Searching for a path, looking for guidance

Asking the question of whether science could be different is turning our gaze toward the future. Science is the way in which human curiosity and creativity are channeled, through the development of new practices and concepts, to enable us to better understand the world. At its core, science has a perpetual engine for its renewal and improvement, in a process with no end. We cannot predict how the science of the future will be, but we can stay assured that it will have new elements that are not part of current scientific practices.

Two possible attitudes can be taken trying to address such a question. One is a prescriptive attitude, trying to define abstractly what science is or what it should be. The other is a descriptive attitude, recognizing that science is what emerges from its practice and cannot be defined a priori. These two attitudes coexist and are necessary to each other. It is impossible to prescribe how science should be without knowing in detail its development and its practices. Similarly, the exercise of describing scientific practices cannot be an end in itself but must be functional to the understanding and improvement of science.

If we want to try to describe how science can be different, we can start from the description of what science is and has been. We may be lead to think that we may disagree about what science should be and become, but not about what it has been. I would argue that, on the contrary, there can be different perspectives on the history of science, and the recognition of the multiplicity of perspectives can make our discussion about the future of science richer and more interesting.

Another distinction we can make is between considering science from an epistemological or from a historical and sociological point of view. In the first case, we are concerned strictly with our knowledge of the world, its nature, and the method we use to acquire it. In the second case, we immerse ourselves in the practice of science, entering laboratories, salons, universities, and institutions. When we ask ourselves whether science can be different, we often implicitly think of this second case. Science, as a human enterprise, follows the events in the development of society. In this context, we can ask ourselves what factors have stimulated great scientific developments such as ancient Alexandrine science or modern Enlightenment science. Or we can ask ourselves what social structures have influenced the demography of scientists. Or we can ask ourselves what relationship exists between the capitalist society in which we live and the development of the so-called "Big Science," which requires enormous capitals and often alienates the researchers who contribute to it.

This distinction can be useful. It allows us to distinguish between causes and effects, between what is intrinsic to the way we describe and understand the reality of natural phenomena, and what is contingent on human doing in a particular place or period. On the other hand, it is easy to realize that the contingencies of our scientific practice determine the methods we use, and even the concepts to which we have access. Today, we tend to refer to the reflection on science as "Science Studies," leaving fluid the characterization in terms of the specific disciplines: philosophy, history, sociology, psychology, politics… Again, to be able to talk about

epistemology, we cannot avoid broadening our gaze and confronting aspects that are not strictly scientific, that have to do with social relationships, power relationships, the way we organize work in teaching and research, and the way our institutions function.

Let us acknowledge the vertigo that we must confront: to speak about science consciously, we must embrace the complexity of the world - a rather terrifying task, that even scientists themselves often prefer to avoid. When we feel lost because we are faced with a great task, it is a good practice to familiarize ourselves with those who have already successfully tackled it. Just as in science we stand on the shoulders of giants to try to take a new small step ourselves, I believe it is essential to know a recent revolution that has changed and is changing the way we think about science, and above all, the way we do science. I want to provide a taste of it in these few pages, with no claim of exhaustiveness, but rather trying to indicate a path to approach the question "could science be different?".
It is time to say the f-word, that terrible word so demonized, opposed, and distorted, that even those who recognize themselves in it often prefer to avoid it. And yet not using it is a betrayal of the life and work of a multitude of people, and of the revolutionary scope that it has had. Yes, feminism has had a revolutionary impact on science. Here are some examples. There seem to be several aspects to highlight, which make feminism in science a particularly interesting case to discuss. One, quite obvious, is that thinking about the rights of a group that represents more than half of humanity but is a minority in science can provide important clues as to how science can change when prejudices fall and the demographics in science begin to change. Another is the richness of feminist thought about science, which is not limited to a generic critique of past science, but builds on it to suggest what it means to do science as feminists. And, above all, the proof of the pudding: we can discuss concrete examples of how feminist thought has already contributed to creating a different science, starting from practices and moving on to epistemology. If we want to get to epistemology, let us be led by feminists.

Challenging narratives

Before delving into the discussion on science and feminism, we cannot avoid the issue of the absence of women in scientific research. It is a revealing issue and a good starting point. I prefer to leave it to other readings to discuss how millennia of patriarchy have led to this.
Here, I want to start with today's data and from my perspective, wondering where women are in scientific research. For example, which country in the world has the highest percentage of women in the research world? The answer may surprise you. The first is Myanmar with 75.6%, followed by Venezuela with 61.4%, Azerbaijan with 59%, Mongolia with 57.5%, Tunisia with 55.4%... The first European country on the list is North Macedonia with 52.3%, while countries that prominently feature in the European scientific landscape in terms of resources and visibility

such as Germany, France, and the Netherlands only reach a measly 28.0%, 27.0%, and 25.8%, respectively. (The data I am reporting were collected by UNESCO. I am not reporting the United States since they have not provided their data, but from internal evaluations, we can deduce that the percentages are as low as those of these last European states.)

What these data reveal is that the conditions of research differ from country to country, and we cannot flatten ourselves on a narrative often dominated by the Anglo-Saxon perspective. If we think we understand the presence or absence of women in science solely in terms of a one-dimensional female emancipation, we risk falling into serious errors. (It may seem ridiculous, but there are really those who think that the fact that there are relatively few female researchers in a country like Sweden implies that women are inherently uninterested in science). The diversity of elements that contributes to these data and their variability from country to country tells us how difficult it is to talk about scientific research by making generalizations. The peculiarities of science that are attributed to it in one country may not be so in another. I have heard Iranian colleagues tell how they were drawn to research in pure mathematics as it was considered a suitable activity for women, akin to poetry, an intellectual rather than practical activity. I have also heard Italian colleagues tell how they decided to do laboratory research rather than theoretical research under the impression that practical work was more suitable for a woman than abstract work.

The lens through which we must look to understand these data is that of power relations: not only those of women in the society in which they live but also how science positions itself within that same society. What value does this society give to scientific research? What percentage of the country's gross domestic product is invested in higher education and research? With what respect does society treat its teachers and researchers? And how much does it pay them to work in research?

This is a case where the peculiarities of the scientific field are less relevant than the larger issues of power relations in the society in which we live. If we recognize injustices in the workplaces where science is done, I find it myopic to discuss how science can change without asking how society can change. We are faced with issues that have to do with rights and politics. One cannot timidly hide behind a circumscribed critique of research and the academic world when, in fact, the solution to the problems we pose requires shaking the foundations of the social structure of our world.

Finding women, understanding science

We have shifted our focus from the absence of women to their presence, not only by looking at geography but also at history. The more we investigate the history of science, the more we discover the hidden presence of women. Recovering the stories of female scientists is not merely a matter of curiosity relegated to some stories. These stories make us rethink the foundations of what we mean by science.

The contributions of women to scientific research have been diminished, treated as ancillary artisanal work, perpetuating the image of science made up only of abstract ideas and not practical knowledge. Examples of this are 18th-century scientists such as botanist Maria Sybilla Merian, known for her beautiful illustrations, or anatomist Anna Morandi Manzolini, creator of highly precise wax anatomical models. In the same period, we find important female scientists who were assigned roles as mere assistants, such as astronomer Maria Winkelamann-Kirch. In astronomy, the idea that women could perform "boring" tasks at low cost led to them being entrusted in 1887 with the massive amount of photographic plates that mapped the entire sky for the first time. We still know little or nothing about women like the four humble nuns of the Vatican Observatory who cataloged 481,215 stars by hand, while we have more information about the American women of the "Pickering Harem" at the Harvard College Observatory.

An important element of feminist criticism of science lies precisely in revaluing certain practices, traditionally excluded from the narrative of science, as an integral part of the construction of scientific knowledge. In fact, it is precisely in these practices that we find female figures excluded from institutions and the limelight of the news, yet still discovering and experimenting in the interstices of the research to which they have access.

There are a whole series of activities that have traditionally been practiced by women and from which women have been excluded when these activities have become institutionalized fields of scientific research. Examples of these are midwifery, nutrition, botany, ecology, pharmacology... and even chemistry, before it was called that. In an ancient alchemy book, it was written, "Whoever desires to investigate the secrets of the dogma, let him not fail to take as an example everything that can help him. Do you not see how a woman is accustomed to clean dirty clothes by pouring hot water over them? Follow her example, so that you may not fail in your art."

For those branches of scientific knowledge developed around traditionally feminine practices, the term gynocentric science has been coined. Recognizing knowledge and practices in this area questions the fragile borders with which we distinguish scientific knowledge from other forms of knowledge. In a society that recognizes the value of scientific knowledge, labeling knowledge and practices as unscientific has often historically served not so much to refine science, but rather to exercise power: gynocentric science is an example of this.

The danger we expose ourselves to when we try to harness science within reductive definitions and narratives is evident. Every narrative arises from the need to emphasize some new aspect of revolutionary importance, but becoming accustomed to such narratives pushes us to forget the cumulative aspect of scientific progress. How that body of practices and knowledge that we call science has been defined over millennia in a very long refinement process of which the

revolutions we speak of are just a passage. I refer, for example, to the narrative that modern science was born with Galilean experimental method: although the introduction of experiments has effectively revolutionized science, this does not imply that all prior knowledge could not be scientific. We can go through our wishlist for the definition of science and see when in history each element has been...
The danger we expose ourselves to when we try to constrain science within reductionist definitions and narratives. Every narrative arises from the need to emphasize some new, revolutionary aspect, but becoming accustomed to such narratives pushes us to forget the cumulative aspect of scientific progress. And how that body of practices and knowledge we call science has been defined over millennia, in a very long refinement process of which the revolutions we speak of are just a passage. I refer, for example, to the narrative that modern science was born with Galilean experimental method: even though the introduction of experiments did indeed revolutionize science, this does not imply that all previous knowledge could not be scientific. We can scroll through our wish list for the definition of science, and go back to see when in history each element was introduced. We can go back in time, to the mathematization of the world of Pythagoras or to the naturalistic explanations of the school of Miletus, or even further back to the detailed observations of the stars in Babylon. And perhaps we will end up at the beginning of time, at the essence of human beings so widely identified in the oldest and most diverse myths: in curiosity, the beginning of every scientific enterprise. If it is indeed so, I am happy to repeat the saying "curiosity is a woman" and to thank Eva wholeheartedly for having taken the forbidden fruit of knowledge.

“Has Feminism changed Science?”

If “curiosity is a woman,” can we also say that “science is a woman” as women do it? Feminists have posed this question. Is there a feminine way of doing science? When we consider so-called gender-centric sciences, can we find peculiarities in female ways of knowing and doing? And when we instead consider sciences traditionally dominated by men, can we think that changing the demographics would change the science as well?
The answer to this question can be found in a lot of feminist literature concentrated between the 1970s and the 1990s, and summarized in the text by London Schiebinger, “Has Feminism changed Science?”. In short: the answer is yes, and there are several examples of it.
Medicine and biology were the first fields to see the entry of women in research, leading to the current situation where women outnumber men in terms of university degrees. Women researchers (and men researchers who became aware of feminist issues) have exposed how models and results were affected by gender stereotypes. This is a typical example of how science becomes different - and better - when we recognize how archetypes and paradigms influence our way of creating scientific models, and even more so how this can influence the experimental

method used. It is interesting to look at the entire history of science done on the female body, from the reproductive system to the brain, with ideas that have been passed off as scientific and now appear simply ridiculous to us (see for instance Schiebinger's book “Nature's body” or the more recent Saini's book “Inferior”). Thus, on the one hand, we find pontifications on the female body that give a distorted image of it, while on the other hand, there is a lack of data in experiments involving these bodies, whether it be female lab animals or women in clinical trials. In this case, it is evident that there is simply a problem of "bad science" that can be corrected with the methods of science itself, by improving the sample of data used or by making the construction of models more objective by freeing them from the reins of prejudice.

Returning to the question of the feminine in science, in molecular biology, the example of Nobel laureate Barbara McClintock, described in the fundamental book by physicist and philosopher Evelin Fox Keller, “A feeling for the Organism”, allows us to try to glimpse what science might be like in a world where the feminine and the masculine can both be expressed. For McClintock, empathy and passion for the organisms studied are a fundamental vehicle for their holistic understanding: organisms, she says, must be “allowed to speak,” not dominated.

Empathy and passion are also found in the studies of the pioneers who revolutionized primatology between the 1970s and the 1980s. The stories of Jane Goodall, Dian Fossey, and Birutė Galdikas, their relationship with the primates they studied, and their struggle for the preservation of nature have reached a wide audience. But we must also remember Meredith Small, Linda Fediga, Sarah Hrdy, Jane Lancaster, Telma Rowel… All these scientists began to study the role of females in primate groups, studying their behaviors beyond the stereotypes that sought to find ‘justification’ for the iniquities of human societies in the societies of our primate cousins. Women observe the animal world with different eyes, approach it differently, and open up behaviors and dynamics that had remained “invisible” to their male colleagues. New eyes to see the world lead to a new and better science.

A similar path can be seen in paleoanthropology and archaeology. From the role of the "gatherer woman" in human evolution studied by Sally Slocum, Nancy Tanner, and Adrienne Zihlman in the 1970s, to the development of agriculture theorized by women such as Patty Jo Watson and Mary Kennedy, or from the criticism of the definition of what counts as an "instrument" discussed, for example, by Sally Slocum, to the importance of ceramics in the study of ancient civilizations emphasized by Rita Wright... In all these cases, the presence of a "critical mass" of women in the field - by which I mean, literally, in archaeological excavation sites - has revolutionized the history of our origins. Women have changed science for the better.

Let me hope that these examples (and perhaps some further insights inspired by them) have convinced you that feminism and female scientists have changed the method, direction, and results of science. It is precisely at this point that the thorny issue arises: to what extent can this be true? Certainly, when the sciences touch on our humanity, prejudices and value judgments are more likely to creep into our scientific practices. But doesn't 2 + 2 equal 4? When it comes to the

"hard sciences," it seems that feminists cannot contribute in any innovative way. Of course, one can admit that feminism can suggest an improvement in working conditions in physics or chemistry, or an improvement in the way these subjects are taught. But in the end, 2 + 2 = 4, chemical processes remain the same, the particles of the Standard Model do not change properties, and so on. Is this true? Not exactly... Where is the error?

I believe that the error of those who reject any discussion of gender when it comes to hard sciences is a philosophical error about the philosophy of science. When we think that the scientist's job is to "take a look at God's cards" or to explore a world of Platonic forms that are out there waiting for us to discover them, we are making metaphysical assumptions that stiffen our path towards discovering the world and could lead us astray.

Mathematics, which might seem like the hardest of sciences - also hard in the inflexibility of its theorems - is, in my opinion, the best example to start with. What mathematics is is the subject of philosophical reflection. Some believe that mathematical structures exist in themselves: mathematical structures do not depend on us, and the task of a mathematician is simply to discover them. Another way to see mathematics is as a creation rather than a discovery: when we do mathematics, we create new languages, new logics, and new worlds. I believe that this second possibility allows us to take a pragmatic attitude towards reality: nature is a book written in the language of mathematics not because reality is a Platonic incarnation of an independently existing mathematical world, but because the mathematical language captures aspects of the natural world. If we think of mathematics as a creative process, it is natural that it can depend on the imagination of the creator. Scientists draw on all their creative resources, determined by their experiences - including the gender dimension of their human condition.

An E-Quality Manifesto

Recognizing the innovative contribution that women have brought to scientific research and the presence of a gender dimension both in the organization of research and in science itself should not lead us to think that having more women in research and taking into account a gender dimension is all that is needed to have a different science. This is not the case. Prominent feminist philosophers such as Sandra Harding and Helen Longino in the 80’s have transformed the question from whether there is a specific feminine way of knowing (a question that could mislead towards unsustainable essentialist theses) to what it means to do science and produce knowledge from a feminist perspective (a question that is intrinsically inclusive in nature).

The answers formulated by feminist philosophers of science have produced valuable and impactful literature, whose main points can be summarized in the following commitments (building on Fedigan’s list of tools for gender analysis):

- making research more democratic,
- opening up the discussion of research priorities,

- eliminating research that exploits nature or other human beings,
- using a representative sample as data,
- being aware of the risk of extrapolation from one context to another,
- recognizing our values and beliefs,
- being honest about our assumptions,
- resisting explanations stripped of social and political context,
- being responsible in the language we use,
- questioning what counts as science,
- continuously rethinking our theoretical models,
- reworking and reshaping research tools as circumstances change,
- considering the institutional organization of science,
- understanding the gender dynamics in research contexts.

If you asked a feminist how science could be different, her answer would start with these points. And this is my answer to the question.

This summary of feminist demands in philosophy of science arises from the history, struggle, reflection, successes, and failures of women in scientific research. However, these demands have universal value and center on the heart of what makes science what it is. I want to emphasize in particular the provisional nature of what science finds. It is this aspect that allows science to change, correct itself, improve. This provisional aspect of continuous evolution is intimately linked to democracy. It is no coincidence that one of the key moments in the development of science, when men for the first time formulated laws for natural phenomena, without any mention of supernatural entities such as spirits and gods, occurred at the same time as men for the first time formulated laws for their coexistence, in the first parliament of humanity, without a law that was imposed by divine will.

Feminist reflection on science cannot be separated from the struggle for women's rights in society in the broader context. It is certainly a matter of equity. But this should not overshadow how feminist criticism of science is in fact a constructive criticism for a better science. The examples given above in different disciplines, from life sciences to hard sciences, show how the introduction of a new perspective, in this case brought by women, has simultaneously led to an advancement and improvement of science.

In epistemology, it is interesting to mention how this manifests, with an example taken from the rich literature of feminist epistemology. The example I want to talk about refers to the notion of objectivity. Women's experience has often been one of having access to elements of reality ignored by the dominant scientific community: either because they were part of the personal experience of being a woman, through their own body or experience, or because women had eyes to see relevant data that others had neglected due to prejudice, or because, forced as women to work in research directions not considered mainstream, they found space to investigate new unexplored domains. In all these cases, women bring a different, alternative perspective, and what is seen from such a perspective is just as true as what the dominant perspective had

pretended until that moment was certain and established. How to reconcile the fact that different observers can both possess (different) elements of reality with the notion of objectivity? Such a question can terrify the naive scientist! But even some more experienced philosophers may find themselves without the tools to reconcile this idea with a realist position that is solipsism-proof.
In feminist epistemology, a possible answer was given by Sandra Harding: "perhaps the notion of objectivity can be strengthened as a resource to enable researchers to arrive at less partial and distorting claims." Harding does not see the plurality of perspectives as a step towards relativism, on the contrary, it is precisely the collapse of a vision of scientific truths as monolithic that guarantees their objectivity. The plurality of perspectives, each leading to elements of reality, allows us to reconstruct reality as a mosaic, of which new pieces continue to appear, going on to compose a representation that is increasingly faithful to the phenomenon we want to understand. While perspectivism was accused of weakening objectivity, Harding coins the term "strong objectivity" to indicate how the plurality of perspectives, in communication with each other, allows us to improve our understanding of the world. This is a way of thinking about objectivity that resonates much better with contemporary science, for example with the trend in biology to describe living systems as processes rather than in terms of substances, or with the ubiquitous presence in contemporary physics of relational aspects, as in the case of the dependence of measurements on the observer in quantum mechanics. It is natural to think that many of the paradoxes discussed in these sciences could be resolved if a notion of objectivity like the one proposed by Harding were actually applied.

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It is possible for science to be different? Science has already changed, as our perspective on it has changed. In this essay we have taken the standpoint of women in science, and this has opened up new possibilities, new ways of engage each other interrogating Nature, and achieving scientific results. The path taken by feminism is now being followed by other communities that have traditionally been excluded from science due to racism, homophobia, xenophobia, ableism... or simply due to the economic disparities that are widening as never before in our society. Feminism, I believe, provides tools to address these challenges and to think collectively about the kind of science we want.