



## Tracks of a minor chemistry education

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**ABSTRACT:** The framing of Chemistry, as a 'Science of Nature', with emphasis on a project of modernity and built on capitalist-colonialist foundations, can be understood as a parameter to assess the historical moment that we know as the Anthropocene. Our objective in this writing-workshop is to present and discuss the position of Chemical Science in the geography of knowledge, as well as to propose theorization of an educational field to think about ethical, aesthetic and political strategies that mobilize the knowledge related to the transformation of substances and that create deviations from dominant ways of thinking and acting in the Anthropocene. To do so, we elaborate three tomo-vacuoles of thought: i) the territory of modern/colonialist Chemistry; ii) inhabit the ruins of the Anthropocene; iii) traces of a minor chemistry education. Then, a minor chemistry education emerges as a power for the co-creation of a chemical thought based on our relationship in/with/throughout the world. Through traces, we cultivate molecular traces that allow us to hope for possibilities in chemistry education. Traces as clues to a collective present that deterritorialize scientific practices captured and explored by the totalizing, homogenizing discourse of progress and development, which makes a more than human world unsustainable.

**KEYWORDS:** Philosophies of Difference; writing-workshop; hyperobjects; schooling; Anthropocene.



“La tortuga que  
anduvo  
tanto tiempo  
y tanto vio  
con  
sus  
antiguos  
ojos,  
[...]”

(La tortuga, Pablo Neruda)

### **The oddness of certain encounters**

After swimming for a few kilometers, some green sea turtles (*Chelonia mydas*) find, on Trindade Island, a volcanic island located in the Atlantic Ocean about 1200 km east of Vitória - Espírito Santo, a nesting site. The encounter of the Turtle with the Island grants the flourishing of life. On a typical day, the rocks meet the seawater at the same instant as the seawater meets the rocks. The rocks and the water provide an encounter that has been arousing philosophical thoughts for many years and, even more recently, the thoughts of those entitled as Geologists. Rocks, defined by this group of people, are a natural association of minerals in defined proportions. Minerals, on the other hand, are understood as solids, also natural, with ordered atomic arrangements, homogeneous and defined compositions. Such conceptualizations, which emphasize the natural aspect of these categories, rocks and minerals (NICKEL, 1995; BRANCO, 2015), are drawn upon when, for example, Santos et. al. (2022) question whether rocks can be formed by sources considered unnatural. Thus, would they still be rocks if formed by plastic? The reason for this questioning lies in the encounter between seawater and a series of apparent rocks on Trindade Island. According to a group of researchers from the Federal University of Paraná, plastics compose some of the rocks found on the island. The article became news and a headline that broadened reflections on this category of synthetic polymers and on the science of chemistry, along with its implications for industry. The article in question introduces us to other texts that report on plastics in coastal environments, remote islands, mountains, the surface of the water, polar regions, the depths of the oceans, among other places. The relation with plastics can affect us in a number of ways. The turtle's somewhat strange or foreign encounter with rocks, that begin to incorporate plastic into their previously mineral and therefore natural structure, is an example of how human action interferes in the geohistory of this common space and place we call planet Earth. What would such a turtle say in its



Therolinguistic records (DESPRET, 2021)? "I had evidence of Gaia operating, turning into rock that which kills my relatives - yet another of the products of those who call themselves human." Plastic, as a hyperobject (MORTON, 2013), is beyond a spatial and temporal understanding of its existence, given that it takes an estimated 450 years for it to decompose in nature. Directly responsible for the ends of the world, as Ailton Krenak (2019) writes, such hyperobjects are products/effects of capitalist-colonist ways of life and views of the world.

The consolidation of Chemistry as a natural science was primarily based on Eurocentric conceptions of the world. Such statement, as harsh as it may seem to those who have not yet comprehended the harms caused by modernity and coloniality, allows us to grasp a series of "later" advancements of what has been called the industrial "revolution". The set of desires and subjectivities that lead to belonging to a group - being a chemist, chemistry, chemistry teacher - carries with it a modern and, consequently, a colonial root. The spread of an ideal way of life, in other words, a "developed" way that could only be achieved through what technoscience could provide, undermined the world - or the world as multiplicity. This scientific and technological "progress", in the modern colonialist and Eurocentric fantasy, which has promoted countless silences and suppressions of differences, is the plan of this text. Some call it the Anthropocene, others the Capitalocene, the Plantationocene. In all of the former options, Chemistry is there, making its presence felt, including in the formal act of writing Chemistry with a capital letter - a habitus we learned and adhered to at university in order to affirm the importance of this science.

Chemistry, a science that studies the transformation and composition of substances, may be in the unfolding of all these ways of life forged in the Anthropocene, Capitalocene and Plantationocene (HARAWAY, 2016), but could it also, as a study of the transformation of substances, allow the possibility of composing other ways of life? Anti-hegemonic ways of life that compose with the multiplicity of the world and not with the attempt of a general standardization. Could chemistry and its education alert us about the evils and harms of modernity and coloniality? Within the scope of these issues, our aim is to present and discuss the position of Chemical Science inside the geography-knowledge field, and also offer the theorization of an educational field to reflect about ethical, aesthetic and political strategies that approach knowledge related to the transformation of substances that create deviations from the dominant ways of thinking and acting in the Anthropocene.

To this end, this writing workshop (PONTIN; GODOY, 2017) will be fragmented and woven into three tomo-vacuoles. Rigue (2021) understands that the premise of the tomo-vacuole is the "[...] possibility of being broken and ruptured anywhere, like a rhizome. Tomo-vacuole that expands by



contagion (...)" (p.16), like knots that intertwine gestures, flavors, intensities, incongruities, characters, that expand by intensity, desire and dispersion. These are the three tomo-vacuoles of the text: i) the territory of modern/colonialist chemistry; ii) inhabiting the ruins of the Anthropocene; iii) minor chemical education.

The first one intends to outline considerations about the territory of modern/colonialist chemistry, based on some historical aspects addressed by Isabelle Stengers and Bernadette Bensaude-Vincent (1992) in the book "History of Chemistry". The second one sets out to touch on the current historical moment, the Anthropocene, and the implications and imbrications of Chemical Science in this dynamic, mainly based on what we have had the chance to experience in our contexts of experience and training. Finally, in the third part, we rehearse theorizations of the minor chemical education that began to be mobilized/tensioned/developed in the thesis "Chemical Education in the Anthropocene" (FARY, 2021) and which unfolds in the distancing from the institutionalizations, standardizations and study plans interested in and addressed to modern/colonialist chemistry.

### **The territory of modern/colonialist chemistry**

Writing Chemistry with a capital letter, as a proper noun, denotes a kind of entity with an abstract existence, arranging and putting in partition certain knowledges and practices. Allied to the network of hegemonic relations, which sometimes dictate ways of life, chemistry, as an entity that seems to be in all the processes, places, labels, drugs & medicines of the pharmacopornographic world presented by Preciado (2018), of the utilitarian order of the modern world, has its identity and territory in a permanent relation of dispute.

Chemistry, as a modern science, is an attempt to overpower and expand knowledge, coming from a European territory and the connections that that same space-time provided and consolidated under the sign of modernity - of logic and mathematical reasoning. This movement also led to the strengthening of modern mechanisms, such as the strengthening of the idea of the state, discipline and compulsory school education.

Education works either as an instrument used to facilitate the integration of the new generation into the logic of the present system and cause them to adjust to it, or as a <practice of freedom>, and is the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world (ANDERSON; BAZIN, 1977, 83).



In 'Science and In/Dependence', Anderson and Bazin (1977) argue that the first and third worlds form a single system. They point out how the notion of science inculcated in countries with third world status, such as Brazil, reproduces alienating and reproductive industrial and educational processes, including scholars ones, by benefiting the mere spread of abstract knowledge far removed from reality, to the detriment of pedagogical work that allows us to think about the concrete situations in the lives of students that characterize them, this social, political and economic reality. This discussion also restates the identity of modern/colonialist chemistry, as it gives priority to how it reads the world in its contexts of action, without the possibility of broadening understandings and actions in/with/throughout the world. Not to mention, of course, that such endeavors emerge from this Cartesian detachment between body and mind, linked to the distinction of "[...] separation and distinction of the subjective and objective aspects of knowledge and the Victorian morality of control and mastery of feelings and impulses by force of will and practice of attention" (KASTRUP; CALIMAN, 2023, p. 62).

As Isabelle Stengers and Bernadette Bensaude-Vincent (1992) have shown, chemistry becomes a science in the midst of disputes over its territory and identity in the field of different sciences. The authors (BENSAUDE-VINCENT; STENGERS, 1992) propose the identity of chemistry as the guiding thread of their narratives, as they believe that this science has its own uniqueness in defining its territory throughout history. And they attribute this to the multiplicity and heterogeneity it occupies, given its ramifications from studies involving microscopic, macroscopic, symbolic and human aspects, beyond the boundaries between the living and the inert, the organic and the inorganic and to the diverse interests linked to pharmacology, agriculture, technology and industrial scales. By giving chemistry multiple meanings, it gives this field of knowledge an identity that is in the process of being rebuilt at each specific era. Furthermore, to create definitions in search of an identity for chemistry is to delimit a territory, which also allows a dissembling.

The identity and territory of chemistry, according to Bensaude-Vincent and Stengers (1992), can be thought of in five different historical moments: i) the explanation of the origins of Chemistry, with the multiplicity of artisanal and cultural practices, in which alchemists, metallurgists, mystics and also skeptics and rationalists, gave Chemistry the character of diversity; ii) Chemistry in the 18th century, as a field that disputes its legitimacy as a science, represented mostly by physicists and doctors, mostly academics, who disseminate knowledge through public experiments; iii) the academic and professional conception of Chemistry in the 19th century, disseminated mainly by professors; iv) in the 19th and 20th centuries, the role that Chemistry acquires in the industrial scenario of production and work, with inventors, engineers and chemical entrepreneurs; and v)



Chemistry subdivided into various disciplines with a hybrid and autonomous character, which promotes another identity for chemists who work in different segments of research and/or production (BENSAUDE-VINCENT; STENGERS, 1992).

In the dispute over scientific and economic territory, witch-hunts and privatization processes took place, mostly in Europe. The persecution of the ancestral knowledge of perfumers, cosmetics manufacturers, midwives and those who made therapeutic remedies with essential oils and plants, along with the economic context of the privatization of land and agriculture, which gained strength in the 16th and 17th centuries, mark the transition from the Middle Ages to the Modern Age. In order for science to acquire a scientific status, the empirical knowledge of women in the Middle Ages was persecuted, many of which were to form part of the scope of chemistry - transformations of nature into tonics, tinctures, medicines and cosmetics. These ways of producing knowledge came from pragmatic knowledge of the uses of elements of nature, passed down from generation to generation (FEDERICI, 2017).

Within the scope of this discussion, Sílvia Federici (2017) questions whether the establishment of the modern scientific method was the driving force behind the witch-hunting movement. In developing the question, she points to a kind of "ideological bricolage" (FEDERICI, 2017, p.367), which relates to elements of medieval Christianity, rationalist discourses and interests in the accumulation of capital, in which European elites intended to extinguish modes of existence that threatened the structure of political, economic and scientific power.

The mechanical universe of scientific rationality, originated in the Enlightenment Age, revealed a nature governed by laws, which according to Federici (2017, p.364) "disenchanted the world", as the animist vision and the connection with the elements of nature were at odds with the interests of exploiting nature and depredating the environment, with the ways and means of capitalist and colonizing exploitation. In this regard, modern Science became a fundamental factor in the disintegration between human beings and nature.

Another historical aspect that we will highlight is when the science of chemistry at the end of the 17th century was intertwined with practical artisanal knowledge (perfumery, metallurgy) and negotiated its autonomy and legitimacy as a science with solid foundations in the 18th century. It is with the figure of Lavoisier that we approach this moment. With an equipped laboratory, the scientist carried out his experiments in a closed system, subjecting them to the use of scales. Through the thermal decomposition of mercuric oxide II, Lavoisier observed that the initial mass was the same as that of the substances produced, thus concluding that the mass was constant. With



this observation, the scientist pointed out the famous mantra of chemists: in nature nothing is created, nothing is lost, everything is transformed, which became known as the principle of conservation of mass. Lavoisier's sagacity was to use the scale as an instrument to validate his research, which by that, revolutionized chemistry and its methods, contributing to the creation of facts. At this point in history, it was the scale, as an instrument that provided precision, capable of subjecting the knowledge of chemistry to analysis, that marked the passage between science and technique, since subjecting chemical reactions to the use of the scale created an atmosphere of proof. Lavoisier, the last person portrayed in the 18th century, changed the territory of chemistry by reorganizing theory, practice and technique.

This period in the history of chemistry, in which the identity it acquires is forged in a modern/colonialist matrix, reflects what Enrique Dussel (1993) pointed out when he established a reading of modernity based on an understanding of a modern civilization that is perceived as more "developed" and "superior", as if such superiority would oblige it, as a moral requirement, to develop the more "primitive". Thus, for modern thinking, as the barbarian would oppose the civilizing process, modern praxis should, if necessary, use violence to destroy the obstacles to modernization. Finally, for modernity, the victims formed would be interpreted as an inevitable act, since the "barbarian" would be blamed. The fact is that over the following centuries, chemistry, with its achievements, was built on the model of the triumph of those modern progressive ideals. However, we know that part of those ideals has been drained and the products of chemistry are key players in this exhaustion (MOCELLIN, 2015).

Chemistry in the 19th century came to be seen as a respected and prestigious profession, and is each way and more, breaking itself away from the prejudices of alchemist practices. Its identity was that of a mirror science in positivist terms, with multiple capabilities and at the service of science and industry. In this century, a new theorization of chemistry emerged, that of substituting one element for another in a given compound, would become known as organic chemistry, of which its products aroused industrial interest and thus the construction of molecules would open up a new field to be explored: the chemical industry. The 20th century was marked by an interest in different materials. If historical periods were once classified as the Stone Age, the Iron Age, the Bronze Age, this one will perhaps be marked by the Rubber Age, the Aluminum Age, the Silicon Age, the Plastic Age and all the variety of materials sought by anthropocentric industrial interests. Bernadette Bensaude-Vincent and Isabelle Stengers (1992) point out that a new industrial logic emerges in this context, that of finding materials that perform a certain function, which ends up redefining the identity of industrial chemistry.



Next, we'll talk about plastics, those seen by green turtles (*Chelonia mydas*). Plastic as an almost naturalized material - in rocks and in minds - is the point of dissembling that we will include as one of the milestones of another historical moment, or even geohistorical, since the authors (BENSAUDE-VINCENT; STENGERS, 1992) approach the historical narratives of Chemistry until the middle of the 20th century. As follows, we will approach the moment that comprises the identity and territory of chemistry in the 21st century. The volume "Inhabiting the ruins of the Anthropocene" is about thinking about how the development of chemistry knowledge has forged products/effects to the point of defining a new geological era, the Anthropocene, such as the fragments of mineralized plastic seen by green turtles (*Chelonia mydas*) on Trindade Island. Are they inhabiting the ruins of the Anthropocene? We will approach this period as the presentification of chemistry in today's environmental problems, in other words, we will present the space it occupies inside the geography-knowledge field after the industrial revolution and the Great Acceleration.

### **Inhabiting the ruins of the Anthropocene**

Mark Fischer (2022), in "Capitalist Realism", tells us that "An ideological position is never really successful until it is naturalized, and it cannot be naturalized as long as it is still thought of as a value, and not as a fact" (p. 34), therefore the author makes a distinction between what is "real" and what is understood as "reality". Based on Lacan, Fischer (2022) argues that the Real would be what reality would like to suppress, so we understand the Real to be an "unrepresentable x, a traumatic void that can only be glimpsed in the fractures and inconsistencies in the field of apparent reality" (p. 35). Capitalist realism, an ideological intersection of reality, in which a naturalized understanding that there is no "way out" for capitalism, provokes us to foresee and foretell this understanding in the context of discussions that mark the notion of the Anthropocene. The techno-scientific productions of recent centuries have taken as their starting point a reality that, when we call it "capitalist/colonialist" and point to its foundation in a project of "modernity" that unleashed a developmentalist way of life, causes us to feel unease. When we start to question these prevailing ideologies, new possibilities emerge. Possibilities for understanding that the way we live our lives, based on such ideological biases, is a distortion of the Real.

What we call the Anthropocene, as a controversial classification for the Geological Era, when confronted from the perspective of other species, leads us to an understanding that many other species have been living in the ruins of the Anthropocene for years, and many others have already become extinct - as Goulson (2021) reports, referring to insects. The multiplicity of existences on





the planet is constantly challenged by the creation of hyperobjects that we continue to produce, stimulate production uncritically and consume - like a small plastic green turtle - not from the island of Trindade, but bought for 12 reais at Shopee. This hyperobject has a purpose - the relief of stress probably caused by the capitalist/colonialist way of life on which the project of modernity is based. You only have to squeeze the Shopee's plastic turtle to feel the synthetic polymers working satisfactorily between your fingers, at least for human stress. The smell of these synthetic polymers is also very distinctive, triggering a whole shape of memories that take us back to all the other plastics we've lived up with - since forever. Can a plastic turtle swim to where the rocks are made of the same material as it?



Picture 1 – La tortuga.

Source: the authors (2023).



According to the authors Bernadette Bensaude-Vincent and Isabelle Stengers (1992) the first time the term "plastic" was used was in 1909, when the chemist Leo Hendrik Baekeland referred to the classification of substitute products for natural compounds. The manufacture of the first plastic material resulted from an interest in finding a substitute for ivory in billiard balls. Two processes were used to obtain polymers: polyaddition and polymerization reactions, which consist of juxtaposing two molecules after opening the carbon cycles, and polycondensation, when two molecules are joined by eliminating a third. In 1939, research into polymers thrived and a race for plastic materials began. Plastics emerged strongly all over the world as substitutes for glass, wood and steel. The image of chemistry at this historical moment, with plastics, would be that of a "protector of nature", as it could synthesize materials to save the life and diversity of animals, even if it was already alarming us about the consumption of fossil-based materials for their production. How can we save a nature that we have chosen not to be part of? The one that we have chosen to use as a dumping ground for inputs. How can we protect nature with a science that has become a fundamental factor in the disintegration between human beings and the very notion of nature? As unwelcome guests, we accommodate ourselves and reshape it - indiscriminately, as Darren Aronofsky provokes in *Mother* (2017).

With regard to plastics, Zalasiewicz et al. (2016) conclude their research by stating that they are already present in sufficient numbers to be considered a technofossil and that they will form a record of human presence on Earth. The Anthropocene, or even its heteronyms Capitalocene, Plantatiocene, inaugurates the era in which humans situate themselves as a geological force and compete with other natural forces, human and non-human, for the impact and transformation of the planet. These human interventions, or those of some humans, raise the question of mapping, or even carrying out a kind of genealogy, for looking for the markers and conditions that allowed such unsettled problems to emerge. We will use the terminology "Anthropocene" as a conceptual key to address the environmental problem and present the territory of chemistry in contemporary times.

The Anthropocene Working Group (AWG) defends the Great Acceleration - and its abundance of oil - as a likely synchronous marker. There are also other contestants, such as technofossils: plastic, metallic aluminum, concrete and the decay of plutonium, which play a part in the characterization of this new geological era (SILVA et al, 2018; 2020). These technological materials are likely to exist in the future, as potential markers of the Anthropocene, given that these materials did not exist before human and industrial activities.

The arrival of the Anthropocene shows an almost apocalyptic scenario of human capacity to alter



the environment to such an extent, as in the case of the concentration of carbon dioxide in the atmosphere, that it would take life and living on the planet to another condition and adaptation. This prediction comes to terms with what Tsing (2019) theorizes about life adapting to create other ways of existing ahead of the consequences of these anthropocentric ways of life. What will the spawning of green turtles (*Chelonia mydas*) on Trindade Island be like? Along with plastics, the rates of carbon dioxide and other inorganic substances that act in an ecotoxic way, produce effects to the point of affecting living organisms, and are registered in the geological and historical composition of the planet. This action is engendered and potentiated by modern lifestyles and industries, linked to political and scientific dynamics driven by the desire for development and progress, in which Chemistry, with capital letters, plays a leading role.

The historical efforts and disputes to establish the territory of chemistry, especially industrial chemistry, have enabled us to transform nature in such a way that these changes have had significant environmental and social impacts, including creating the Planetary Boundaries (PB). Of the nine proposed limits, including: loss of biodiversity; climate change; biogeochemical cycles (nitrogen cycle, phosphorus cycle); land use abuses; ocean acidification; changes in water use; ozone layer degradation; aerosol loading into the atmosphere and chemical pollution, some have already been exceeded, such as climate change; loss of biosphere integrity; changes in land use and biogeochemical flows (phosphorus and nitrogen). Of these, climate change and the integrity of the biosphere are considered to have the potential to take the Earth system to a new state. And if the limits of climate change and biosphere integrity are exceeded, this will have a major impact on the whole system.

For Silva and Arbilla (2018), these limits are not just a way through to keep us at a safe distance from their critical value. These limits demonstrate the capacity that some humans, along with Integrated World Capitalism (GUATTARI, 2012) of production and consumption, have to alter and modify the biogeochemical and thermodynamic structure of the planet. We create limits to keep us safe from ourselves, from our own activities, desires, ambitions and modern vanities. We colonized Trindade Island with the result of polycondensation reactions, initially out of a desire to protect nature, which is now faced with fragments of plastic embedded in rocks.

As Stengers (2015) points out, we are on hold during this period of announced catastrophes. And if Chemistry disputes this historical, geographical, social, political and economic space, its educational processes can pay a special attention to these issues, and constitute it with plural ways of doing and consuming science, as well as being and living in society, in order for diverse knowledge and ways of existing and resisting coexist.



Our contribution to these historical narratives is to include the problem of the Anthropocene in the dispute over the identity and territory of the science of Chemistry, and to reflect on a Chemistry Education that presents-inaugurates-tensions strategies for dealing with these environmental issues.

Those issues should be part of projects and research in order to highlight the responsibility that scientists, educators, especially chemical educators, have in relation to which kind of tomorrow is to be expected (SILVA; ARBILLA, 2018). From this, we theorize about a minor chemical education.

Sales and Rigue (2022) write that in contemporary times "[...] we are living in the midst of turbulence, in which the Anthropocene is combined with the excessive positivization of neoliberal tactics in different instances" (p. 126). These tactics subjectivize bodies by cultivating habits, perceptions, among many other ways of perceiving, living, coexisting and experiencing the world.

It is important that we recognize that there are also multiple risks in the naturalizations of existing that we have cultivated in our habits of living in neoliberal society: the excessive positivization of life; the hyper-attention that is increasingly fast and instantaneous, combined with the false sense of freedom; the understanding of health as the opposite of illness; the reduction of the dimension of living to surviving; the reduction of educational practices to the consumption of information as merchandise (SALES; RIGUE, 2022, p. 126).

The Anthropocene - which feeds back on the production of tired bodies, like 'zombies', "[...] that cannot tolerate (...) so much enjoyment of life. So they preach the end of the world as a way of making us give up on our own dreams" (KRENAK, 2019, p. 13). Dynamics that continuously need to feed the desires of a system (such as the school system) to the detriment of vivid learning with direct and visible impacts on life, can also lead us to think about other investments in education, such as "[...] micro-political vibrations of care. (...) educational processes that are also open to metamorphosis: an education that is possible to inhabit" (SALES; RIGUE, 2022, p. 126).

Our bet is to think about minority chemistry. To think, as Lapoujade (2017) says, in order to later then take- a "[...] risk in the indeterminate, without knowing for sure where the connections will lead us" (p. 80). A risk, a threshold, that presents a confident body willing to act. Awakening (KRENAK, 2019) and acting in an already established world, with the hope of cultivating new things, variations that allow uncertain signs to emerge, but filled with a sense of confidence.



The Anthropocene marks serious discontinuities, what comes next will not be like what came before. I think our job is to make the Anthropocene as short and tenuous as possible, and to cultivate, with each other, in every way imaginable, times to come that can rebuild refuges (HARAWAY, 2016, p. 2).

Willing to open up our curious desires, we will now weave the tomo-vacuole "Tracks of a minor chemical education", in order to address some clues and hints that allow us to compose possibilities for a minor chemical education. Shifts in favor of postponing the end of the world, as Ailton Krenak (2019) suggests. Cultivating new conventions, in other words, appeals to the indeterminate with the intention of increasing our powers and rhizomatizing them, to the detriment of contracts and performances that determine content by limiting their powers (LAPOUJADE, 2017).

### **Tracks of a minor chemical education**

Disconnect them for the sake of a new connection  
(DELEUZE, 2010, p. 93).

Based on Deleuze's (2010) invitation, we set ourselves in motion to inaugurate possibilities in chemical education. It's important to point out that the notion of education that affects us is "[...] any movement that produces a change. A movement of thought, a movement of the body, a movement in space" (CORRÊA; PREVE, 2011, p. 187). Movement, therefore, is not limited to a notion of teaching and learning restricted to school spaces. We are interested in an "[...] education that inaugurates invitations - spaces of thought - beyond notions and skills that respond solely and exclusively to neoliberal, market and life-machining demands" (SALES; RIGUE, 2022, p. 126).

The problem of the Anthropocene emerges with the concern of how the knowledge and performances of chemistry act on environmental, social and subjective issues, and what other knowledge, practices, techniques and policies can emerge to think of anti-modes of actuating in chemical education, with regard to the advent of the Anthropocene. In addition, we seek to:

[...] think the unthinkable, the untreatable, the impossible, the unthought of educational thought. To scramble the syntax and organize thought in a backwards logic, constituting another way of thinking about education. The Thinking that ignores received truths, metamorphoses the value of established opinions, seeks to suspend and transvalue the value of all inherited values. It frees itself from the cult of totality, transcendence,



dialectics, metaphysics, humanism, as well as from the tensions of right/wrong, guilt/punishment, good/bad, death/life. It skips from single thought to make singularities possible, to affirm the multiple, to multiply a series of transformations (CORAZZA, 2002, p. 31).

In "A genealogy of Chemistry Teaching in Brazil", Rigue (2017) sets out to investigate the forces that contributed to the emergence of Chemistry as a compulsory subject for all young Brazilians. Through a genealogical panorama (FOUCAULT, 1979), she displays a game of power involved in establishing this science as a discipline in Brazil, and also its first manifestations, in order to identify and understand the conditions of possibility that made it emerge in the curriculum as Chemistry Teaching for all young Brazilians. Some of the main relations of power are: investment in the Space Race; the popularization of the notion: Education for 'all' through individualization, which operates on the basis of Systems Theory; International Agreements; War and Information Technologies; the Propaganda/Subjectivation effects of State campaigns and World War I and II (RIGUE, 2017). In addition, Chemistry emerged from the interests of a Brazilian elite, marked by the dynamics of the State and the technologies of War, since "Chemistry teaching is closely related to a game of power which transforms people as 'all' active in a productive system" (RIGUE, 2017, p. 136). The study focused on the relations of power that institutionalized school chemistry in Brazil, based on theoretical foundations with a post-structuralist bias. Due to this, it allowed us to think about the field of Chemistry schooling from sources and inspirations from other fields of knowledge, such as politics, philosophy, economics, history, among others. A number of questioning therefore were risen from the research:

[...] this research echoes the desire to understand how it is possible to think of educational processes that serve the desiring, unprecedented productions that, ironically, are in the hands of these same young people, reduced to becoming productive citizens? How could we see all the current educational tools at the service of young people's living issues, not reduced to solving questions in exams? How can we detach this youthful potency from the effects of disciplinary power and state control? How could we, from this perspective of seeing chemistry teaching in Brazil, give greater importance to meetings at school, with the same intensity that this study has had on my life? Each and every one of us, 'We are in the same boat' (p. 137).

From the willingness to procreate duce good encounters in education (CORRÊA, 2014), this study asks questions that are far away from modern schooling precepts. On account of that, it raises



possible splittings in the pedagogical approach combined with the dual teaching-learning that has involved chemistry in national schools.

When we think about the field of chemistry education, we have theorizations that help us to work with problems such as the one we have presented so far. One example is "Cordial Content" (OLIVEIRA; QUEIROZ; 2017), which proposes the pedagogy of certain school and curricular chemistry content with the intention of addressing issues aligned with Education related to Human Rights Education. Another series of studies are based on "traditional knowledge", "popular knowledge" or, as we prefer to say, according to the anthropologist Manuela Caneiro da Cunha's (2007) term, "traditional sciences". These work studies, like the one mentioned above, have important points on rethinking the chemistry that is taught in schools. Those are questions about Education for Ethnic and Racial Relations, issues related to sexuality and gender, among others, which are proposed in the rethinking of institutionalized Chemistry Education. Such research is valuable and provides echoes in the space with which it seeks to establish links. When we talk about minor chemistry, however, we are thinking about knowledge related to the transformation of substances without necessarily taking a school-based chemistry as a reference. This article seeks to experiment with writing that stimulates ways of constituting knowledge, resisting and existing, with the aim at addressing the "[...] possibility of a non-barbaric future" (STENGERS, 2015, p.67).

Powerful initiatives for thinking about the field of Chemistry and Science Education - breaking down modern and disciplinary ideals - came up as a Workshop in the "[...] Research-Teaching Group of the Technical Literacy Center (NAT) of the Education Center of the Federal University of Santa Catarina" (PREVE, 1998, p. 107). In this area, it was possible to identify the presence of experiences and practices that verified the production of different studies involving the field of schooling and, accordingly, the training of future teachers. One of these studies was the master's essay in education written by Corrêa (1998) and, as he writes, the power of the Workshop is to cultivate the development of people: [...] capable of creating situations of dialog with people interested in what is being proposed. The use of these strategies aims to break down hierarchies both between knowledge and between people, which would lead to non-authoritarian educational situations (CORRÊA, 1998, p. 70).

From this initiative, subsequent studies were attainable, such as Rigue's doctoral thesis in Education (2020), which comprehends that the workshop is a singularity in the training of chemistry educators, that is to say, a chance to "[...] experiment, open up and rhizome the power of educational work, without requiring the erasure of the body and the will, whether of the student's or the educator's" (p. 256).



Yet, within the scope of Science Teaching, Fary's doctoral thesis (2021) sought to understand knowledge, practices, techniques and policies in order to think of other ways of mobilizing Chemistry Education, at the heart of the Anthropocene problem. In these strategies, based on Narrative Research and interviews with alchemists-witches-scientists who work with agroecology and natural cosmetology, actions are mapped to reactivate, rescue, reappropriate, regenerate, and all the polysemy of Stengers' "to reclaim" (2017); the resumption of the practices of the diversity of chemical know-how. Through their life stories, we discussed the ways in which they exist and resist in the Anthropocene. These women operate around a minor chemistry, a strategy for thinking about a deterritorialization of modern chemistry, and a terrain for mobilizing chemical knowledge in order to act on it in the collective and create political diffusion.

Beyond perspectives that dialogue with institutionalized models of education, the exercise of immanence invites us to learn from experience, from the different voices that inhabit the world and build survival strategies - they set out substances, cause transformations and inhabit the world on the margins. We also understand that this perspective produces discomfort, after all, we always refer to the transformation of substances as Chemistry, and understanding that this is due to the attempt to hegemonize one kind of knowledge over so many others can generate a kind of anguish. Let's embrace the anguish and the understanding that Chemistry knowledge, especially with modernity, is a knowledge that is consolidated from the absence - silencing and erasure - of many other knowledges, bodies and territories.

It is based on the dispute over the terrain and identity of chemistry within the scope of the Anthropocene that we theorize with the concept of the minor, elaborated by Gilles Deleuze and Félix Guattari (2002), about a minor chemistry education. The authors approach the concept of minor literature from the literature of Franz Kafka.

For the authors (DELEUZE; GUATTARI, 2002), minor is not linked to a sense of smallness, or any relation to insignificance or belittlement. But as a concept that possesses a certain marginality and co-creative resistance. In regards to that, we have made a conceptual shift away from minor literature (DELEUZE; GUATTARI, 2002). Besides, we also emphasize the concepts of minor education (GALLO, 2002; GALLO, 2013); minor environmental education (INOCÊNCIO; OLIVEIRA, 2021); minor biology (SANTOS, SILVA, MARTINS, 2021); among others, which provide horizons of possibility and mobilization of the 'minor' concept in chemistry.

We are interested in a minority movement, a molecular movement:





[...] minorities and majorities are not distinguished by their numbers. A minority can be larger than a majority. What defines the majority is a model to which one must conform: for example, the average European adult male city dweller (...) whereas a minority has no model, it is a becoming, a process (DELEUZE; GUATTARI, 1992, p. 214).

The concepts of "molar" and "molecular" can cause some ambiguity, as - in a text about chemistry - the same words lead us to other understandings and conceptual operations. Here we take the meanings listed by Deleuze and Guattari (2002) when they state that:

Every society, but also every individual, is therefore crossed by two segmentarities at the same time: one molar and the other molecular. If they can be distinguished, it's because they don't have the same terms, the same correlations, the same nature or the same type of multiplicity. But if they are inseparable, it's because they coexist, they pass into each other, in different ways, as in the primitives or in us - but always one presupposing the other. In short, everything is political, but all politics is both macro-political and micro-political (p. 90).

To co-create a minor chemistry is to organize chemical thought based on our relationship in/with/through the world. Therefore, it is crucial to abandon the idea of understanding chemistry knowledge based on contracts and the abstraction of concepts. Thinking chemically from a smaller perspective also requires abandoning prescriptions, recipes and scripts to open up situations with students. It's essential to get rid of the ties and ideals that have already taken root in the school-disciplinary-curricular-methodological field, and heading to cultivate new routes, trajectories and experiences with the living beings.

While the school machinery, for example, operates in a molar logic: public policies, standardization, schooling, evaluations, performativity, competitiveness, visibility, hierarchies, bureaucracies and other measures that reproduce the abstract logic of a model at several levels of society; molecular practices operate by deviation, singularization, breaking the model and evasion, lines of flight... This does not make the relation between these "forms" of education (molar and molecular) a mere opposition or dichotomy, because they are inverse terms, but asymmetrical, and can establish different power relations between them, and can even coexist (AUGSBURGER; CERVI, 2016, p. 885-886)

Singularities! School can become this territory for mobilizing minor chemistry, but it is important to consider that minor chemistry exists/emerges/pulsates regardless of school and schooling systems.



Minority chemistry doesn't want to be bigger, given that the unity it deals with becomes empty, totalizing and pretentious. Minority chemistry is molecular, relational, and cannot be reduced to a discursive contract guaranteed by laws, norms, syllabus and other standardizing documents. Molecular chemistry is circumstance, an encounter between beings.

Tsing (2019), commenting on the clues that Matsutake collectors follow, tells us: "[...] not all clues are good guides. How many times have I found a protrusion in the ground that, when pressed, brought out only air: a mole's tunnel!" (p. 39). Like Tsing, we list clues that we call tracks - the tracks of a green turtle that can show us the place chosen for life to live in efficiency, but tracks that can also lead us to mole holes. Following the tracks carefully, noticing the encounters, those who have passed before us, the more than human relations (human and non-human (RIGUE; SALES, 2022)), are part of what has provided the writing that follows - not as a certainty, but in the dwelling of uncertainties.

To outline considerations about minor chemistry, we follow the line that Gallo (2013) defines, based on the philosophers Gilles Deleuze and Félix Guattari who relate Kafka's literature as a minor literature, we have some characteristics:

The first of these characteristics is the deterritorialization of language. Every language has its territoriality, it is in a certain physical territory, in a certain tradition, in a certain culture. Every language is immanent to a certain reality. Minor literature subverts this reality, disintegrates this realness, tears us away from this territory, this tradition, this culture. [...] it leads us on searches, to new encounters and new escapes. Minor literature always leads us to new forms of working as agents. Its second characteristic is its political branching. It's not that minor literature necessarily has a political content expressed directly, but it can only be political because of the agency it is. Its existence is political: its act of being is first and foremost a political act in essence. (...) For minor literature, the very act of existing is a political, revolutionary act: a challenge to the established system. The third characteristic of minor literature is perhaps the most difficult to understand and to identify, in some cases. In minor literatures, everything acquires a collective value. The values no longer belong to and influence the artist alone, but rather the entire community. A work of minor literature does not speak for itself, but speaks for thousands, for the whole community (GALLO, 2013, p. 62-63).

Based on these theorizations about minor literature, in order to think of minor chemistry as a device for reflecting on minor chemistry education, we have adapted the main characteristics of this theorization to the field of chemistry.



Thus, minor chemistry is characterized by three axes: a) a deterritorialization of modern/colonialist chemistry; b) a political branching; and c) the use of a collective agency.

Hence, as a device for creating meanings around training processes, we theorize about minor chemistry education, which goes beyond the school space, as it affects being, living and acting in society to become aware of the synergistic impacts on health - ours and the rest of the environment of which we collectively build and are built from.

Minor chemistry education, as a strategy to scrutinize and sensitize the present moment, can help us think about the political uses of chemistry knowledge to mitigate the effects of the Anthropocene. And thus constitute knowledge that leads to scenarios that are not sickened by the captures of modern/colonialist/capitalist subjectivity. In order to systematize the theorizing about minor chemistry education, we have listed a few tracks.

Track 1 - A minor chemistry education is desirable.

Track 2 - An education for minor chemistry is rhizomatic, horizontalizing and with social, political, environmental, affections, and...and...and...

Track 3 - Minor chemistry education is collective and micropolitical.

Track 4 - A minor chemistry education is deterritorializing industrial chemical notions that contribute to chemical pollution for the Anthropocene; a non-conformist chemistry.

Track 5 - Minor chemistry education is not a commodity.

Track 6 - Minor chemistry education is not institutionalized and institutionalizing.

We have cultivated some molecular tracks of thought that allow us to hope for possibilities in chemistry education. Tracks as clues for us to act in a collective present, threatened by scientific practices captured and exploited by the totalizing, homogenizing discourse of progress and development, which makes unsustainable living in the world with living beings.

Deviating from the dominant ways of thinking and acting in the Anthropocene is an urgency in the face of the evils of modernity and coloniality. Minor chemistry education cannot be reduced to a discursive contract guaranteed by laws, norms, syllabus, among other totalizing documents with a normalizing character. A minor chemistry education is circumstance, an encounter between beings - human and non-human (RIGUE; SALES, 2022), a possibility in the midst of the advent of the Anthropocene, or even in the midst of hesitation. As Donna Haraway (2016, p. 142) points out, "Perhaps 'The Hesitation' is a more appropriate name than Anthropocene or Capitalocene! 'Hesitation' will be engraved in the rock strata of the earth; in fact, it is already written in the mineralized layers of the earth." As long as we remain immobile, producers of imbalances that reach



the turtles - sentinels of the seas - our hesitation will continue to make up the layers of plastic rocks observed by the green turtles (*Chelonia mydas*) on Trindade Island. Just like turtle hatchlings that break out of their eggs and hatch after incubation, together we removed the sediment that had immobilized us. A moment of hatching - about to explore the open sea - marked by the unpredictability of encounters.



Picture 2 – plastic-turtle-plastic.  
Source: the authors (2023).



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[4] "In a writing workshop it is possible to experiment with the different procedures that make up the writing process - you can try them out on different supports, different ways of connecting them to the body - but it is always good to remember to bring them back to writing, it is in it and with it that action and experimentation need to be done" (PONTIN; GODOY, 2017, p. 1569). Thus "[...] opening up spaces for words to be placed one by one, attempts and repetitions, processes and duration, to sketch out a writing, to trace it, to execute it" (PONTIN; GODOY, 2017, p. 1560).

[5] As Kastrup and Caliman (2023) write, "Separating mind and body can be one of the effects of disciplinary social practices such as those at school, which often end up building disembodied and abstract knowledge" (p. 35).

[6] "Experimenting is trying to answer constantly unasked questions in the best possible way" (LAPOUJADE, 2017, p. 78).

[7] To find out more, we suggest reading the article 'A genealogy of Didactics through the lens of initial Chemistry teacher training' (RIGUE; CORRÊA, 2021), which presents the play of forces that shaped the establishment of Specific/Special Chemistry Didactics in Chemistry teacher training courses in Brazil. The proposed analysis follows the historical line of the conformation of a notion of Didactics from the perspective outlined by Comenius (2006), going through the production of archives that materialize its development on the national scene, until the displacement of General Didactics, from Pedagogy, to Specific/Special Didactics, present in the other degrees. The interweaving of these forces follows the emergence of Specific/Special Chemistry Didactics on the Brazilian scene, with the inheritance and promise-slogan that mastery of didactic techniques would guarantee the training of a teacher capable of teaching everything to everyone.