "True" or "Real" interpretation in regards to the constitution of water.

So far we've seen three interpretations or world-views pertaining to the constitution of water:

1. The account of Lavoisier, accepted at the time, : hydrogen and oxygen combine to produce water, H-O, which is a compound.

2. The CP hypothesis: Phlogisticated water and dephlogisticated water combine and cancel each other out to produce pure water, which is an element.

3. The *synthesis view:* Negatively electrified water and positively electrified water are combined and produce water, which is again an element.

In the face of the "distance problem", the "dying" CP hypothesis, and the *synthesis view* started to gather some support from the scientific community. Being unsatisfied with this fact, as the Lavoisierians acknowledged the implications of the "distance problem" but could not accept either the CP hypothesis or Ritter's views, which they did not consider as proper science, many prominent supporters of Lavoisier started to develop solutions to the "distance problem". The competition between these three alternatives soon gave birth to three hypotheses which were offered to those who accepted the "water as a compound" hypothesis. The first one, developed by Georges Cuvier (1769-1832) but originated by the mathematician Gaspard Monge (1746-1818) was the *imbalance hypothesis.* According to Monge, electrolysis resulted in an imbalance of substances around each electrode; electrolysis is taken to abstract in each of the waters one of its constituent parts, leaving it in excess of the other constituent part.[50]The *imbalance hypothesis* faced the problem that the said imbalance was not observable, and it was difficult to show how such an imbalance of hydrogen or oxygen in water would have no visible effects.[51]

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[50] Wilkinson, *Elements of galvanism, in theory and practice, with a comprehensive view of its history, from the first experiments of Galvani to the present time, etc., p.150.*
[51] Chang, *Is Water* H_2O*?*, p. 83.

Another solution to the "distance problem" was offered by Cuvier, and this time he was the originator of this hypothesis; this is the *invisible transport hypothesis*. According to this hypothesis, the electricity running through the water gets hold of one part of a water molecule, which enables the other part to be released then and there. Then, the electricity alongside the captured molecule, runs to the other electrode and releases the captured molecule there. After electricity has transported the water molecule to the electrode, it returns to the battery where it completes the electric circuit.[52]While this hypothesis had a significantly higher degree of plausibility attributed to it, it still faced some problems. The main difficulty with the *invisible transport hypothesis* was that different bodies of water could be exposed to electrolysis, bodies which were connected with sulphuric acid, or even a human part. The difficulty lies in the fact that at the time many chemists would have been uncomfortable with the notion that hydrogen or oxygen could pass through sulphuric acid without being affected in some way, and the contemplation of the possibility that hydrogen or oxygen could pass through the human body seemed outlandish.[53]

The final hypothesis which was formulated in order to account for the "distance problem" was the *molecular chains* hypothesis. This hypothesis was conceptualized by the Latvian chemist Freiherr Christian Johann Dietrich Theodor von Grotthuss (1785-1822). According to the *molecular chains* hypothesis, there exists an invisible chain of molecules within the body of water connecting the two poles. Each water molecule is polarized, with hydrogen being positive and oxygen being negative. In Grotthuss conception, the "voltaic pile" functioned similar to a magnet, thus, when the battery was switched on, the decomposition would be initiated; the negative electrode would get hold of the hydrogen particle right next to it, it would neutralize it and then release it. The oxygen particle, without its counterpart hydrogen in that water particle, would get hold of the next available hydrogen particle close to it, which would lead to the formation of a new water molecule. The electrical repulsion and/or attraction of the electrodes would guarantee that the initial configuration of the molecules be restored, and it would go on, as long as the battery would be on.[54]The *molecular chains* hypothesis was the one which enjoyed a high degree of acceptance from the Lavoisierian camp, albeit with some problems of its own. Consensus had not been achieved.

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[52] Ibid.
[53] Ibid.
[54] Ibid. pp. 84-85.

The invention of the Voltaic pile which was employed with the aim of providing "hard-proof" in favor of the somewhat "canonical interpretation" (Lavoisier's view) pertaining to the constitution of water, turned out to be a *pharmakon*[55] for all scientific parties involved. For the Lavoisierians it turned out to be "poison", since it presented to them the *distance problem*, a problem which continued to puzzle them for more than 20 years and although some possible solutions had been offered, none enjoyed widespread acceptability. The *distance problem* in turn was a "remedy" for the phlogistonists who alongside the recently formulated *synthesis view* camp, started to enjoy some degree of acknowledgment from the scientific community, as their views seemed to be intuitive and in accordance with some of the most fundamental ontological commitments of the time, but most importantly could account for the *distance problem.* At the dawn of the 19th century, we see three different interpretations, world-views, ways of reducing Being, each with its own distinct metaphysical and methodological commitments, trying to account for the constitution of water. We have two camps, the phlogistonists and the synthesis-ists, whose image of the world is that water is an element, and the Lavoisierians whose image of the world is that water is a compound. In this plurality of world-views and projected images of nature, consensus has not yet been achieved even in the face of the dogmatism exhibited by the Lavoisierians.[56]

2.3. Water as HO

For the better part of the 19th century, many questions pertaining to the nature and constitution of water remained open. Amidst the debate on whether or not water is an element or a compound, another question emerged: What's the atomic constitution of water? While the people of today have a *ready-at-hand* answer to this question this was not the case for the

[55] We employ the ancient greek term Pharmakon with Derrida's intended usage, pharmakon as remedy, but also pharmakon as poison. For his excellent discussion please see his "Plato's Pharmacy" in his *Dissemination*.

[56] Chang, *Is Water H_2O?*, p. 86. Author's note: Although Chang refers to the Lavoisierians as dogmatists throughout his book, I've tried to limit the employment of the word as much as possible and intend to use it only when necessary for my arguments. The issue on whether or not the Lavoisierians were in fact dogmatic in their adherence to Lavoisier's views although important, is not paramount in our inquiry. However, it's interesting to note that the plurality of world-views in this time flourished partly because of the fact that Lavoisier's theory didn't "prove its melt" at least by today's standards. Had there been a way to shield it from the *distance problem*, would this plurality of world-views have occurred?

scientists of the 19th century. Testament to this is Chang's account of an author who identified himself as a certified lunatic residing at the Hansell Asylum in London who sent two satirical letters to *Chemical News* around the 1860s, ridiculing the chemist's inability to reach a consensus pertaining to a matter so simple, as the nature of water. What is more, the self-proclaimed lunatic author, ridiculed the chemists on their inability to have an agreed method, or system of notations, upon which to disagree or agree upon.[57]In this section we will inquire into the ways in which scientists reached the consensus that the atomic constitution of water is H_2O and the methods which they employed to make this conclusion manifest.

As we've already discussed, the leading interpretation or world-view at the dawn of the 19th century was that water was a compound. Despite the difficulties raised by the *distance problem*, and the fact that phlogiston-based accounts alongside Ritter's views had some supporters, the Lavoisierian account was the "canonical interpretation" on the issue. It was not long after the electrolysis of water became a common scientific practice, that a new interpretative framework emerged, a new world-view, that being the chemical atomic theory. The "architect" behind this theory is none other than the English John Dalton (1766-1844). Dalton's atomic theory blended the ancient Greek atomic theory with the eighteenth-century chemistry of compositions. Essentially, Dalton realized that some significant regularities in the proportions by which various chemical substances combined with each other could be elucidated if one assumed that chemical combination was the "lumping together" of atoms of specific weights.[58] An example of his thought would be the distinction and consequent notation of the five oxygen-nitrogen compounds known to him, as NO, N_2O, NO_2, NO_3 and NO_2O_3 . It's interesting to note that the details of Dalton's atomic theory were not widely accepted by the chemists of the time, but his conceptualization of chemical reactions in terms of "lumping together" of different atomic units of elementary substances, became common practice.[59]

Dalton's conception of the atom was not, like our modern day conception of it is. In our view, his image of the atom was partly informed by his metaphysical and ontological commitments, in this case, by his belief in the existence of caloric, like for Lavoisier. Dalton believed that atoms were spherical bodies and their structure consisted of a small hard core

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[57] Chang, *Is Water H_2O?*, p. 134.
[58] Ibid. p. 135.
[59] Ibid.

enclosed by an "atmosphere" of caloric. The core determined the atomic weight, while the caloric "atmosphere" determined its size.[60]The fact that most chemists abandoned his idea pertaining to the size of the atom, and focused on atomic weights instead, serves as testament to our claim that Dalton's image of the atom, his world-view, was partly informed by his metaphysical and ontological commitments, or a soft-confirmation of our hypothesis at the very least. We make this observation because we want to highlight the fact that so far all the leading scientists of the 18th and 19th centuries we have been discussing, have constructed their hypothesis in accordance with their ontological commitments, or in accordance with their view of the way the world is. Their projected images of nature, and the way they have chosen to embrace Being, affords us with the opportunity to see different worlds, or different versions of a world, which incorporate different entities. And so far we've seen that these differently populated worlds, are as "real" or as "true" as any other world, and it all boils down to which one of these worlds scientists chose to embrace. We just wanted to briefly mention this here in passing, as an extensive discussion will follow on section **3.**

Let's return to our story. Dalton, aside from being considered as "the father of chemical atomism", was also the one who popularized the already existing notion that water is HO. However, given what we have discussed so far, a question emerges: how did Dalton arrive to this conclusion, given that he had some strange ideas about the shapes, size, and structure of the atom, ideas which as we observed were not accepted by the chemists of his time? Dalton is a prime example of a well-informed scientist when it comes to the limitations of his theory, or his world-view. Dalton knew that trying to prove that water is HO by means of experimentation, would be a "fool's errand" since atoms were unobservable. So, he arrived at his conclusion by employing one of the epistemic virtues we noted in our introduction, the virtue of simplicity. Given that Dalton only knew of one compound of hydrogen and oxygen, couldn't it be the case that the answer to the question: What is the atomic constitution of water?, would be as simple and straightforward as a one-to one combination of hydrogen and oxygen atoms? And that's in fact the route he followed.[61]Of course, this is not the whole story, and it would be unjust to state that Dalton simply elected to believe that water is HO because of simplicity. According to Alan Rocke[62], Dalton had serious physical reasons for employing simplicity in his reasoning; Dalton

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[60] Ibid.
[61] Ibid. 138.
[62] Rocke, *Chemical atomism in the nineteenth century: From Dalton to Cannizzaro*, p. 36.

thought that atoms of the same element would repel each other because they were not attracted to each other by chemical affinity, which would counterbalance the repulsion of the caloric contained in each of them. Thus, if a molecule contained a larger number of similar atoms it would be less stable. Water appears to be stable, therefore, water is HO.[63]

Dalton's reasoning for determining that water is HO is truly fascinating. What's fascinating about this story is the following observation: Today we know that the "Real" constitution of water is H_2O. But how do we know this? *Textbook science*[64] informs us, that the atomic weights of hydrogen and oxygen are 1 and 16 respectively, hydrogen being the unit. When scientists break down water in the lab, they get 1g of hydrogen for 8g of oxygen. This means that there must be two atoms of hydrogen that combine with each atom of oxygen to create a molecule of water. What *textbook science* doesn't inform us however, is how we came to know that the atomic weights of hydrogen and oxygen are 1 : 16? Someone who wanted to answer this question would argue that we know the molecular formula of water to be H_2O, so if the gross combination of weights of hydrogen and oxygen are 1 : 8, then the ratio of their atomic weights is 1 : 16. To an agile philosophically inclined mind, the problem with this line of reasoning is obvious. It employs circular reasoning. It employs circular reasoning because the answer to the question "how do we know that the atomic weights of hydrogen and oxygen are 1 : 16?" is answered by the assumption that water is H_2O. However this is precisely the question which we wanted to answer in the first place: How do we know that water is H_2O?[65]Keep in mind that at the time there were no independent reasons for supposing this, so in order to avoid this kind of circularity, Dalton employed simplicity.

We've seen why Dalton indeed chose to consider simplicity in his line of reasoning. It afforded him with a way to break the kind of circularity he would have faced, as illustrated in the afore-mentioned example. In addition, if molecular formulas could be determined based on considerations of simplicity, then this meant that atomic weights could be determined on the basis of molecular formulas. So, Dalton tried to establish his "New System" of chemistry based on his rules of simplicity, rules which were meant to pave the way in determining the relative weight of atoms and their molecular formulas.[66]

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[63] Chang, *Is Water H_2O?*, p. 138.
[64] I employ the term *Textbook Science* as intended by Kuhn in his *The Structure of Scientific Revolutions*.
[65] Chang, *Is Water H_2O?*, p. 138-139.
[66] Ibid. p. 139.

2.4. Water as H_2O: A pluralistic story

Despite Dalton's attempts to establish his rules of simplicity as the "go-to" method for establishing molecular formulas, his rules were not espoused by the rest of the scientific community. The reasoning for this is quite simple; although Dalton went into great lengths to avoid circularity in his reasoning that water is HO, the fact that he based the entirety of his "New System" on rules of simplicity was ultimately unjustified. In addition, his "New System" was lacking the ability to determine the atomic weights and molecular formulas in more complex situations when one or more compounds with more than two elements were involved. For example, his system could not determine the molecular formula of Priestley's "heavy inflammable air", which is carbonic monoxide using today's nomenclature, or "carbonic oxide" according to Dalton's nomenclature[67]. In our case at hand, analysis conducted in 1831, revealed that "carbonic oxide" was constituted by 0.75 parts of carbon and 1 part of oxygen. While we today know that carbonic monoxide, CO, has atomic weight-ratio of 3 : 4 between its constituents, if we follow Dalton's rules of simplicity, this can easily be represented in another way. The combining weight-ratios for carbonic monoxide can be represented as 6 : 8, which would suggest that the proper notation for carbonic monoxide would be C_2O.[68]

In order for the scientists to be able to reach the conclusion, and the consensus, that water is H_2O, they first had to agree on entire sets of atomic weights and molecular formulas. But in order to do that, having discarded Dalton's simplicity rules, they first had to establish a commonly accepted method of acquiring that information, or certain criteria which would enable them to proceed with their inquiries. This led to the preservation of the atomic weight assessment of O=16 in all oxygen participating reactions. Similarly, every other decision which the scientists made, had its own implications when it came to other reactions and compounds. The desideratum of the scientists was simple: Every decision and agreement made on the set of atomic weights and molecular formulas had to be consistent with one another. Dalton embraced simplicity, the rest of the scientific community embraced consistency. And although consistency might appear to be a daunting desideratum, it was much easier to be attained than the attainment of an agreed upon method with which consistency could be achieved. In fact, a

[67] Ibid. p. 140.
[68] Ibid.

plethora of different and competing sets of atomic weights emerged, and infinitely many interpretative frameworks, world-views, which could account and were consistent with a vast number of known observations, flourished.[69]The history of how water came to be known as H2O is the history of a plurality of worlds, a plurality of systems, a plurality of ways of reducing Being in the world. On this issue pertaining to the developments within the field of atomic chemistry we will return on section **4** as it demands an extensive treatment.

Chemists did not reach a consensus pertaining to the “best method” upon which they could account for chemical weights and molecular formulas until the 1850s. The story on how this consensus was achieved starts in 1809 when the French Joseph-Louis Gay-Lussac (1778-1850) published a crucial, for our discussion, paper in response to Dalton’s “New System”.[70]Gay-Lussac is an important figure in our story for the fact that with his publication, he offered an alternative way of accounting for molecular formulas: Instead of focusing on weights, Gay-Lussac focused on the volume of gases. Through this work he observed that when gases reacted chemically with each other, they did so in very simple volume ratios.[71] For example, when 2 volumes of carbonic oxide combined with 1 volume of oxygen they produced 2 volumes of carbonic acid; similarly, the combination of 1 volume of nitrogen with 3 volumes of hydrogen, produced 2 volumes of ammonia. Gay-Lussac’s observation has tremendous significance for our story on the discovery of water since it gave birth to the idea that equal volumes of gases contain equal number of particles, an idea which Rocke playfully denotes as EVEN (equal volumes - equal numbers).[72]

Although Gay-Lussac is responsible for the EVEN conception, his metaphysical commitments, or his mentor’s, did not allow him to embrace this idea. The EVEN conception was at odds with that of his mentor’s, namely Claude-Louis Berthollet, who had doubts accepting the law of fixed proportions in chemical combinations as a universal truth, and as such, Gay-Lussac shied away from endorsing the EVEN conception.[73] While Gay-Lussac did not embrace EVEN, the italian Lorenzo Romano Amedeo Carlo Avogadro (1776-1856) did. In his published paper of 1811, Avogadro worked out the consequences of EVEN for the atomic

[69] Ibid. p. 141.
[70] Ibid. p. 142.
[71] Ibid.
[72] Ibid.
[73] Ibid. pp. 142-143.

theory. He argued that the molecular formula of a compound should be determined from the combining volumes and not from "unjustifiable" suppositions, like Dalton's. What is more, based on EVEN, Avogadro came to the conclusion that the atomic constitution of water was in fact H_2O! A problem emerged however. While EVEN did give Avogadro the formula H_2O for water, it also demanded two volumes of it. In order to reply to this problem and uphold EVEN, Avogadro's idea was to split the water molecule in two volumes. This way of accounting for the problem however, gave rise to another problem, which was that it required the splitting of an oxygen atom in half, which was impossible. So, Avogadro found another way to uphold EVEN and account for the atomic constitution of water: He supposed that the oxygen particle must have been a double-atom molecule, and the same was assumed for hydrogen. In this way, he could uphold EVEN, by maintaining the correct ratio between the numbers of oxygen and hydrogen atoms. Under this latter conceptualization, the correct notation for water would be $2H_2+O_2=2H_2O$.[74]

Despite the fact that we, today, could agree on the fact that Avogadro's H_2O formula for the constitution of water is the correct one, such an agreement wasn't reached at the time of his publication. As was noted earlier, the debates surrounding the correct way, and by that we mean an unequivocally acceptable way, to account for atomic weights and molecular formulas, raged well into the 1850s. It is not the case that Avogadro's ideas went unnoticed by the scientific community of the time. On the contrary, they were noticed and discussed, but ultimately rejected by most for good reasons. The problem with Avogadro's ideas was that they were very hypothetical, dwelling deep into unobservable territory, and on the face of it, *ad hoc*: his hypothesis couldn't be accounted for based on experimental work.[75] In addition, while Dalton's "New System" might have been rejected by most, his ideas and scientific stature were still very influential and had specific arguments against Avogadro, and most specifically on the latter's endorsement of EVEN. According to Dalton, the observed volume-relationships were only approximate and did not reflect anything fundamental about chemical combinations.[76]In addition, Dalton also had serious physical arguments against Avogadro, partly informed by his own "simplicity rules" and his metaphysical commitment to caloric. More specifically, Dalton's view, as we discussed earlier, was that all atoms were full of self-repellent caloric fluid, and

[74] Ibid. p. 144.
[75] Ibid. p. 145
[76] Ibid. p. 143.

chemical combination could only occur between different types of atoms which exerted an attractive force of chemical affinity on each other strong enough to overcome the self-repulsion of the caloric fluid.[77]Under this conception, the problem with Avogadro's hypothesis was that he could not account for why two atoms of the same kind could stick together, and even if they did, why their "lumping together" would stop at two atoms.[78]

Avogadro's ideas finally became accepted in the year 1860 at the Karlsruhe Congress. The person who has been credited for making this possible, was the Italian chemist Stanislao Cannizzaro (1826-1910). While there have been a plethora of historical interpretations on how this consensus was achieved, we will examine two; the "traditional" interpretation according to which Cannizzaro's "passion" opened the eyes of the scientists to Avogadro's brilliance, but also, Chang's revisionist account on how this consensus was achieved.[79] The latter is of tremendous philosophical interest for our purposes, as it highlights the methodological pluralism operating at the time of the discovery of water, and showcases that this discovery was a product born out of a plurality of systems of practice and world-views. Under this interpretation the acceptance of Avogadro's ideas was not because of Cannizzaro's passionate presentation of them, although he surely re-worked and publicized his views. Rather, what led to the acceptance of Avogadro's method of accounting for molecular formulas was the fertility of the ground, paved by a plurality of world-views and interpretations to be found in the field of atomic chemistry. Chang follows Rocke in believing that the "crucial battles" had already been fought and won way before the Karlsruhe Congress and that what Cannizzaro did was to advance a new way of looking at things, along with various other considerations, which however were already circulating. We will offer a retelling of the story according to the "traditional interpretation" in this section so to conclude our historical inquiry into the history of the discovery of water and we will focus on Chang's interpretation in the fourth section, as his account has tremendous philosophical implications for our discussion of pluralism, reality, and truth.

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[77] Ibid. p. 145.
[78] Ibid.
[79] Chang is calling the traditional interpretation as a "myth", an over-exaggerated account. (See. p. 146). In addition, Chang's revisionist account is not the only account of this sort, indeed, for more see Rocke, Alan J. *Chemical Atomism in the Nineteenth Century: From Dalton to Cannizzaro* (1984) Columbus: Ohio State University Press, Rocke, Alan J. *The quiet revolution of the 1850s: Social and empirical sources of scientific theory*. In The chemical sciences in the modern world , ed. Seymour H. Mauskopf, 87–118.(1992), Philadelphia: University of Pennsylvania Press.

According to the “traditional interpretation”, the Karlsruhe Congress of 1860 was held with the explicit aim of bringing uniformity to chemical notation and atomic weights. In that congress, Cannizzaro, who had been working on Avogadro’s ideas throughout the 1850’s and had managed to synthesize elements from all the different fields of chemical research operating at the time with Avogadro’s as the bedrock, took the opportunity to present his system. Although Cannizzaro’s ideas at the time of his presentation did not impress anyone, he distributed a pamphlet to the participants of the congress which eventually had the effect of persuading everyone involved. As Julius Lothar Meyer (1830-1895), a participant at the congress, stated upon reading Cannizzaro’s pamphlet on the train back from Karlsruhe, “scales fell from his eyes” and everything suddenly made sense.[80]And so, consensus was achieved and the statement: *Water is* H_2O became a true statement for evermore.

3. Ontological Pluralism and Feyerabend’s metaphysics of abundance

Before we proceed any further with the historical inquiry of the discovery of Water as H_2O and its meaning for our thesis; an exposition of the sort of the ontological pluralism we advocate is due; a pluralism informed by Feyerabend’s “metaphysics of abundance”. Feyerabend was critical of the scientific monists metaphysical views on science; specifically he has had specific arguments against the success of science and the role of the scientific monist attitude in grounding that success. While his arguments merit further exploration; we are interested in presenting his *positive arguments*, or his *alternative* to scientific monism; as this is our endeavour as well.

According to Brown, Feyerabend’s metaphysics of science are complex and somewhat obscure, but with a careful examination, one can grasp exactly what his “metaphysics of abundance” position entails. There are five central metaphysical arguments, five theses, that Feyerabend offers in relation to issues pertaining to reality: *i) the abundance thesis, ii) the ineffability thesis, iii) the Aeropagite thesis, iv) Aristotle’s Principle* and *v) No appearance/reality dichotomy* all of which are crucial in understanding his metaphysical positions and the kind of ontological pluralism we attempt to offer.

[80] Hartley, *Studies in the history of chemistry*, p. 185.

3.1.1. The Abundance Thesis:

In his "Conquest of Abundance", Feyerabend argues that the world exhibits abundance and complexity and that "The world is a complex and many-sided thing".[81] According to Feyerabend,

> "the world we inhabit is abundant beyond our wildest imagination. There are trees, dreams, sunrises; there are thunderstorms, shadows, rivers; there are wars, flea bites, love affairs; there are the lives of people, Gods, entire galaxies."[82]

This abundant world which Feyerabend presents is "limited" by human activity; in our attempts to organize, classify and categorize this abundance; we try to simplify the world.The first step of this limiting begins at the perceptual level; when our perceptual and cognitive mechanisms filter much of this abundance. The invention and development of the grand dichotomy between *appearance* and *reality* is the main product of this human effort of simplification; "the process of simplifying the world", a process which has defined much of modern philosophy and science.[83]

Feyerabend's *Abundance Thesis* states that: the world is abundant, complex, made up of many types of things and events, including those that are hazardous, unstable, and precarious.[84]

The *Abundance Thesis* implies that the process of simplification we described earlier, and the invention of the dichotomy between *appearance* and *reality*, cannot possibly encapsulate or describe the abundance and complexity of the world, or Being.[85]

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[81] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 145.
[82] Feyerabend, *Conquest of Abundance*, p. 3.
[83] Ibid. p. 5.
[84] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 145.
[85] Ibid.

3.1.2. The Ineffability Thesis

The *Ineffability Thesis* is an ambiguous metaphysical conception and needs to be understood in the context of the next thesis the *Aeropagite Thesis* in order to dispel any possible confusion and potential Kantian-readings. The two main components of this thesis is Feyerabend's claim that "Ultimate Reality, if such an entity can be postulated, is ineffable"[86] and " Being as it is, independently of any kind of approach, can never be known."[87] The *Ineffability Thesis* states that:

> "Ultimate Reality itself is ineffable and unknowable."[88]

Feyerabend's thesis is offered as a counter to the realist insistence that reality can be captured or be mirrored by theoretical posits or theories.

3.1.3. The Aeropagite Thesis

The *Aeropagite Thesis* states:

> "But we can describe and explain our interaction with certain emanations of God or, to express it in a less theoretical manner, we have access to the ways in which Ultimate Reality reacts to our approach...What we do know are the various forms of *manifest reality*, i.e., the complex ways in which Ultimate Reality acts in the domain...of human life. Many scientists identify the particular manifest reality they have developed with Ultimate Reality. This is simply a mistake."[89]

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[86] Ibid.
[87] Feyerabend, *Conquest of Abundance*, p. 205.
[88] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 146.
[89] Feyerabend, *Conquest of Abundance, p. 214.*

According to Brown, Feyerabend believes that although we cannot know Ultimate Reality, we can interact with it in certain ways, and those ways can be both coherent and successful to a certain extent. If we approach reality under a Newtonian stage-set, we get one manifest reality which vastly differs from the projected image of nature, or reality, we would get if we approached it under a Quantum Physics stage-set, Greek Mythology or Christianity. Feyerabend's point is there are many manifest realities, projected images of nature, but none can be identified with Ultimate Reality. [90]

Whereas there can be various reading on what Feyerabend means by "manifest reality", in my understanding, I take it to be that manifest realities could be a part of Ultimate reality, but only a small part of it; an identification of the manifest realities with Ultimate reality would be a compositional fallacy, as Brown notes. The choice for this reading of Feyerabend's *Aeropagite Thesis* is that it better illustrates and exemplifies the ontological pluralism he advocates and his conception of the stage which is part of the overall pluralistic conception. As such the *Aeropagite Thesis* can be better presented in this manner :

> "Ultimate Reality, though ineffable, responds to many (but not all) different approaches in a more or less successful coherent way- a fairly stable structure of responses constituting a manifest reality. It is a mistake to identify manifest and Ultimate realities."[91]

3.1.4. Aristotle's Principle a.k.a. "The Existential Criterion of Reality"

According to *Aristotle's Principle:*

> "Real is what plays a central role in the kind of life we identify with."[92]

One of the most pretty straight-forward theses, essentially, Feyerabend is stating that what is called "real" is what plays a role in the practices and forms of life we have chosen to embrace.[93]

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[90] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.146.
[91] Ibid. p. 147.
[92] Feyerabend, *Conquest of Abundance*, p. 201.
[93] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 147.

3.1.5. No Appearances/Reality Dichotomy

One of the fundamental thesis for our purposes which highlights P. K. Feyerabend's stance on the "nature" of Reality, a stance which we share, is his "*no Appearances/Reality dichotomy"* thesis. According to Feyerabend:

> "[T]here is no grand dichotomy, with a solid trustworthy, genuine reality on one side and deceiving appearances on the other...The notion of reality makes excellent sense [only] when applied with discretion in the appropriate context."[94]

One of Feyerabend's core tenets is that the distinction between appearance and reality is not an ahistorical absolute; it is not an inevitable or obvious conclusion either. This is of paramount importance in our discussion; since this is exactly the point we try to highlight in our discussion of the history of the discovery of water. Qua Feyerabend, this distinction between reality and appearances is a contingent historical invention in response to particular struggles and obstacles that has been maintained and enforced by authoritative traditions; scientific monists, with their insistence on simplifying abundance and the narrowing-down of epistemic possibilities. [95] In our own research in the history of the discovery of water; Feyerabend's *No Appearance/Reality Dichotomy thesis*, proves its mettle; the aim of examining the historicity of the discovery of water as H_2O was just this; to highlight that this discovery which today is deemed as an "objective fact" about nature, is a historical product; a combination of different viewpoints and interpretations; which led to the production of this "objective fact".

The dichotomy between appearances and reality, is not a universally valid dichotomy, at best, it could hold in local distinctions, under particular stage-sets, paradigms or interpretative frameworks; it can only make sense in a very local and specifically defined context.[96] Again, this is the point we try to stress in our research. That water is H2O holds true, is an "objective fact" of nature, only if we take this to mean that it's truth depends on the context, or framework in which this statement is situated in; in other words, under the synthesis that occured during the *Quiet Revolution*. Under a different set of atomic weights, a different system of chemical

[94] Ibid.
[95] Ibid.
[96] Ibid.

theories, the statement water is H_2O, possibly wouldn't hold true, and it would certainly not have been considered an "objective fact of nature".

According to Brown, Feyerabend's *No appearances/Reality thesis* bears a striking resemblance to a passage in Nietzsche's *Twilight of the Idols*:

> "The true world - we have abolished. What world has remained? The apparent one perhaps? But no! With the true world we have also abolished the apparent one."[97]

3.2. Feyerabend's alternative metaphysical image of the world

It seems that the themes of Feyerabend's theses appear contradictory to one another, and different metaphysical pictures emerge. The aim of this sub-section is to provide a coherent metaphysical picture of Feyerabend's metaphysics and present the alternative image which he offers instead of the scientific monist's image of reality. The reason for doing this is because our own metaphysical thesis, image of the world, is heavily inspired by and in accordance with Feyerabend's own, and an explication of the fundamental themes of his account, serves as the foundation upon which our own thesis develops.

The tensions that arise from reading the *Five These* can be classified as:

1) What. if any, access do we have to Reality? For Feyerabend describes reality as inaccessible, ineffable, unkowable, but also, as framework dependent, reactive and responsive to the different choices and perspectives employed by different people.[98]
2) What can we know about Reality? If it is ineffable then how do we know that it is abundant?[99]
3) Is it possible to reconcile claims that Reality is unknowable and ineffable with the rejection of the dichotomy between appearances and reality?[100]

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[97] Nietzsche, *Twilight of the Idols,* p. 486.
[98] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.147.
[99] Ibid.
[100] Ibid.

One key component in explicating and understanding Feyerabend's metaphysical image of the world is his concept of Being. In addition to what we already discussed in our introductory section, Feyerabend states the following about Being:

> "Being...provides some of those acting independently (not all of them) with manifest worlds they can expand, explore, and survive in (manifest worlds are in many respects like ecological niches). Inhabitants of a particular manifest world often identify it with Being. They thereby turn local problems into cosmic disasters."[101]

Being is unknowable and ineffable, too complex to be grasped in its entirety by intelectual simplifications. Being is resisting, but Being is also pliable; Being is that which reacts, that which responds, to our practices, our choices of interpretative frameworks, our stage-sets. Being is many places in Feyerabend's work is called "Nature", "the world", "ultimate reality", even "God".[102]

Being is contrasted with manifest realities or manifest worlds. Manifest worlds are partially at least knowable because they are the products of the way in which Being responds to our beliefs, practices, interpretations; manifest worlds are projected images of nature. Aristotle's principle, or the *existential criterion of reality thesis* we mentioned earlier, applies to to manifest worlds, to projected images of nature (or Being), not to Being; this is the case since, again, the manifest worlds, these projected images, are a product of our interpretative frameworks, systems of practice. [103]

On manifest worlds: It is important to keep in mind that manifest worlds are *not* ideal entities or phenomenal worlds; they are not mental or conceptual in the traditional sense. Manifest worlds are not even as tidy, neat or well behaved as our best-developed scientific theories might suggest or hold them to be: "But the manifest worlds themselves demonstrate their fragmentary character; they harbored events which should not be there and which are classified away with some embarrassment."[104]

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[101] Feyerabend, *Conquest of Abundance,* p. 204.
[102] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.147.
[103] Ibid.
[104] Ibid.

It is crucial for our purposes to understand what exactly Feyerabend means by the terms "Being" and "worlds" without reducing his metaphysical image into a neo-Kantian account,which would impede the importance and novelty of the alternative image he tries to offer:

"The idea that reality is uniform but ineffable is not the only possible way of bringing order into what we think we know. Another way which is, as far as I am concerned, is less one-sided...would be to admit that there are many different kinds of objects and features, that they are related to each other in complex ways, that some of them, such as fashions in architecture, furniture, and dress, reflect human interests while others, though manufactured with the help of complex equipment, seem to be more independent, and that this hierarchy becomes the more obscure the more we try to remove ourselves from it...An *ontological (*epistemological) *pluralism seems closer to the facts and to human nature."*[105]

The above passage is crucial in our discussion for two purposes: a) it highlights the connection, a connection which we also uphold throughout this paper, between *ontological* and *epistemological pluralism*, and also. b) it provides us with an insight into the sort of metaphysical image Feyerabend has in mind; an *ontological, epistemological pluralism,* which is his alternative to scientific monism. When it comes to the connection between *ontological* and *epistemological* pluralism, Feyerabend is a firm believer in that epistemological pluralism *is the actual state of affairs in science* and if we want science to be a successful enterprise then, it should be a permanent condition. The relationship between *ontological* and *epistemological pluralism* emerges when someone, like the author ,or perhaps even Feyerabend, takes science to be a guide to ontology; ontological pluralism would be the best assumption to support such a view.[106]

When it comes to Feyerabend's *ontological* (epistemological) pluralism, his denial of the appearance/reality dichotomy is key in understanding the kind of image he offers. The distinction between Being and manifest worlds, is *not* a variation of that dichotomy; it would be a pitfall to think of it in such a way, especially since Feyerabend explicitly is against it. Manifest worlds should be understood as ecological niches, whereas Being should be understood as

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[105] Feyerabend, *Conquest of Abundance*, p. 215, emphasis my own.
[106]Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.148.

encompassing them (the manifest worlds) rather than standing in opposition or apart from them. [107]

Regarding the question of our access to Being, Feyerabend states that humans,as parts of the primal world, Being, are subjected to its whims.[108]The primal world, Being, is the very same world we live in, we act upon, the world we experience. At the same time however, it is not the world we cognize or know. Manifest worlds are not existing on a seperate metaphysical realm, nor are they phenomenal worlds; they are integral parts of the primal world, Being or nature, for the fact that they are products of our theories, interpretative frameworks, stage-sets, beliefs, ways of living. [109]

In his discussion on the "ineffability" and "unknowability" of Being, Feyerabend is not making a neo-Kantian claim; he doesn't talk about the existence of separate realms of appearances and things-in-themselves, or that we do not have any access to Being. What Feyerabend is instead arguing about is that no practice, no interpretative framework, no single theory, takes the world as a totality. The ineffability and unknowability of Being stems from its abundance; its complex, overlapping, and malleable nature, cannot be encapsulated in any single formulation, cannot be grasped in any one single interpretative framework. [110]This is of course in accordance with the strong pluralism which Feyerabend advocates, and as Longino notes: "Those advocating strong forms of pluralism are claiming that the complexity of natural processes eludes complete representation by any single theoretical or investigative approach available to human congizers."[111]

A second sense in which Feyerabend discusses the "ineffability" of Being is related to our experiencing of the world. More precisely, there are aspects of our experience of the world that are incommensurable with what we can explicitly understand. The richness of our experience of the world outstrips our conception of it and the world very often appears to misbehave in various ways, given the ways we have conceptualized it. There are many encounters with Being that are vastly different from and incommensurable with our cognitive and linguistic skills. This is why Feyerabend believes that Being is "unknowable" but that at the

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[107] Ibid.
[108] Feyerabend, *Conquest of Abundance*, p. 204.
[109] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.148.
[110] Ibid.p. 149.
[111] Ibid.

same time, it responds differently to various approaches to it. There is a multiplicity of manifest realities; some approaches have created relatively coherent reliable worlds, while others have failed to do so. All that we can really say about Being is that we have no grounds for identifying it with x or y manifest reality, projected image of nature. [112]What we really know is the ways in which Being acts in the domain (the ontological niches) of human life.[113]

One last key component which ties Feyerabend's metaphysics together and provides us with the opportunity to understand the nature of manifest worlds and their relation to Being, is his conception of causal-semantic actions. According to him, "understanding a subject means transforming it."[114]This transformation that comes when a human agent tries to understand, is part of the nature of manifest realities, projected images. Objects, events, happenings, are all changed, all transformed, by being known for as Feyerabend states: "Even the discovery of an immanent structure changes the scene, for the events-as-they-are and the events-known-to-have-the-structure do not affect people in the same way."[115] This is both fundamental, but also exemplified by, our discussion in the history of discovery of water. Advances in electro-chemical theories, Avocadro's EVEN conception, the debate between the phlogistonists and oxygenists, *transformed the nature, and composition, of water.* Water underwent a change from being thought of as substance, to a compound, from being HO to being H_2O. Every piece of knowledge added, every new interpretative framework, transformed water for evermore; it gained a new status, a new chemical constitution; its value and meaning changed.

The transformation of water, or the transformation of any subject matter that comes along with understanding, is a result of what Feyerabend calls the *active character of inquiry*. Throughout our inquiry we saw, and we will witness further in the upcoming sections, the unique ability of scientists to create or reshape realities; this is exactly what Feyerabend has in mind by the *active character of inquiry* and with his account of causal-semantic actions. Scientists are able to create or reshape realities because they a) "act causally upon the world...and they have to if they want to 'discover' new entities" and b) "create semantic conditions engendering strong

[112] Ibid. p.150.
[113] Feyerabend, *Conquest of Abundance*, p. 214.
[114] Feyerabend, *Conquest of Abundance*, p. 12.
[115] Ibid.

inferences from known effects to novel predictions and, conversely, from the projections to testable effects”.[116]

Science involves the causal manipulation of the world in order to create or stabilize structures upon which we can rely in our attempt to understand and act. This is a very fundamental cognitive ability, due to the fact that world is so abundant with many complex and malleable structures and in order to be able to grasp this abundance (in some extent),in order to be able to predict and explain events and happenings, we materially transform our environment in order to simplify it.[117]

In addition, science also has the ability, to create semantic conditions under which structures such as those mentioned above become manifest. Feyerabend’s image is strongly influenced by Bohr at this point. Qua Bohr, a measurement apparatus creates the semantic conditions that make possible the assignment of physical properties. Without some spatial frame of reference, the semantic conditions for speaking about the position of an object, simply put, does not exist; there can be no such claim as: “Particle p is at coordinates {x,y,z}”, without having agreed upon, or invented, a frame of reference. In a similar vein, without the invention of an apparatus that is able to react in a measurable way to impacts from particles, the semantic conditions for momentum do not exist. Bohr believed that the most fundamental discovery of quantum physics was that *not all measuring apparatuses are compatible*; *it is not the case that the semantic conditions for all structures can exist simultaneously.* Precisely because the semantic conditions for position and momentum cannot exist simultaneously, particles cannot have determinate precise positions and momenta simultaneously, hence the “uncertainty” or “indeterminacy” between them. Bohr applied this approach, “complementarity”, to most fields of scientific inquiry, like biology and psychology, but also, to culture and morality, not unlike Feyerabend. Feyerabend takes Bohr’s “complementarity account” and applies it to both metaphysics and epistemology. The multiple, incompatible, complementary sets of semantic conditions is “transformed” into Feyerabend’s own “manifest worlds”.[118]

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[116] Ibid. p. 144.
[117] Brown, “The abundant world: Paul Feyerabend’s metaphysics of science”, p.149.
[118] Ibid.

Fundamentally; there is no dichotomy between the process a) of creating or reshaping the world and b) the creation of semantic conditions because “the dichotomy between [semantic] descriptions and [causal] constructions are much too naive to guide our ideas about the nature and the implications of knowledge claims.”[119]What is happening instead, is that scientists, or human agents generally speaking, take causal-semantic action of the world; in this sense, scientists are “sculptors” of the world, or to use the Goodmanian terminology, world-makers.[120]Feyerabend is quick to qualify this assertion, in accordance with the *Areopagite Thesis*, : “I do not assert that any combined causal-semantic action will lead to a well-articulated and livable world. The material humans...face must be approached in the right way. It offers resistance; some constructions...simply collapse. On the other hand, this material is more pliable than is commonly assumed.”[121]In other words, the pliability of Nature, is always limited by the resistance.[122]

The world is abundant with all kinds of objects, events, relations and structures. This world has many unstable, hazardous, incomplete and ambiguous elements; it is also rich in structures, clarity and a relative constancy. The order and the disorder of the world are intimately connected. The experience and activity of human beings brings them in touch with this abundance, albeit in limited ways. Nature, Being, is always resistant but also receptive to, our conceptualizations. There is no way to distinguish between our experiences those that reflect “Reality” and those that are deceiving appearances, because all of our experiences encapsulate some aspect or other of Being. But only an aspect. It is a mistake to equate an aspect with the totality, as the scientific monists do. Manifest worlds, projected images of nature, are not only a product of scientific inquiry, nor do they only contain its products, they also contain a plethora of other elements that we value in our practices, in our chosen interpretative frameworks, in the way we have chosen to live. Manifest worlds are a kind of “ontological niches” which is partially made and remade by us, just as organisms partially make and remake their ecological niches.[123]

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[119] Feyerabend, *Conquest of Abundance*, p. 144.
[120] Brown, “The abundant world: Paul Feyerabend’s metaphysics of science”, p.149.
[121] Feyerabend, *Conquest of Abundance*, p. 145.
[122] Brown, “The abundant world: Paul Feyerabend’s metaphysics of science”, p.149.
[123] Ibid. p.150.

3.3. The world as interpretation

> I still don't remember how this happened
> I still don't get the wherefores and the whys
> I look for sense but I get next to nothing
> Hey boy welcome to reality[124]

The re-statement and explication of several fundamental themes in Feyerabend's pluralistic image of the world allows us to return to our own thesis and explicate our contention that: *the way the world is, is the way we choose to live in it. A plurality of alternatives presents us with different ways of how to live in the world and therefore it presents us with different ways the world is; the world is our interpretation of it*. As we mentioned in our introductory section this contention is not only of the normative kind, it also has a metaphysical component; we are proposing an *ontological (epistemological) pluralism* in the sense which we identified and defined in the previous section and akin to Feyerabend's own. We are arguing that there is no *one way the world is, rather there are plenty of ways the world is, all of which can be equally real, or true, but also false, depending on the interpretative framework we have chosen to embrace.* In this assertion of ours, we are essentially echoing Feyerabend's *ontological pluralism;* we are sharing his belief that Being, cannot be encapsulated by any single, one, interpretative framework. As such, what we can *really say* about the world is that a theory, an interpretative framework, a stage-set, can only grasp one of the many aspects of Being.

With the "staged dichotomy of the real" we tried to establish and showcase the absence of immediacy between a human agent and nature, with Feyerabend's *ontological pluralism* which highlights the abundance of Being, we tried to emphasize the ways in which a holistic "Real" image of the world, or a holistic notion of "Reality" is unattainable. The scientific monists notion of "an all encompassing Reality" crumbles, for the reason that we are working with stage or framework- dependent "realities", or manifest worlds. As we've already mentioned, but will highlight further in our inquiry in the "evolution of electro-chemistry" these stages or frameworks, consist of a plethora of various metaphysical and methodological considerations, each of which projects a "real" image of nature attuned with its settings, i.e. its metaphysics and epistemology;

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[124] These are lyrics to the song "Reality" by David Bowie, in his album *Reality* (2003).

and while each such image is capable of grasping an aspect of Being, or an aspect of Reality if you will, it never encompasses its totality; this is in accordance with the *no appearances/reality dichotomy thesis*.

This doesn't mean that all our interpretations of the world will be correct, or will be true, there can be images of nature which fail to meet the criteria of "reality" or "truth" that were set up by its settings, and hence will fail to qualify for being "true" or "real", or they will be resisted by nature to such an extent that pursuing them further will be self-defeating. This is something with which once again we are in agreement with Feyerabend and his *Areopagite Thesis.* What we claim is that in those cases in which the produced images of nature satisfy their intra-systemic criteria, satisfy the demands set by their settings, or are able to provide only partially resistant accounts on Being, then all these images, or these projected "realities" are equally "real" or "true".

The history of the discovery of water we have followed so far, and the history of electro-chemistry to which we will turn our attention in the next section, has afforded us with the opportunity to see that through the interaction of many realities, of many ways the world is, of competition and development, of many ways in which scientists tried to understand, led to a transformation; the transformation of the concept water, water as a substance, water as a compound, water as H_2O. This transformation we argue, and we will return to this point in the following sections, was a product of the ability human agents have to take causal-semantic action on the world. Water as H_2O is a product of the human ability to shape reality, to causally manipulate the world and create structures, atomic theories and sets in our case, upon which they can rely to understand their world, but also provide the semantic conditions upon which these structures can become manifest, the various aparati that chemists employed in order to create such structures, i.e. the findings of the experiments conducted using the voltaic pile, Lavoisier's own experiments, or as we will see in the following section Dumas' "detective work".

The world is our interpretation of it, precisely for the reason that the world doesn't have any all-embracing "Truths" or "Realities" in it. Nature is approached in many different ways, and the many ways we approach nature, and our interpretation of it, constitute its "reality". Whether the world is populated with caloric or phlogiston, with water as an element, or water as a compound, depends on the interpretative framework we have chosen to embrace, the stage we have chosen to project this or that reality, depends on the criteria we have deemed desirable, and also on the resistance by nature.

In the spirit of Feyerabend, instead of restricting ourselves in providing an argument for why the monistic image of science is fundamentally, in our opinion, flawed, we try to provide a positive alternative. Because we believe that science has, and can be, a successful human endeavor, we feel the need to rehabilitate some of its more problematic areas; such as the dichotomy between *appearances* and *reality* and the belief in all-encompassing Realities and Truths. We share Feyerabend's belief, and that's what we try to showcase throughout this paper that this *in fact* the case, that epistemological pluralism is the *actual state* of affairs in science. What we are also insisting on however is that if we are to take science as a guide to ontology, as something which we can rely upon to settle metaphysical and ontological issues, *we need to assume ontological pluralism*; as this assumption both supports better but also fits with *epistemological pluralism.* This is the reason for which we call the philosophical position we advance as ontological pluralism, or perspective realism if you wish (in the sense of realism we have been discussing). The main tenet of our thesis is that the more images of nature we have, the more realities we project, leads to many different ways of approaching the richness of Being. Many different ways of approaching the richness of Being lead to more alternatives, more interpretative frameworks, more images of nature; they lead to an expansion of knowledge and a deeper, multifaceted, understanding of nature. We believe that *ontological pluralism* can be a tool with which we can manage the abundance of Being, and make coherent but also successful manifest worlds, without reducing the richness of nature to all encompassing "Truths", "Realities" and "dichotomies" which hinder understanding. As Dewey states: "The world is a scene of risk; it is uncertain, unstable, uncannily unstable. Its dangers are irregular, inconstant." [125]What we are arguing is that this instability is a feature of the abundance, it's an inevitable feature of our relationship with Being, as such, it's in our best interest to embrace this abundance, its complexity and uncertainty in the best way we can; enter *perspective realism*, or *ontological pluralism.* The consequences of our position for science and scientific inquiry will be addressed in the concluding sections.

[125] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p.150.

4. The History of the Discovery of Water Revisited: Intermission II:

In section **2** we inquired into the "traditional" narrative on how water came to be known as H_2O. We identified at least four distinct world-views, Priestley's "water as an element world" populated with the entity he coined "phlogiston", Lavoisier's "water as a compound world" populated with the entity he coined "caloric", Ritter's "water as an element world" where electrolysis was seen as synthesis rather than decomposition of water, and Dalton's "water as compound with the atomic constitution of HO", which was populated with atoms whose structure consisted of a small hard core enclosed by caloric. As we previously mentioned, all the entities in which these scientists believed and considered to be "Real", have turned out be "unreal" by the lights of the scientific community in our era. Yet, as our narrative tries to show, the "reality of the statement water is H_2O" was born out of worlds and interpretations populated with "unreal entities". This is not to say that we are faced with a paradox here, or that this fact makes the reality of the statement "water is H_2O" "less real". Rather, our retelling of the history of water aims to bring to the attention of the reader that the "Reality" of the statement "water is H_2O", was secured only when the scientists were able to achieve consensus on the proper conceptual schemes ways and sets of experimental rules with which they could sustain the manifestation of its "Reality"; only when causal-semantic action took place.

Water was thought of to be many things and experienced a variety of transformations, one of which transformed into H_2O. But water was also Lavoisierian, it was thought of as a combination of hydrogen and oxygen atoms which combine to produce the compound H-O; water was also an element according to the CP hypothesis, a combination of phlogisticated and dephlogisticated water which combined and canceled each other out to produce pure water; water was also an element under the synthesis view, a product of the combination of negatively and positively electrified water. That we have found an acceptable, agreed upon, way with which we labeled the statement "Water is H_2O" as a "True" and "Real" fact about nature, that does not mean that this is all there is to the story.

According to our view, the reality of the statement "Water is H_2O" is not an "objectively Real fact" of the world, in the sense we have been discussing about. That does not mean it's not a *real fact about* the world. As we've tried to show with our narrative, the world doesn't have "all encompassing Real facts". Rather, the world is populated with human beings who try to account for physical phenomena in a variety of ways they have chosen to approach nature, with a variety of different theoretical, conceptual and methodological frameworks, and they try to make “nature fit” their images of it. The reality of our entities, and the truth-status of our statements, is entirely depending on the ways we interpret nature. Recall that this was precisely our problem with theoretical monism. Issues pertaining to the “Reality of something” cannot be settled unless this “Reality” is assumed in the first place. This doesn’t mean that “talk of reality” is moot, on the contrary, what it means is that talk of reality should be restricted to framework-dependent realities; realities as grasping aspects of Being, realities as being able to to be both receptive, but also, resistant to Being. This is one of the consequences of our perspective realist position, but we believe a positive one, the rehabilitation of the concept of “Reality”, from an all encompassing strict and troublesome Reality, with the more appropriate, humble, malleable, reality; a consequence stemming from the *no appearances/reality dichotomy thesis,* from the “staged dichotomy of the real” thesis, from the *causal-semantic action thesis* and from the “*ineffability of Being thesis”*.

The reality then, about the status of water was a product of the clash of different world-views, each having its own entities, its own metaphysical commitments, its own explanatory devices and its own shortcomings. These shortcomings and the inability of each of these different world-views to make “nature fit” entirely into their conceptual schemata, is what led to the classification of water as H_2O. The consensus of 1860 was achieved as result of the parallel evolution, competition and interaction between the different interpretative frameworks: Scientists needed to find a way upon which they could agree on the notation of sets of atomic weights and formulas, they needed to establish a *common* method which could be accepted by the entirety of the scientific community of acquiring that information, and they needed to find or agree upon certain criteria which would enable them to proceed with their inquiries. And the scientists did just that; they established the atomic weight assessment in all oxygen based reactions as O=16, and agreed that the way to inquire about the notation of atomic weights and molecular formulas should be based on considerations of consistency; every decision and agreement the scientists would hitherto have, required that it was consistent with one another. Yes, consensus was achieved, and yes water came to be known as H_2O. But as our retelling has showcased this reality was manufactured out of the need of the scientists to be able to proceed in a uniform way at a very fundamental level; not because of a belief in an “objectively Real” fact about water, but rather because they acted in the way scientists act: they acted causally upon the world and tried to discover and account for the existence of new entities, they transformed the world, and they tried to create the semantic conditions under which their structures could manifest.

The interplay between different and competing *projected images of nature* led to the production of an *image of nature in which water is* H_2O*.* And this image of nature as we've been urging, is surely a *real* image of nature. But its reality is dependent on the framework which brought it about in the first place, in this case, a *reality brought forth from a plurality of interpretative frameworks and world-views, a reality which nevertheless is entirely dependent and holds true only within such framework(s).* Yes, water is H_2O, as long as this statement is taken to be *true and real* in the sense we have been discussing thus far; a localized and framework-specific reality. As Feyerabend put it:

> "[T]erms such as SCIENCE or ART are temporary collecting-bags containing a great variety of products, some excellent, others rotten, all of them characterized by a single label. But collecting-bags and labels do not affect reality; they can be omitted without changing what they are supposed to organise. What remains are events, stories, happening, results, which may be classified in many ways but which are not divided by a lasting and "objective" dichotomy."[126]

4.1.The History of the Discovery of Water Revisited: The Developments within Atomic Chemistry

Our historical narrative so far has afforded us with the opportunity to see the different metaphysical and conceptual frameworks of the scientists working on the field of chemistry during the 19th century and the entities populating their different worlds. In section **2** we focused on the debate between phlogiston and oxygen based accounts and tried to highlight the importance of this debate in the history of the discovery of water. Chang refers to the traditional narrative as a "myth", or at the very least a one-sided account which leaves aside many complex developments and philosophical insights.[127]Chang's more elaborate narrative focuses on the developments in volumetric reasoning, and how these developments affected atomic

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[126] Feyerabend, "Art as a Product of Nature as a Work of Art". p. 93.
[127] Chang, *Is Water* H_2O*?*, p. 146.

chemistry, during the time period we have been discussing. Gay-Lussac's volume-relations and the idea that volumes could be indicative of the numbers of atoms involved in chemical reactions, the EVEN conception we referred to in section **2**, was a widely circulated idea in all textbooks of chemistry after 1809. However, not every chemist took Avogadro's conception of EVEN for granted, and its acceptance, or partial acceptance, depended, once again, by the different epistemological and metaphysical commitments each scientist held. Berzelius' remark in 1813 highlights just this fact:

> "there is no other difference between the theory of atoms and that of volumes, than that the one represents bodies in a solid form, the other in a gaseous form. It is clear, that what in one theory is called an atom, is in the other theory a volume. In the present state of our knowledge the theory of volume has the advantage of being founded upon a well constituted fact, while the other has only a supposition for its foundation"[128]

Berzelius did not take EVEN for granted and his own conception of EVEN differed from Avogadro's in some important respects: Berzelius still considered atoms hypothetical entities, rejected the application of EVEN to compound gases and he also rejected the idea of polyatomic molecules of elementary gases. Essentially, rather than being a committed believer to the idea of EVEN, at least under Avogadro's conception, Berzelius had his own interpretation, his own world-view on EVEN: he was taking volumes as measure of atoms, independently of combining weights, leaving the question pertaining to the relation between the two measures open.[129]

Before we proceed any further with this inquiry into the history of atomic chemistry and the consequences it has for our paper, it's important to take a brief moment to illustrate the conception of the atom during this period and the kind of volumetric reasoning we are discussing. An atom was "a chemically indivisible unit, that enters into combination with similar units of other elements in small integral multiples".[130]In this definition Rocke was concerned with distinguishing atomic weights from equivalent weights but as Chang points out weight is not the

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[128] Berzelius, Jöns Jakob. 1813. Essay on the cause of chemical proportions, and some circumstances relating to them; together with a short and easy method of explaining them [part 1]. *Annals of Philosophy 2*: 443–454

[129] Chang, *Is Water H_2O?*, p. 147.

[130] Rocke, *Chemical Atomism in the Nineteenth Century: From Dalton to Cannizzaro*, p. 12.

only property by means of which chemical atoms can be analyzed; in fact another conceptualization of chemical units can be in terms of the volumes they occupy as well as their weights.[131] A helpful way to conceptualize this is to think of little boxes containing gases. There is a 2:1 volume ratio between hydrogen and oxygen which combine to make water. This 2:1 ratio holds no matter how small the (absolute) amounts of these two gases are. Now, by extending the application of this line of thought into the smallest possible units, we can reach the idea of *volumetric chemical atoms.* One does not need to know what the absolute values of weight or volume are, as long as one can find out the relative numbers of different units involved in a reaction. [132]

Volumetric thinking brought forth the concept of *valence,* or *valency* as was the term employed in the era we are discussing. *Valency* is the conception of August Wilhelm Hofmann (1818-1892) who developed this idea during his lectures in London where he was appointed as the first Director of the Royal College of Chemistry. In his *Introduction to Modern Chemistry* published in 1865, Hofmann noticed that hydrogen and chlorine gases combined in a 1:1 volume ratio, to make hydrochloric acid, hydrogen and oxygen combined in a 2:1 volume ratio to make water, and hydrogen and nitrogen combined in a 3:1 volume ratio to make ammonia. These relations afforded the molecular formulas of HCl for hydrochloric acid, H_2O for water and H_3N for ammonia. What's of importance for our discussion is that these relations indicated confirmed relative numbers of volumetric atoms and *not hypothetical numbers of atomic particles* as in Avogadro's "more metaphysical" conception. By continuing his work on volumetric atoms Hofmann discovered that chlorine, oxygen and nitrogen, all had different "atom-binding powers", all had the ability to combine with 1, 2 and 3 volumetric atoms of hydrogen. These molecular formulas, and the valency of 1, 1, 2 and 3 for H, Cl, O, and N, provided atomic chemists with the groundwork around which a whole system of molecular formulas and atomic weights could be built.[133]

Hofmann's conception of *valency* paved the way and provided firm foundations for a solid system of atomic chemistry. What's important for our discussion is the way in which, Hofmann came up with the concept of *valency* and how his epistemological and metaphysical

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[131] Chang, *Is Water H_2O?*, p. 147.
[132] Ibid.
[133] Ibid. pp. 147-148.

commitments contributed to this conceptualization. According to Chang, this development in atomic chemistry is “a triumph of *operationalism”.*[134] Essentially, operationalism is exhibited throughout Hofmann’s working out of valency, but is also a common trait of the leading chemists of the nineteenth century; their findings are firmly established by and easily reproduced in laboratory operations. The way these chemists proceeded was by entertaining a plethora of theoretical ideas but choosing to focus on those ideas which could be linked with laboratory operations, and they tried to find, invent and secure more of these links. The chemists of this era were willing to theorize but they were focused on the theories and ideas which could be put under laboratory scrutiny. It’s fundamental to note that their practice had nothing in common with the positivists, abstaining from all talk of unobservables like atoms and molecules, but they neither were naive realists; they held no firm belief in their images of atoms and molecules, nor any dogmatic adherence to axioms and first principles. Their philosophical attitude according to Chang was born out of humility, not by a resignation to the uncertainty of the unobservable, but by an active pursuit of knowledge, with the acceptance of the limitations inherent in humankind.[135]

4.2. The many roads dilemma.

In his famous poem “The Road not Taken”, Robert Frost writes:[136]

> I shall be telling this with a sigh
> Somewhere ages and ages hence:
> Two roads diverged in a wood, and I—
> I took the one less travelled by,
> And that has made all the difference. (16-20)

The narrative we’ve been following thus far enables us to highlight one fundamental for our purposes point; there are many possible alternatives to follow. As Chang notes, a plethora of competing theories about the atomic-molecular constitution of basic substances were compatible with the *accepted* body of evidence. This situation led to a well known problem in the

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[134] Ibid. p. 148.
[135] Ibid.
[136] Frost. R., *Mountain Interval,* New York: Henry Holt and Company, 1920.

field of the philosophy of science, namely, the problem of *underdetermination of the theory by evidence*, and the circularity between atomic weights and molecular formulas was the source of this issue.[137]

The dimensions of the problem of underdetermination of the theory by evidence are revealed if one considers that there were multiple sets of atomic weights being employed up to the nineteenth century. As Rocke notes, by 1816 at least nine (!) different systems of atomic chemistry were in existence, and this cornucopia of atomic systems didn't slow down till the middle of the century.[138]This plurality of atomic systems stemmed from disagreements about atomic weights which led to disagreements about molecular formulas, but these disagreements were also linked to deeper issues. According to Chang, five major systems of practice can be clearly identified and distinguished as being in operation during the era we have been discussing, systems which were in parallel development due to the interaction and competition with each other; in an environment where Being is so uncertain, so unstable, so volatile, there are many alternatives to follow.[139]The five major systems of practice operating at this time were: [140]

1. *The weight-only system:* This system focused on determining and using atomic-weight values inferred from the macroscopic combining weights of substances, on the basis of certain assumptions about molecular formulas. The scientists working in this system focused on chemical analysis rather than providing theoretical explanations of phenomena.
2. *The electro-chemical dualistic system:* In contrast to *the weight-only system*, the working scientists in this system focused on providing theoretical explanations of phenomena. A fundamental operational aspect of this system was the employment of the Voltaic pile, in order to conduct electrolysis on various substances. The observed chemical reactions were interpreted as a product of the electrostatic attractions and repulsions of the atoms.
3. *The physical volume-weight system:* The chemists working under this system, which originated by a familiar figure in our narrative, Avogadro, took both weights *and* volumes as measurable properties of atoms. This system was realist-oriented: With EVEN as the

[137] Chang, *Is Water H_2O?*, p. 149.
[138] Rocke, Chemical atomism and the evolution of chemical theory in the nineteenth century, p. 2.
[139] Chang, *Is Water H_2O?*, p. 149.
[140] Ibid., pp. 149-150.

fundamental principle, the scientists working under this system wanted to find out the *Real* properties of the atoms and molecules of the various substances.

4. *The substitution-type system:* This system was developed in response to the *physical volume-weight system* and *the electro-chemical dualistic system.* A group of organic chemists, disappointed by the speculative nature of *the physical volume-weight system* and its search for the *Real*, decided to focus on *classification* as the aim and operationalization activity of this system. Jean-Baptiste Dumas (1800-1884) paved the way for how this system would operate by his idea of “types”, that is structural templates given by certain simple substances like water and ammonia.
5. *The geometric-structural system* (a name derived by Chang): This system was developed by chemists who were antithetical to the Dumian idea of “types”, and the notion that “type-formulas” were representative of the actual geometry of molecular structures. The chemists working in this system were inspired by the crystallographic tradition and focused at getting directly at the geometry of molecular structures.

The five major systems of practice we have identified, following Chang, serve as testament to the presence of *the problem of underdetermination of theory by evidence* present in the era we have been discussing. There were many alternatives all consistent with the known observational data and their interpretation depended on which way of reducing Being the scientists embraced. What is more, in addition to the problem of *underdetermination*, there was the fact that not even one system of practice was a “perfect candidate” if we add to the equation other desiderata aside from consistency with observations.[141] *The weight-only system* was found wanting in terms of its settling of molecular formulas, which were done in arbitrary manner. *The physical volume-weight system* had to face the difficulties that were directed towards Avogadro’s’ metaphysical considerations. Similarly the *electro-chemical dualistic system* suffered a substantial blow when it was discovered that very different atoms could substitute each other; like the highly electronegative chlorine and the highly electropositive hydrogen.[142]

[141]Ibid., p. 150.
[142]Ibid.

4.3. The Karlsruhe Consensus: The extended cut.

Amidst *the problem of underdetermination of theory by evidence* and the sea of competing interpretative frameworks and systems of practice with none being perfect, as each one suffered its own shortcomings, scientists did eventually reach to a consensus at the Karlsruhe Congress of 1860. Somehow, in some way, scientists did agree on basically the same system of atomic weights and molecular formulas that we still accept in our era. In our first-retelling of this story we noted that Cannizaro is supposedly responsible for synthesizing and circulating Avogadro's ideas in a way that the scientific community deemed acceptable and that is which led to the consensus. However, we also mentioned that this was just a part of the story, and that in fact the consensus was achieved by a fertile ground paved by the developments within the field of atomic chemistry. This sub-section offers a retelling of that story: how, and in what ways this consensus was achieved. Our aim with this re-iteration of the story is to show that the ways in which the scientists resolved the issues we have been discussing.

The problem of *underdetermination* was eventually solved by developments that occurred within the field of atomic chemistry. Progress in structural theory such as the ordering of the valency of carbon at 4, enabled the consequent determination of molecular formulas for simpler compounds, which consequently led to the fixing of atomic weights. This progress was achieved by the very presence of the different systems of practice operating in in this era. The plurality of the different atomic systems afforded these developments to occur. As was mentioned, each system "zoomed-in", to employ Chang's terminology, or focused, on what it could handle very well, on what it could account for intra-systemically. *The weight-only system* focused on gravimetric analytical chemistry, which flourished in the middle of the nineteenth-century. *The electrochemical dualistic system* focused on substances that were susceptible to "clean" electrolysis. Each different system offered a new set of facts and insights, and contributed in its own way in building up a body of chemical knowledge, and consequent progress within the field, in ways which the other competing systems could not manage.[143]

It was after almost half a century of continuing development, of interaction and competition of these systems that it was finally possible to "zoom-out", and make a synthesis of

[143] Ibid.

the various elements of these systems, and eventually, the systems themselves. The introduction of the concept of valency enabled this initial synthesis to occur. With the introduction of valency, *the physical volume-weight system, the substitution-type system,* and *the geometric-structural system,* all synthesized elements from their competitors, with the appropriate adjustments. For example, when *the substitution-type system,* was able to improve its operational success, this paved the way for chemists being able to attribute a sense of *reality* to the models of molecular structures they had previously invented solely with classification purposes in mind. After these developments the chemists started to consider that an oxygen atom *really* did bind two hydrogen atoms together in a water molecule or that a carbon atom *really* did bind with four hydrogen atoms to a molecule of methane (or marsh gas as it was known at the time).[144]The molecular formulas worked out in a way that ended up matching very well with the molecular formulas used in *the physical volume-weight system.* The increase in the success of this "matching up" between the bodies of knowledge each system contributed, allowed scientists to be more confident in the *realism* of this synthesis, which allowed a further synthesis, the synthesis with elements from the *geometric-structural system.* This synthesis was achieved by considering the carbon atom as a tetrahedral structure in three dimensions. It was the synthesis of these three systems that which paved the ground, and allowed the Karlsruhe Consensus of 1860, the synthesis that gave birth to the **T**ruth and **R**eality of the statement: "Water is H_2O".[145]

Someone could argue that the field of atomic chemistry before the Karlsruhe Consensus was a muddled place. However, it is this muddled environment that which allowed the consensus on the molecular formula of water, among other things. All the five major chemical systems operating in this time contributed each in its own way, a significant piece of knowledge in the extended body of chemical knowledge, whether it was via the discovery of new substances, or in the different approaches to analyzing new and old substances, or in the operational knowledge of atoms, or in the classification of or organic substances or finally, in their prediction and explanation of various chemical reactions. All these contributions in the field of chemistry stem from scientists who held vastly different world-views and interpretations in their ways of approaching and reducing Being.[146]

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[144] Ibid.
[145] Ibid. 150-151.
[146] Ibid. 173.

Returning to our story, it seems that consensus had finally been achieved. Rocke has called these advancements and reform in organic chemistry as the “Quiet Revolution”.[147]It’s the “Quiet Revolution” that which is responsible for the fixing of the sets of molecular formulas and atomic weights, including H_2O. And yet, unlike the name suggests, this was not a “quiet” revolution at all. Many textbooks report that something significant had just happened in the field of chemistry, a “revolution” had taken place. Hofman’s report serves as testimony to this:

> ”No chemist will need to be reminded that, during the last quarter of a century, the science of chemistry has undergone a profound transformation; attended, during its accomplishment, by struggles so convulsive, as to represent what, in political parlance, would be appropriately termed a Revolution.”[148]

Despite this talk of a revolution taking place, what we have here is not the displacement of one dominant world-view, or system, in favor of another. As we have been discussing this clearly was not the case. We do not have a Kuhnian paradigm-shift. Rather, what we have here is a pluralistic pattern of development. And yet, it is clear that after the Karlsruhe congress, consensus was achieved; a consensus on the set of atomic weights and molecular formulas was achieved. We discussed in this section that the “Quiet Revolution” was brought about by the synthesis of different elements of the five major systems of practice operating at the time. But what sparkled this synthesis? And why only some of those systems were synthesized, while others did not?This is the issue to which we now turn our attention.

4.4. Setting up the stage

One key episode in the history of the “Quiet Revolution” revolves around chlorine-hydrogen substitutions. According to the story, Charles X held a royal ball at the Tuileries, when suddenly his guests were struck by noxious fumes coming from the chandeliers. A familiar figure in our narrative was called in to investigate the phenomenon, namely, Dumas. During Dumas’

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[147] Rocke, “The quiet revolution of the 1850s: Social and empirical sources of scientific theory”.
[148] Hofmann, *Introduction to modern chemistry experimental and theoretical, embodying twelve lectures delivered in the Royal College of Chemistry, London.*

investigation it was revealed that the fumes consisted of hydrochloric acid gas. The candles of the chandelier had been bleached with a chlorine-based bleach, to whiten them, and during the bleaching process, some of the hydrogen in the tallow was replaced by chlorine from the bleach. It was due to this incident, and due to Dumas' detective work, that a whole "research program" was initiated, led by Dumas. This research culminated with the announcement of Dumas in 1834 that he was able to identify empirical laws concerning hydrogen-chlorine substitutions.[149]

Dumas' discovery pertaining to hydrogen-chlorine substitutions proved to be a tremendous thorn in the side of the chemists working in this era. This was the case because hydrogen and chlorine had very different individual properties and it was very hard to make sense on how they could replace one-another. More specifically, the hydrogen-chlorine substitutions raised the following problem: in some reactions, the replacement of hydrogen by chlorine did not significantly alter the properties of the substance. In acetic acid, (the essence of vinegar, today's formula being $C_2H_4O_2$) and in trichloroacetic acid ($C_2HCl_3O_2$), this certainly was the case. However, this problem gave birth to a very crucial idea: It led chemists to entertain the notion that chemical properties were determined by molecular structure *as well as* the nature of the atoms in the structures. Another issue that hydrogen-chlorine substitutions raised was the following: hydrogen is highly electro-positive and chlorine highly electro-negative; although their combination made sense, the substitution of one for another raised a major problem for the electrostatic explanation of chemical combination.[150]

Chlorine-hydrogen substitutions are important for our discussion because of the way this discovery impacted the five systems of practice we identified earlier. Chlorine-hydrogen substitutions did not affect *the weight-only system*: these observations could be added to its body of empirical observations and the chemists working under this system continued their work without any obstacles. To the scientists working under *the physical volume-weight system* this discovery was welcomed with grace; learning that chemical combinations were not strictly governed by electrostatic affinities. Unfortunately the news of this discovery were not so great for *the electro-chemical dualistic system*, which was the prominent system of practice in this time. The chemists working under this system had a crisis at their hands. Dumas' discovery in

[149] Chang, *Is Water H_2O?*, p. 174.
[150] Ibid., p.175.

fact created a "two-stream breach" within *the electro-chemical dualistic system*. The two streams were: a) to give up entirely on explanations of chemical combinations and shift the attention to explaining the constitution of molecules, or b) stay with electro-chemical dualism but make some severe adjustments that don't sit well with the rest of the system. But even for those who chose to embrace the second option, sticking with dualism, the facts of chlorine-hydrogen substitutions raised serious doubts about the main explanatory medium of the system, namely electrostatic attraction as the Real and universal mechanism for chemical bonding. Despite noble attempts by Berzelius among others, to try to reconcile the chlorine-hydrogen substitutions with *the electro-chemical dualistic system*, the system suffered defeat: they had to admit the chlorine-hydrogen substitutions, and they had to admit that a plethora of organic molecules is not governed by electro-static forces.[151]

Following the demise of *the electro-chemical dualistic system* and Berzelius' electrochemical rules, a group of scientists chose to follow a different path, trying to see what forms of molecular constitution could allow for simple and systematic classifications. This way of approaching Being gave birth to *the substitution-type system*, with "detective" Dumas at its head, an influential system which flourished in the 1840's up until the "Quiet Revolution".

Another important aspect of *the electro-chemical dualistic system's* demise, which as we noted was the dominant system until the late 1830's, was that chemists were not restricted anymore in the ways they could inquire about the constitution of compounds, they only had to be bounded by the electro-chemical reasoning only in those instances where electrolysis had actually shown the operational duality of dualistic composition, for the rest of their inquiries they could proceed with *the substitution-type system* or with the other alternatives at hand. A weather of uncertainty with rays of *whatever-works* or *anything-goes* was the forecast on the weather channel from the 1840's all the way to the Karlsruhe Consensus.[152]

With both Dalton's (recall Section **2**) and Berzelius' restrictions on how molecular structures should be conceived being severely weakened, chemists had an open-range of possibilities and alternatives to explore, including Avogadro's formulations and structures. This by no means meant that Avogadro's ideas were accepted, since his conception of bonding, on

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[151] Ibid., pp. 175-176.
[152] Ibid. p. 177.

how two atoms of the same kind could bond together, still couldn't be explained, it just meant that chemists started entertaining his ideas. In the absence of the *Real* there are many roads to transverse.

Avogadro's ideas started to be serious contenders with the introduction and the establishment of the concept of valency. It's important to see how this development fits into our story. According to many *substitution-type* chemists, in the type-formula of water, oxygen was the element which did bind the hydrogen atoms together; so the type-formula for water according to some type-chemists would be OH_2. This was the case because Oxygen was thought to have a kind of "atom-binding power" or "atom-fixing power".[153]The idea behind this line of thought was that various elementary atoms had different numbers of "bonds", where bond is employed here to mean "a point of attachment" which allows it to link with other elements.[154] This number of bonds was responsible for the form of chemical combinations because "no element, either alone or in combination, can exist with any of its bonds disconnected."[155]This "combining value of the elementary atoms is usually termed their *atomicity* or *atom-fixing power*."[156]The problem with this way of thinking was that well, it implied that one atom in a molecule chain was "more active" than the others. This essentially meant that different parts of a molecule had different ontological statuses, which was arguably a disturbing notion.[157]

The idea of an atom in possession of a magical "atom-fixing power" was soon abandoned and was replaced by the notion of valency. Developments within *the substitution-type system* itself brought forth this change. Charles Frédéric Gerhardt (1816-1856) codified the type theory in 1856, accepting Hofmann's ammonia type as well as Williamson's water type. This is important in our discussion because these two types did not have a central binding atom; their notations did not imply that Oxygen, or Nitrogen in the case of ammonia, had any special "atom fixing powers". Chemists realized that the centrality of the oxygen and nitrogen atoms in the water-type and ammonia-type molecules did not rest in their "magical active power" but rather in being one atom which bonded with multiple atoms at once. But how

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[153] Ibid. p.179.
[154] Ibid.
[155] Frankland, *Lecture notes for chemical students, embracing mineral and organic Chemistry.*
[156] Ibid.
[157] Chang, *Is Water H_2O?*, p. 180.

was this achieved? Operationalism makes its appearance again. Chemists tried to examine what was operationally significant in the “atom-fixing power” of Oxygen and Nitrogen atoms in water and ammonia types. The operationally significant thing about atoms was their chemical divisibility and indivisibility. As such, the idea that Oxygen and Nitrogen had some “magical atom-fixing power” was rehabilitated; Oxygen and Nitrogen were just atoms which had the ability to bond with multiple atoms at once, but this didn’t make them ontologically prior, or ontologically special, to other atoms.[158]Furthermore, the operational manifestation of the number of atoms within a molecule was arrived at with the employment of substitutions. A passage from Charles Bloxam, a Professor of Practical Chemistry at King’s College in London, exhibits this kind of thinking: “the hydrogen in ammonia can be replaced by other bodies *in thirds*, showing that there must be three atoms of hydrogen present, whilst the 14 parts [by weight] of nitrogen, cannot be replaced in fractions, so that it must represent a single atom.”[159] Two things to note here: a) It was due to this inability to be replaced in fractions that which operationally defined an atom, and b) the nature of the ammonia type was that a single atom of nitrogen was able to combine with three separate atomic units simultaneously. Similarly, the water type boiled down to one oxygen atom’s ability to combine with two separate atomic units at the same time. The number of atoms were operationally specifiable via the employment of atom-counting by volume or by the comparison of combining weights.[160]

According to Chang, the identification of the operational basis of valency and of type-formulas led to higher degree of belief in their reality. By the 1850’s most of the chemists working under *the substitution-type system* had ceased being instrumentalists about types. This degree of realism allowed chemists to be confident in their findings and afforded them the opportunity to start building a new system of atomic chemistry with the combination of various elements from various systems and the employment of various methodologies. The first was to combine volumes of gases, then from volumetric reasoning (volumetric atom counting) the molecular formulas of reaction-products were deduced; from the observed combining volumes and the molecular formulas, the atomic weights of the elements involved could be deduced;

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[158] Ibid. p.183.
[159] Bloxam, *Chemistry inorganic and organic with experiments and a comparison of equivalent and molecular formulae.*
[160]Chang, *Is Water H_2O?*, pp. 182-183.

finally, via the employment of these atomic weights other molecular formulas from other combining weights could be inferred.[161]

What we have here is a prime exemplification of a pluralistic framework of conducting scientific inquiry. The increased degree of confidence in the reality of *the substitution-type system* allowed for a synthesis to occur. When the types were considered to be real representations of molecular constitutions, and when the "atom-fixing power" was clearly defined, *the substitution-type system* matched up very well with *the physical volume-weight system*. This initial synthesis was born out of the fact that certain substitution reactions allowed the tracking of *both* volume and weight of well specified atomic units in compounds. Recall that this synthesis would not have had taken place if it was not for Dumas' detective work and his findings on chlorine-hydrogen substitutions which led to the demise of *the electro-chemical dualistic system* and the restrictions it posed pertaining on chemical combination. Finally, *the substitution-type system* also matched up very well with *the geometric-structural system* and in fact "breathed new life to it" by contributing specific ideas such as the tetrahedral carbon to be employed by the later in geometric constructions. At long last a new system of chemistry was born. A system with a firm grasp on the phenomenological aspect on the combination of atoms, but without any pretense of knowing the "*Real*" properties of atoms or the "*Real"* cause of chemical bonding, again in the sense of "Real" we have been opposing to.[162]The stage for the Karlsruhe Consensus had been set.

5. *The Alternative*(s).[163]

In the lyrics to the song "The Alternative", Chris Corner writes:[164]

> To the alternative to real world,
> It's just time for me and a fantasy,
> Be blind to myself,
> To idolize.

[161] Ibid. p. 183.
[162] Ibid. pp. 183-184.
[163] Part of the title pays tribute to IAMX's song "The Alternative', from the album *The Alternative* (2006).
[164] Chang, *Is Water H_2O?*, pp. 183-184.

The historical narrative we've been following so far is revealing: in the episodes of the history of the discovery of water, there was no absolute "Real". The quest for the "Real nature", or the "Real constitution" of water became displaced by the much humbler exploration for the "real". This was the case partly because many of the systems we have examined so far faced such tremendous resistances from Being which they couldn't account for, but also because the multiplicity of chemical systems in existence which tried to produce a coherent, stable, account of water (among other things), produced new knowledge, new facts, and posited new obstacles for any one single system to overcome by itself. Eventually, precisely for those reasons, a synthesis occured; a synthesis which transformed water into H_2O.

This the attitude after all, exhibited by most of the chemists working in the field of atomic chemistry during the era we have been examining. *The weight-only system* focused on chemical analysis of phenomena instead of providing theoretical explanations using atomic-weight values, *the physical volume-weight system* worked with Avogadro's conception of the EVEN and considered both weights *and* volumes as measurable properties of atoms, *the substitution-type system* "zoomed in" on the "type-formulas", while the chemists working under *the geometric-structural system* were focused on the derivation of the geometry of molecular structures. All these four systems, had one thing in common: They tried to interpret nature in different ways, using their own intra-systemic criteria, aims and methodologies. However, the chemists themselves were not blind to the shortcomings of their systems, but most importantly they weren't blind to the developments that occurred within the other systems of practice operating at the time. They weren't blind to the plethora of alternative ways of approaching and interpreting Being, other ways of managing its abundance, ways of creating and shaping one of its many aspects.

The synthesis that occurred and led to the "Quiet Revolution" serves testament to this fact. A long period of interaction, competition and parallel development within the field of atomic chemistry, a period which was marked by new information, new facts, new observations that each system contributed in its own unique way, afforded the chemists with the opportunity to finally "zoom-out". This "zooming-out" led to a synthesis of the various elements of these systems, and paved the way for the Carlsruhe Consensus.The five systems of practice, their different methodological approaches and their different images of nature, set the stage upon which a new image of nature was produced: the image in which the statement "water is H_2O"

was a real fact *about* nature. The Carlsruhe Consensus serves as testament of the causal-semantic action that scientists, and all human agents in general, take on the world. Only when the frames of reference could finally be agreed upon, only when the semantic conditions, the sets of atomic weights and molecular formulas were agreed upon, only then scientists were able to stabilize the structure we have come to know as water; only then its reality became manifest.

I think our discussion on the history of the discovery of water provides us with ample evidence to support the *ontological (epistemological) pluralist viewpoint* we have been advancing, which we argued, following Feyerabend, that is in fact the actual state of affairs in science; the world of science is a world in which the abundance of Being is embraced. The reality of water as H_2O was brought forth from a plurality of interpretative frameworks and world-views; after intense periods of scientific debates, competition, interaction, but also of parallel developments.

We have been urging throughout this paper that questions pertaining to *reality*, are firmly rooted in the metaphysical and methodological commitments of the systems of practice, interpretative frameworks, and ways of approaching Being we have elected to follow. This attitude is clearly exhibited in the field of atomic chemistry. In *the weight-only system*, there was no commitment to the "absolute Reality" of atoms whatsoever, the *physical volume-weight system,* was only committed to the "absolute Reality" of atomic weights and volumes as physical properties possessed by the atoms. *The electro-chemical dualistic system,* aspects of which we will discuss more extensively shortly, was the only system which had a strong commitment to "absolute Reality", as the chemists working under this system had an image of nature in which there existed well-confined particles in possession of electric charge and the forces that atoms exerted upon each other. *The substitution-type system* was as non-committal to the Reality of atoms as *weight-only system*, with the exception that it conferred a degree of Reality to the radicals as chemical units. Finally, *the geometric-structural system* was committed to the Reality of a topological spatial Reality between the atoms, but this didn't determine the three dimensional actual shape of atoms.[165]

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[165] Chang, *Is Water H_2O?*, p. 195.

In our interpretation of the historicity of the history of the discovery of Water, the *reality* of water as H_2O was born from a collaboration, competition, and interaction of different "realities", of different ways of reducing the abundance of Being. A synthesis of these various realities, these various ways in which scientists took causal-semantic action on the world, transformed and led to the *reality* of water as H_2O. The history of electrochemistry serves as a bona fide example of scientific inquiry being conducted in a pluralist fashion; many alternatives, many realities, many ways of approaching Being. The five chemical systems of practice we identified were all consistent, to a degree, with the accepted body of evidence but their interpretation of nature varied vastly. The realities, images, and truths they produced, were not to the exclusion of other alternatives.

The problem of underdetermination of theory by evidence which we discussed highlights just this fact; many alternatives, consistent with the known observational data, but each alternative had its own shortcomings. The choice to which alternative to follow, which "truth to pursue", depended on which way of reducing Being the scientists embraced. The image of water which the chemists working under *the weight-only system* envisioned was on an equal footing with the image of water which *the substitution-type system* envisioned. The Carlsruhe Consensus was a result of a synthesis brought forth from the acceptance that all competing chemical systems we examined had their own images of nature, their own true facts about nature, their own realities, but also, their own shortcomings. This was the case for the simple fact that Nature provided obstacles, but at the same time, showcased its malleability; many different aspects of its Reality were captured.

The synthesis that was brought about was a culmination of the different methodological and metaphysical interpretations of approaching *Being*, a combination of different *real aspects of Being*. The *way the water is* was brought forth from a plurality of *ways the water is*; an image of water which was cultivated from a collaboration, competition and development of other images, of a variety of ways of capturing aspects of Nature. All of the electro-chemical systems we examined contributed in their own unique way an *image of nature, an aspect of Being.*

In the face of the resistance, but also of the richness, which Being posed to the scientists of the era, the scientists chose those aspects of Being, those facts, this or that piece of knowledge, produced from the multiplicity of interpretative frameworks in existence, which could create, complement and stabilize their structures the best. The end result was a multifaceted image of nature, encompassing the individual realities each system of chemical practice had managed to capture, which could finally satisfy the demands of Being, its resistances, but at the same time, highlighting its complexities, its intricacies, its unique ability of being approached and molded into many different ways.

. The history of electrochemistry is not a history of embracing either/or *alternatives*, but rather a history which highlights that the decision to embrace an *alternative*, depends on the production and availability of *alternatives* in the first place. The synthesis which led to the acceptance and the truth of the statement "Water is H_2O" is a culmination of *alternatives*; *alternative ways of seeing, alternative ways of interpreting, alternative ways of approaching Being*. The production and availability of these alternatives is what led to the production of commonly accepted semantic conditions, which finally allowed water to be made manifest and be transformed into H_2O. We believe that the history of the discovery of water clearly shows that *epistemological pluralism* is in fact the actual state of affairs in science.

5.1. Intermission III: The electro-chemical dualistic system

We purposefully left out, for the most part, one system of practice in the above discussion, to which we will now turn our attention, namely the *electro-chemical dualistic system*. How does this system fit in the *alternative* account we have been trying to offer? As we discussed, *the electro-chemical dualistic system* posed severe constraints on the ways upon which other systems of practice conducted inquiry, given that it was the dominant system of practice for a long time, and it was only after its demise, that "this image of plurality" we have been advocating, flourished. Distant howls of a monist image of science start to echo in the pluralist image we have been advocating.

The case of Berzelius himself, the leading proponent of *the electro-chemical dualistic system,* will put these monist howls to rest. We read in Berzelius' letter to Laurent, with whom they had diametrically different ways of approaching Being[166], of 1844:

[166]According to Chang, Laurent tried to reform inorganic chemistry following organic clues, while Berzelius tried to reform organic chemistry following inorganic clues. Chang, *Is Water H_2O?*, p. 186.

> "I am by no means blind to the extension of theoretical knowledge which may follow from the method which you have chosen. It will therefore be best if we each follow our own route amicably, in the hope that science will draw profit from both."[167]

A more convincing case for the pluralistic image of science we have been advancing is the way in which Berzelius conducted scientific inquiry. Although Berzelius was the father of *the electro-chemical dualistic system*, his work clearly exhibits that he was engaged with a plethora of elements from the other systems. He worked extensively in *the weight-only system*, making analyses of the highest precision. In his decisions on the set of molecular formulas and atomic weights he used a wide array of chemical knowledge and chemical analogies obtained from his interaction with the other systems. He even practiced, although to a limited scope, atom-counting by volumes, in the cases in which electrolysis yielded gases, although he did not accept Avogadro's metaphysical considerations. Through his work in more than one system of practice, and his interactions with them, Berzelius' made some severe adjustments to *the electro-chemical dualistic system* itself.[168]Berzelius himself after all, wasn't blind that his interpretative framework was just "*an alternative";* he embraced and accepted the *alternatives*, worked with them, improved them, even encompassed them in his own system.

6. The creation of images: Consequences and afterthoughts.

> "We have no image
> We're just called the good friends
> We call the madmen back
> As they fly to the ant hills
> We never know, we never know
> We sleep in satin nights
> Throwing energy like bluebirds
> In twilight"[169]

[167] Ibid.
[168] Ibid.
[169] Peter Murphy, "Cascade", from the album *Cascade (1995).*

The history of the discovery of water, what a fascinating journey this has been! In the present section we will discuss the consequences that adopting an *ontological (epistemological) pluralist* viewpoint has for science and emphasize on the benefits that such a viewpoint has.

One fundamental aspect of adopting the *ontological (epistemological) pluralistic stance* is that its scope is not limited to the subjects of science, history, or philosophy of science only. We want to offer this alternative viewpoint as a guide to everything related to human inquiry and action in society. This is one of the key differences of the kind of pluralism we advocate with say Chang's. Chang's pluralism is limited in scope; his inquiry into the history of discovery of water and the conclusions that can be drawn from it, are limited to the area of the history of the philosophy of science; his aim is to rehabilitate the field of the history of the philosophy of science, and showcase, in a Kuhnian way, the ways in which the context of discovery can be a valuable guide to scientific inquiry. What we aim to achieve with our own inquiry into the history of the discovery of water is to showcase that Being or Nature, demands to adopt a pluralistic stance. We share Feyerabend's belief that science, and philosophy, are one of the main ways that mankind has of "tapping" into the abundance of Being. As such, we will now offer a positive argument for this alternative account of living, of being, of embracing this abundance, as being applicable to all aspects of human life and inquiry, with epistemology and ontology at the forefront.

As we've already discussed, and our inquiry into the history of the discovery of water highlighted, scientists take causal-semantic actions on the world, in order to manage the abundance of Being. Human beings in general are able to create new concepts, new theoretical frameworks, new interpretations which allow certain structures and regularities to be made manifest. Human agents are "world-makers" not only because they are able to create new arrangements of things, but mainly because they are able to provide the contextual conditions, both causal and conceptual, which allow said structures and regularities to manifest.[170]

What's fundamental for this discussion, and was the point which we emphasized upon during our inquiry into the history of the discovery of water, is that the processes by which human agents tap and manage abundance and allow them to create manifest worlds, are

[170] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 150.

responsible for the creation of more abundance.[171] After all, wasn't this the case with the systems of electro-chemistry? Each system tried to tap and manage this abundance and by doing so created "a new manifest world", created a new piece of knowledge, crafted a new fact about Being. By trying to account and mold this abundance, new questions, new patterns, new regularities emerged; regularities which posed a problem for the system(s) in question. This in turn led to more efforts of managing abundance, but also of managing the newly created regularities, patterns, obstacles. Abundance created abundance.

A consequence of this "abundance-creating-abundance" aspect of the richness of Being is that, as we mentioned earlier, no single approach will be suited to account for all contexts, for all aspects, for all questions, that pertain to Being. The abundance of Being and our constant "abundance-creating-abundance" efforts to manage it, means that there will necessarily be a multiplicity of different manifest worlds, which are dependent on different human aims, times, and interest groups.[172]This is one of the positive arguments for the *ontological (epistemological) pluralism* we advocate. Instead of being afraid of this multiplicity and richness that Being exhibits; instead of shying away from the various alternative ways we have crafted for accounting for this abundance, we can embrace it. *Ontological (epistemological) pluralism*, which is necessary according to Feyerabend for science, allows science to get at the different, overlapping and potentially vastly different realizable structures that can serve our explanatory but also practical aims.[173] Again, as we mentioned earlier, context, locality, is of paramount importance under this account. It is a mistake to assume that the structures which we employ to solve one problem, will be useful in the solution of another. In other words, we should always keep in mind that different structures can be employed for different purposes, and as such, we shouldn't assume that we have achieved any degree of universality. Universality can be achieved, but this is a hard fought-after achievement.[174]

I think it is evident why traditional realist accounts, and by that I mean scientific monist accounts, are ill-equipped to grasp this metaphysical picture that we have been advocating. Inspired by Feyerabend who advanced this *ontological (epistemological) pluralism* in his attempt to provide a positive alternative to the dogmatism exhibited by scientific monists, we followed

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[171] Ibid. p.151.
[172] Ibid.
[173] Ibid.
[174] Ibid.

the history of the discovery of water for the same reason. We tried to show, by employing a historical example of scientific practice, that scientists do not work with absolutes. Due to the fact that Being is so abundant, unstable and rich, any particular stage, any particular interpretative framework, cannot encapsulate its totality. A single interpretative framework, a single scientific theory, can only grasp an aspect of the totality. Science can only grasp aspects of Being due to the fact that inquiry is bound by context and purposes of those guiding it. Instead of struggling for the impossible, all-encompassing truths, all-encompassing realities, we should embrace what science can do: it can help us grasp certain aspects of Being and can help us stabilize the sets of structures we have employed which can reliably guide our expectations.[175]

A question that emerges is where does our position stand in terms of the realism/anti-realism debate. Like Feyerabend, we are very reluctant to classify this point of view as "realism", but also the term "anti-realism" doesn't seem compatible with many aspects of our position; we think that with the rejection of the appearances/reality dichotomy, and the with rehabilitation of the term reality we have offered, the distinction between the two camps is significantly weaker. I think that the best way to describe the *ontological (epistemological) pluralist* position is in terms of perspectival realism, in the spirit of Giere, i.e. scientific theories or interpretative frameworks can only grasp some aspects of reality, aspects which are theory and observation-laden and as such will always be limited and unable to grasp the totality, or as "abundant realism". [176]

6.1. Ontological pluralism and the consequences in society: Let's read more comic books!

In the year 1954, the American psychiatrist Fredric Wertham (1895-1981) published his *Seduction of the Innocent.* In this book, Wertham argued that comic books were a negative form of literature because they led to juveniles becoming delinquents. His main argument was that comic books, including superhero comic books, with their exposition of themes related to violence, sex, and drug-use, encouraged similar delinquent behavior to young children. Although today Wertham's scientific practice at the time, the sample size he employed in his

[175] Ibid.
[176] Ibid.

research as well as his scientific ethos, has come to be severely scrutinized[177], *Seduction of the Innocent* managed to spur a Congressional Hearing in the United States at the year of its publication which led to the formation of the infamous in the comic-book world CCA (Comics Code Authority) which lasted until 2011.

The U.S. Senate decided that Wertham's psychiatric study had sufficient merits in arguing that indeed comic-books lead to juvenile delinquency and as such decided to take action. The CCA *banned* any depiction of gory, violent, sexual, and drug-related themes, as well as it prohibited the depiction of government officials, state employees such as police-officers or judges, in a manner in which it could be construed that their authority was challenged.[178]The CCA was enforced by the Comics Magazine Association of America, which screened the comic books for the existence of such themes, and if deemed that no such themes were in existence, approved the comic books for regulation to the public.

What is of particular interest in our discussion about the invention of the CCA is the way in which it was formed. It highlights the relationship between science and political authority and is one of the many examples that can be found in which a scientist or a group of, has used its intellectual authority, coupled with its political power, to enforce a specific view on the world. We believe that *ontological pluralism* can shield society from such an adverse effect.

It's important to keep in mind that the decisions that are being made when conducting any form of scientific inquiry are decisions which are in part about what kind of structures we select, how to project them, transform them, or stabilize them. These decisions have the ability to both create worlds, but also, destroy them. Scientific decisions can have severe consequences for the welfare of individuals, social-institutions, or in this case, what kind of comic-books we are allowed to enjoy.[179]This is why it's fundamental to have a plethora of alternatives to choose from; the availability of alternatives affords us with the opportunity to have more options when it comes to choosing structures. We need not forget that any sort of decision, is an open decision under an *ontological pluralist framework.* The abundance of Being, its malleability, the disorder exhibited in nature, and the perspectival and framework-dependent

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[177] Tilley, "Seducing the Innocent: Fredric Wertham and the Falsifications that Helped Condemn Comics", pp. 383-413.
[178] Senate Committee on the Judiciary, Comic Books and Juvenile Delinquency, Interim Report, 1955
[179] Brown, "The abundant world: Paul Feyerabend's metaphysics of science", p. 152.

knowledge we have on Nature, forces us to accept the fact that science does not have an absolute authority when it comes to decision making, This is the case because even though science is one of the main ways we have to gain access to Nature, it still only grasps an aspect of the totality. Science alone therefore, cannot be the end-all-be-all when it comes to making a decision.

Recall that according to *Aristotle's Principle,* or the *Existential Criterion of Reality,* which is one of the fundamental themes in *the ontological pluralistic framework*: decisions are a product of the way of life we have chosen to embrace; the way we choose depends on what we value. When we have a choice of manifest worlds, the consequences of our choice for what we find valuable, is the main consideration for the choice we make. Science is an interest group amongst many other interest groups; it has its own values, its own ways of conducting inquiry. That we have elected to embrace certain values by pursuing science, that doesn't mean that the values we have embraced will be best suited, or best fitted to serve all needs, solve all decisions, independent of context. In a world rich with abundance, the intellectual, and special authority of science, should be restricted on a case by case basis. Perhaps in this way, we will be able to read more comic books!

In conclusion: *the ontological (epistemological) pluralistic viewpoint* has as its starting point the abundance of Being and its structures, the fragmentary and framework dependent character of knowledge, the relationship between understanding and world-making. It offers a refreshing alternative to monist images of science; it emphasizes that science is in fact working in a pluralist way, as exhibited in our inquiry into the history of discovery of water. Finally, *ontological pluralism* provides positive arguments for embracing a multiplicity of alternative viewpoints both in the context of scientific inquiry, but more fundamentally, as a way of living in a society, as a way of embracing Being. As Nietzsche put it:

"All the beauty and sublimity which we have ascribed to real and imagined things, I will reclaim as the property of man: as his most eloquent apology. Man as poet, as thinker, as god, as love, as power - oh, the royal liberality with which he has lavished gifts upon things in order to *impoverish* himself and make *himself* feel wretched! His greatest feat of selflessness has been that he admired and worshipped, and knew how to conceal from himself that it was *he* who had created what he admired."[180][181]

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[180] Nietzsche, *The Will to Power,* p. 91. (Emphasis original).
[181] I would like to thank Ms. Eirini Kopanou for her tremendous support in all aspects of writing this paper; and our communal interactions with Being. This one is for you E.

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