

1. Technologies in “making the invisible visible”*

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“What do you do Dad?” My son Jacopo was still little and, like all children, he was curious about his parents’ jobs, if for no other reason, to be able to tell his teachers and schoolmates.

“I work at the university.”

“Yes, but what do you do at the university?”

... ??? Well, now, err... What do I say now?

“I fix the boilers.”

*Certainly I could have told him the truth, “I’m a sociologist,”
but how would I have explained what a sociologist is?*

In actual fact, what is a sociologist?

*It isn’t easy to answer this question. But one part of the answer
might be that sociologists make the invisible visible. Obviously, this doesn’t
solve the problem because we still need to clarify what this answer actually means.*

A NON-EXCLUSIVE ACTIVITY

If we carefully consider this concept, it becomes apparent that *making the invisible visible* is not exclusive to sociologists. On the contrary, other academics, often more highly regarded, may describe their work in the same manner. Take scientists, for instance.

* “Making the invisible visible” is the translation of the title of the article published by Marina originally in Italian “Rendere visibile l’invisibile. Il ruolo della visione e dell’immagine nella costruzione di una storia delle nanotechnologie” (Maestrutti 2008).

Whether engaged in laboratory research, like molecular biologists or chemists, or exploring the Earth and space to observe their characteristics, scientists have developed various procedures with the specific purpose of illuminating the order underlying the disorder, a characteristic aspect of our experience of the world. Scientific research can be seen as a process of extracting *order from disorder*, as observed by Latour and Woolgar in their study of the laboratory (Latour and Woolgar 1979), enabling us to discern what the vague noise of our perceptions might otherwise overlook.

Some of these processes of *order-from-disorder* extraction reach such a high level of stabilisation that they are reified in artifacts, commonly known as *scientific instruments*. Their role is so crucial that science would not exist without them. One might say, “If you’re looking for scientific knowledge, follow the instruments.”

From the most rudimentary to the most sophisticated versions used in laboratories worldwide, microscopes enable us to analyse the structure and physiology of cells, various types of molecules, and even individual atoms, as seen in the nanotechnology sector with the atomic microscope, which utilises the so-called “tunnel effect” (Maestrutti 2011a; Neresini 2011). Telescopes and satellites have extended astronomers’ vision into the hidden depths of space, while advanced instruments like interferometers can detect imperceptible phenomena such as electromagnetic waves (Collins 2017). Particle accelerators, such as those used by CERN, make sub-atomic particles visible.

Actually, scientists are not making things visible in the way we typically understand this expression. Instead, they are transforming the signals they collect into what Latour and Woolgar (1979) refer to as “literary inscriptions”— that is, numbers, tables, graphs, plots, and even images. These representations digitally render the inputs visible according to theoretical assumptions and visual conventions (Latour 1987; Mody 2006; Maestrutti 2011a). For example, physicists don’t directly observe sub-atomic particles; rather, they observe the traces of their decay after a collision, during which the atomic structure within which they were organised is destroyed.

Thus scientific instruments can be seen as «reified theories» (Bachelard 1953; Latour and Woolgar 1979), contributing to building the world they allow us to observe. They cannot be considered neutral channels through which data representing reality flows to create an intermediary-free image. They are not “objective” in the sense of being “distortion-free”; if anything, the opposite is true. By providing access to a more in-depth vision, they embed and enable ways of building reality that we call “theories.” They make the invisible visible by making it perceptible through the simultaneous process of its construction. It’s not just a matter of recognising that “phenomena depend on certain material instrumentation; rather, the phenomena are thoroughly constituted by the material setting of the laboratory” (Latour and Woolgar 1979: 64).

As part of a socio-technical network, they enable scientists to both see and construct the world (Goodman 1978). Experimental apparatuses precisely create the phenomena that scientists study, as a lengthy transformation and purification process is needed for a

natural phenomenon to become an *experimental entity* (Hacking 1983) — an object whose characteristics enable it to be used in the *trial of strength* (Latour 1987) that takes place in laboratories (Neresini 2019).

The field of nanotechnology provides an illustrative example. Marina Maestrutti's exploration of the history of the scanning tunneling microscope, a tool with "ambiguous" characteristics, demonstrates that its crucial role in the founding myth of nanotechnology depended not only on its ability to make atoms visible but also on its capacity to manipulate them, though under highly specific and uncommon conditions (Maestrutti 2008).

Scientific instruments, such as those in nanotechnology, can be seen as specific instances of *objects* that populate our world and with which we continually interact. Objects, including scientific instruments, are essentially "congealed social agreements, or rather, congealed moments in the history of people acting together" (Becker 1998: 69).

Our interpersonal relations not only result in objects but also contribute to shaping our identities as participants in interaction networks, where objects play a role. Our interaction with these objects is so vital that they are constructed by us while simultaneously constructing us. Scientific instruments are thus part of the vast array of «non-human actors» (Latour 1992) with which we interact daily, and our existence, as well as theirs, is intertwined with this interaction. This profound dependency is better described as "intra-action," than "inter-action"; the former refers to the "mutual constitution of entangled agencies" (Barad 2007). Unlike the conventional "inter-action," which assumes separate individual agencies preceding interaction, the concept of intra-action recognises that distinct agencies do not precede but rather emerge through their relationships: "agencies are only distinct in relation to their mutual entanglement; they don't exist as individual elements" (Barad 2007: 33).

Scientists are, therefore, shaped by the instruments they use, and vice versa.

Yet, scientists do more than make aspects and dimensions of reality visible. Their work in "heterogeneous engineering" (Law 1987, 1991) reveals a world in the making. The construction of socio-technical futures and scenarios accompanies and, simultaneously, nurtures their research and innovation processes, becoming an integral part of them (Borup et al. 2006; Selin 2007, 2008; Jasanoff and Kim 2015; Konrad et al. 2016). Also in this sense, research materialises the invisible, projecting it into a future which can only be imagined.

Just as Diesel described in his book – *Solidarismus: Natürliche wirtschaftliche Erlösung des Menschen* (1903)¹ – the advent of the new world his engine would usher in while he was obtaining the patent for it (Latour 1987), Nicolas Negroponte's *Digital Being* (1995) foresaw what a society completely revolutionised by computers would look like. In the same way, what Erik Drexler imagined in his *Engines of Creation* (1986) contributed to founding nanotechnology research by prefiguring "the coming era of nanotechnology," namely a socio-technical imaginary in which nano-machines would have not only over-

¹ That is *Solidarity: Natural Economic Redemption of Man*.

come all the obstacles currently stopping them from coming to fruition but would also be the main players in a society revolutionised by their advent.

Niels Bohr argued that it is «difficult to make forecasts, especially on the future»: how can we contradict him?² It is precisely this which all scientists do, however, though at differing levels of intensity. Their reasons for doing so are clearly not bound up with the survival of an unresolved conflict between science and astrology, but rather on a perhaps unconscious need to safeguard the fragile knowledge they generate by giving it a time frame long enough to allow it to consolidate. When the facts are first “uncovered,” in fact, they are tentative because they still need to find a place for themselves within a context which did not previously contemplate them, being anyway ordered and stable. Also the world without the microbes before Pasteur was functioning and meaningful, and it is exactly for this reason that the microbes at *statu nascenti* were extremely weak and asking protection. The need to recruit actors to shore up the embryonic scientific facts derives from this, as does the importance of sounding convincing, even to the extent of prefiguring scenarios to make them credible and attractive. This is what the sociology of socio-technical promises and expectations teaches us (van Lente 1993; Konrad et al. 2016), and it is a lesson which Marina learnt and used very well. A considerable part of her work, in fact, focuses on the techno-scientific imagination creation process and its role in scientific research and technological innovation (Maestrutti 2007, 2011b, 2011c, 2016).

MAKING THE “TAKEN FOR GRANTED” VISIBLE

Making the invisible visible, at least in the context explored thus far, doesn't appear to distinguish sociologists in an exclusive manner from other researchers. However, sociologists approach it uniquely, employing an original perspective that guides their knowledge-construction process and defines their epistemological stance. For example, the distinct nature of their «sociological eye» (Hughes 1984; Becker 1998) becomes evident when scientists' envisioned futures are not taken for granted but become subjects of analysis. This involves illustrating their role in the scientific fact-building process and examining how these futures gradually materialise and gain credibility.

The significance of socio-technical scenarios lies in their ability to shape attitudes and drive behaviors in the present, anticipating a future where new scientific knowledge and technological innovations will showcase their solidity and utility. Consequently, these scenarios not only forecast what might be evident in the future but also familiarise us with what is not yet seen as obvious, portraying it as an integral and natural part of our world. When science is still “in action,” its facts remain uncertain, and their ac-

² It is not clear whether it was actually Niels Bohr who first said this, although it has been attributed to him since A.K Ellis's 1970 book *Teaching and Learning Elementary Social Studies* and this Nobel prize winner may have been repeating an old Danish adage.

ceptance—what makes them “ready-to-use”—largely depends on how convincing they appear to potential supporters. This aligns with one of the translation strategies contributing to the enlistment process within the «fact-builders» network (Latour 1987: 104): demonstrating the usefulness of one’s work to others, showcasing its ability to address urgent problems today.

In a similar vein, during their early stages, technological innovations desperately require an expansion of their network of supporters. However, even the most advanced prototypes, such as the initial engines crafted by Diesel with the collaboration of Krupp and MAN technicians (Latour 1987), find it challenging to achieve this goal. This is due to their often faltering performance, easily obstructed by even the simplest obstacles, and because their complete deployment hinges on certain conditions yet to be realised. Consequently, their only recourse is to project into a future where the innovation is fully consolidated and naturalised.

These are the mechanisms that the sociological eye highlights when scrutinising techno-scientific imaginaries and socio-technical scenarios.

Making the formation and functioning of the latter visible also enables sociology to demonstrate the existence of multiple and competing futures (Brown et al. 2000). Consequently, the future we typically envision is none other than the future that manages to emerge in a specific context and time. What sociology *makes visible* is thus a reflection of the precarious nature of what is considered solid, or at least credible. This is not for the purpose of sterile criticism but rather to pave the way for potential alternatives. The sociological eye implies distancing ourselves from the everyday taken-for-granted world, but it is precisely this distancing that renders it visible. The obscure material brought to light by the sociological eye is, in fact, concealed behind the *epoché* upon which our perception of reality rests.

Obviously, this problematisation of what is normally a-problematic does not apply only to socio-technical scenarios and future imaginaries. On the contrary, in the case of techno-science, this deconstruction has been applied by STS, above all, to scientific knowledge and “discoveries” as they emerge.

The endeavor of STS can be summed up precisely in this: making visible the multifaceted, time-consuming, unexpected, routine, messy, and fascinating construction work by which something initially weak and shaky is transformed into something as strong and commanding as a scientific fact. In other words, showing how a process whose outcomes are uncertain and dependent on specific circumstances can lead to knowledge capable of extending its existence and agency well beyond the limited confines within which it has begun to move. Quoting Latour once again, «facts and machines are like trains, electricity, packages of computer bytes, or frozen vegetables: they can go everywhere as long as the track along which they travel is not interrupted in the slightest.» For this reason, «every time a fact is verified and a machine runs, it means that the lab or shop conditions have been extended in some way» (Latour 1987: 249-250).

However, truly understanding the work of scientists, fully appreciating its trajectory, and raising awareness of its value and significance require sociologists to adopt a stance that is challenging to find and even more challenging to maintain. It involves carefully balancing the act of holding a sufficient distance to break up the suspension of doubt that characterises the everyday world of scientists, while simultaneously getting close enough to make this world understandable. Latour and Woolgar articulated this delicate balance well in their introduction to *Laboratory Life* (1979), where they reflected on the most suitable language for making the work of scientists visible. They proposed a “median” language that, on the one hand, avoids the technical jargon used by scientists in their articles and meetings and, on the other hand, retains the ability to take seriously what scientists say and do. This approach involves observing them closely—without obstructing their work—as they participate in assembling the heterogeneous networks upon which their existence, as well as that of the objects they construct (knowledge, tools, facts, and documents), depends.

Nevertheless, there are at least two additional realms where the fabric of everyday life unfolds, often staying beneath the threshold of visibility. These areas have garnered extensive attention from sociologists and scholars in science and technology studies (STS): one revolves around disability, while the other involves the heritage of material possessions and cultural resources subjected to exploitation and subordination through colonialism. What unites these spheres is their shared existence on the fringes of our perception, intentionally overlooked or deemed insignificant and undeserving of recognition.

Revealing the intricacies of scientists’ everyday lives requires a specific perspective aligned with the sociological point of view. However, there’s an inherent risk in this approach, which we might term the *temptation of deconstructing facts*. This risk involves deviating from the necessary detachment required to analyse the construction process in which scientists are involved and assuming an ideal privileged vantage point from which to critically scrutinise it. In doing so, there’s a danger of not only deconstructing scientific work but also eroding its value and credibility. The fact that scientists may take certain aspects for granted or overlook crucial elements for their work—such as the motives behind the funding of their research or the socio-political dynamics inherent in the scientific process—does not imply naivety, ignorance, or ill intent. It doesn’t mean that the knowledge they generate lacks credibility or is misleading. Instead, it simply signifies that they must suspend judgment on certain prerequisites to carry out their work. This condition is inevitable for everyone, and sociologists are no exception. The sociological eye is not a special case; it’s simply different from others.

STS has consistently paid due attention to and strived to take constructive account of this aspect in its research work. The commitment to integrate the co-production relationship between the observer and the observed into research practice was originally emphasised in the strong programme’s principle of reflexivity— that the patterns of explanation proposed by the sociology of scientific knowledge «would have to be applicable

to sociology itself [...] otherwise sociology would be a standing refutation of its own theories» (Bloor 1976: 7)— and is evident in the methodological proposals and ensuing debates it has inspired (Woolgar 1988; Collins and Yearly 1992; Callon and Latour 1992). Later, the imperative to not only make the observer-observed relationship explicit but also epistemologically productive was further emphasised by insights from feminist and post-colonial studies. Notable contributors to this dialogue include Haraway (1991, 1997), Barad (2007), Longino (1990), Harding (2008), and Verran (2002).

Resisting the *temptation to de-construct facts* is thus a fundamental aspect of STS and aligns with the median stance that sociologists strive to adopt for *making the invisible visible*. It involves a delicate balance not only between maintaining distance from and engaging with the social worlds under study but also between essentialism and relativism. This refers to the tension between those who deny the inherent relationship upon which both the observer and the observed depend and those who attribute it solely to the «factbuilders», excluding who studying their work. The sociological eye cannot rely on the «god trick of seeing everything from nowhere» (Haraway 1988: 583), placing itself outside time and space. Instead, it must embrace the awkwardness of its intermediary role, existing «somewhere in between» (Law 1999: 583) — an unstable and uncomfortable position that acknowledges the limitations of both realism and relativism. This represents the temptation to deconstruct facts, as it corresponds to «the perfect mirror twin of totalisation in the ideologies of objectivity; both deny the stakes in location, embodiment, and partial perspective; both make it impossible to see well» (Haraway 1988: 584).

The sociological eye's act of unveiling cannot merely result in deconstruction, as this would only leave heaps of rubble in the field of reality. Bringing to the surface what typically remains buried does not necessitate a disavowal of the robustness of the constructions under examination. This is because what is constructed is generally quite solid (Hacking 1999), and, as per Thomas's well-known theorem, what is defined as real has real consequences.

Demonstrating that scientific knowledge is constructed and context-dependent does not undermine its solidity. Quite the contrary.

FROM THE MARGINS

The capacity of the sociological eye *to make the invisible visible* goes beyond the mere deconstruction of the taken-for-granted or the critical analysis of what is perceived as objective, self-evident, and independent of the constantly reconstructing processes. There is a deeper layer behind everyday life that often eludes our awareness. Consider, for example, the significant contribution of Science and Technology Studies (STS) to the analysis of infrastructures, those socio-technical assemblages underpinning much of our daily lives, such as transport networks, electricity grids, and the web. Among the various aspects

explored by STS, at least two are particularly noteworthy: the processual or, more precisely, relational nature of infrastructures (Star and Ruhleder 1996), and their invisibility (Hughes 1987; Star and Ruhleder 1996).

Regarding the first aspect, STS suggests that the right question to pose about infrastructures is not so much “what” as “when.” Like scientific instruments or any other artefacts, an infrastructure is not «just a thing with pre-given attributes frozen in time», as «a thing becomes a tool in practice, for someone, when connected to some particular activity» (Star and Ruhleder 1996: 112). Thus, infrastructures are essentially processes, and they do not become invisible because, once built, they sink into the background; rather, they remain invisible because they are an ongoing process.

This is why an infrastructure becomes visible “when it breaks: the server is down, the bridge washes out, there is a power blackout. Even when there are back-up mechanisms or procedures, their existence further highlights the now-visible infrastructure” (Star and Ruhleder 1996: 112). It also becomes visible when sociologists bring it out of the darkness of the taken-for-granted, giving it visibility as a study object. Similarly to scientists’ relationships with their research objects, sociologists are also implicated in the construction of what they study. Social phenomena are products of the «trials of strength» (Latour 1987) through which sociologists challenge taken-for-granted routines, testing their resistance and making social phenomena visible as they determine them.

However, there are at least two additional spheres in which everyday life takes shape, remaining below the visibility threshold but extensively studied by sociologists and STS: disability and the patrimony of material goods and cultural resources exploited and subordinated by colonialism. What these share is precisely their survival at the margins of our vision, deliberately ignored or considered unimportant and unworthy of note.

A spotlight has been shone on disability by what is known as the British “social model,” which hinges on the distinction between the condition of individuals lacking parts of the body or physiological functions (impairment) and the disadvantages, exclusions, and difficulties deriving from the incapacity of a given social model to take sufficient account of such conditions. As Marina noted (Maestrutti 2020), the shift in attention brought in by the social sciences from the impaired body to the social context has laid the groundwork for a critical analysis of the role of biomedical knowledge and techno-scientific research, both in overcoming impairment and in constantly reaffirming a normality centered on the individual rather than the network of relations on which even able-bodied individuals depend. It is a contradictory situation defined by the presence of two apparently irreconcilable forces: improving the condition of those with an impairment while weakening critiques toward a collective life organisation designed and acted on as an aggregate of individuals rather than an incessant process fed by the relationships between them.

Technology plays a central role in all this, but the sociological eye constantly calls on us not to underestimate the ambiguity of this stance. In some ways, it might be said that, in the bio-medical field, the technological fix approach leads not only to the repairing of

defects caused by techno-science itself—such as the development of artificial limbs for injuries caused by car or workplace accidents, or adverse pharmaceutical effects or diseases due to unhealthy diets—but also covers up processes that the sociological eye seeks to uncover, such as the cult of the individual that characterises post- or late-modern societies (Lasch 1979; Giddens 1990, 1991; Beck, Giddens and Lash 1994; Bauman 1995).

This technological ambiguity has repeatedly played a relevant role in Marina's work on the subject of robotics (Faucounau et al. 2009; Wu et al. 2011), artificial limbs (Jarrassé et al. 2015), human enhancement (2011b) or cyborgs (2011c). In this and a great deal of her other works, Marina has also demonstrated how misleading it is to consider technology as a separate entity *applying* to bodies, everyday practices, and people's identities, highlighting its indissoluble bond with the construction of social relationships within which both the material nature of bodies as well as objects and imaginaries as well as symbolic worlds find space.

Marina also started employing this approach to align with the post-colonial vision. Through this, her analysis of the relationship between bodies, technologies, and imaginaries gained an enriched awareness of how inequality in resource distribution and social conditions influences the definition of this relationship.

The post-colonial perspective enhances the sociological commitment to *making the invisible visible* with new potential. This involves a dual shift—restoring visibility to the neglect of the global South and revealing the contradictions of the North that keep it subjugated. Furthermore, post-colonial epistemological displacement has heightened our ability to reflect on knowledge, its construction, and its use (see, for example, Harding 2008 and Santos 2018). In particular, the post-colonial perspective illuminates the observer-observed relationship in knowledge construction processes, reinforcing the awareness that the position of the former not only defines what is observable but also how to observe it. In fact, the very relationship between the knower and his/her object of study should not be conceived of as an individual relationship between a single observer and what he/she observes but rather as part of a network of relationships which are both an emerging effect and what make this effect possible. For instance, Verran's concept of «relational empiricism» suggests that researchers must not only demonstrate that their study is a product of a collective of relationships to which they actively contribute but also acknowledge that the «analyst [herself] is configured as an emergent part of the collective» (Verran 2013: 5). As we have seen, sociologists do not study things *per se*, because these things emerge from a network of relationships which they are not simply part of but which result from their involvement in such a network (Law 1999). The relational nature of knowledge and the pivotal role of a sociologist's position are therefore inherently connected. Simultaneously, this connection shapes and delineates their potential—and ability—to *make the invisible visible*.

A spark lit up Marina's eyes, an energy born from the friction between two poles—perhaps best interpreted as a fusion of disenchantment and irony. This intriguing spark, a sign of a sometimes uneasy but always attractive coexistence and a hallmark of those with a sociological eye, often played across her smile.

This occurred because revealing the invisible necessitates a sense of disenchantment—a gradual detachment from the romantic notion that perceives ourselves and our culture as special, unique, self-sufficient, and therefore superior. On one hand, the sociological eye aligns with the progressive rationalisation of modern Western society, adopting, in Weberian terms, a worldview devoid of magic and emotional entanglements. We are now our own masters, yet the awareness gained, including on the potential of the social sciences, has stripped away the comfort of mystery in favor of a cold intellectualism.

On the other hand, as the dominance of techno-science aligns us more closely with other living beings sharing our evolutionary journey of matter and genetic predispositions, the social sciences chip away at the myth of individuality. They cast doubt on assumptions of superiority based on gender, race, and wealth, revealing our inherent dependence on the collective, on relationships, and thus on belonging to intricate networks.

So, it might seem that *unveiling* necessarily leads to *disenchantment*. However, this isn't the case, especially as long as the sociological eye retains its ability to be amazed by the world's variety. What, then, is needed to maintain this ability? Interestingly, it doesn't require sociologists to deny themselves but rather to take themselves even more seriously. For instance, disenchantment isn't an unavoidable fate for sociologists if we wholeheartedly embrace the call to "follow the actors" proposed by Actor-Network Theory, all the while maintaining the specificity of our point of view (Neresini 2022). The idea is that "unveiling" doesn't necessarily imply "removing." Latour (2005), in particular, urges us to "add in," appreciating the richness of the network of relationships we call "social phenomena."

This appreciation emerges when we recognise the heterogeneity of the networks we engage in, extending beyond interactions with other individuals to include objects, machines, and other living beings—*In short, what we may refer to as non-humans*. Furthermore, it occurs when we effectively resist the *temptation of deconstructing the facts*. As discussed earlier, this entails recognising the analytical and social importance of what we reveal as a product of a construction process, rather than diminishing its significance.

In doing so, sociologists position themselves as integral parts of the subjects they observe, laying the foundation for greater humility in our understanding of phenomena. This humility is a pivotal element in fostering a sense of wonder. In this context, sociological knowledge can be considered as a «matter of care» (Puig de la Bellacasa 2011), but in a reciprocal manner: the more sociologists care for their subjects, the more they, in turn, are cared for by the collectives whose lives they contribute to.

Humility, in this context, is synonymous with “irony,” or more precisely, “self-irony”: to experience amazement, we sociologists must not assert superiority. At the end of the day, we are, in a simple yet impactful way, just “telling stories” (Latour 1988).

Marina sometimes reminded us of this. Will we be able not to forget it?

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