TRANSPARENT PROCESS

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Keep biology weird

On disobedient worms and scientific freedom

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Scientia vincere tenebras: If Lord Francis Bacon had a Chevy, he might have stuck this Enlightenment motto on the bumper: knowledge prevails over darkness. This vision of the Enlightenment has prevailed and guided scientific research ever since, especially when science, and the life sciences in particular, are called upon to solve the numerous ecological, environmental and health-related problems of our time. In fact, the prefix bio- is being attached to many non-scientific terms: biotechnology, bioengineering, (personalized) biomedicine, and bioeconomy. But what about biology itself? Will it, can it, or should it become a problem-solver or is that a merely utilitarian vision of science? I would suggest another bumper sticker for today's biologists: Keep biology weird.

This obviously echoes other stickers such as "Keep Santa Cruz weird" or "Keep Portland weird" that issue calls to local communities for more diversity and less gentrification. I argue that a similar call is important when "societal relevance" informs our views of biology, and which projects merit attention and funding. As I will discuss, the sticker also echoes the current wave of "new weird" fiction and scholarly analyses of the weird, offering new ways to think about the relation between nature and society. Lastly, and most importantly, biologists themselves appreciate weirdness: the surprising observations of how life reacts to different challenges and environments. "You see that? That's weird!" conveys something of a puzzle; something that should not have happened but did.

A question of relevance?

As an ethnographer of science, I am interested in how scientists relate to their objects of study: how can their interest and passion be accounted for, other than in terms of the usual platitudes such as "societal relevance"? Most biologists whom I encountered actually showed little interest in the societal relevance of the organisms they study but nonetheless feel that their work is important. This sense of importance does not easily translate into "societal relevance" such as the promise of technologies and applications. At the same time, the need to point to such potential applications, no matter how unrealistic in some cases, drives many biologists into narrative schemes of justification when they present their research at conferences and in funding applications. Doing so, they contribute to repeating dominant anthropocentric and utilitarian storylines even if it is clear that "societal relevance" is a notion that will require a bit more content to become meaningful. Some biologists are currently very concerned about the future of their field because of that reason (Gilbert, 2018; Soto & Sonnenschein, 2021; Stern, 2022).

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Harnessing biology for direct utilitarian and political purposes has a history. In the 1970s, a group of scholars known as The Ann Arbor Science for the People Editorial Collective (AASftP) published a volume called *Biology as a Social Weapon* (AASftP, 1977). It was a reaction against the oversimplification and plain reductionism of the newly emergent approaches that instrumentalized biology for political purposes. The authors deliberately used the word weapon because they were concerned about scholars and politicians misusing biology in forcing it to answer questions that biology does not ask. How to deal with inequalities in society, for example, is not a biological question, though some have tried to justify inequalities by arguing that they are natural (Murray & Hernstein, 1994).

Another type of incarnation, quite literally, of a human-centered and utilitarian approach to biology are model organisms. Not the organisms themselves, but the idea that they represent a "model of" something. This stands in stark contrast to why so many biologists are interested in them. I worked among molecular biologists who use *Caenorhabditis elegans* as a model system. I participated both in lab research and in meetings where they would expound on their new findings and the complexity of this organism. They fell silent when I asked what the worm was supposed to be a model of.

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Caenorhabditis elegans is an interesting entry point to understand the tension between a biology of technological promises and a biology of surprises and weirdness. This tiny critter is where one of the great human salvation stories of our time was rehearsed for the

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first time: the human genome project. The worm was originally not supposed to be weird or interesting. Selected in the 1970s for its anatomic and genetic simplicity, it has in fact run a very different course in research ever since its genome was sequenced: the unexpected keeps on happening in a fully standardized and transparent little nematode. Usually, we look through a microscope to study the worm and its behavior. Let us do the opposite now and use the worm to look back at biology and society.

A new approach to biology

The natural history of *C. elegans* bifurcated in the 1970s, when a particular strain of the species, now known as the N2 or Bristol strain, was placed into an entirely new environment for the worm: the laboratory. The worm's natural biotic environment, characterized by ecological complexity and mutual transformative relationships, came to scientific attention only about a decade ago, prompting new questions about its complex life in its natural habitat (Félix & Braendle, 2010). Outside the laboratory, the worm feeds on different sorts of bacteria, while other bacteria act as commensals and mutualists; it also interacts with vectors such as slugs and snails. It has predators—fungi and mites—and other nematodes as competitors. The isolation of one strain, and its transformation into a model organism required a series of important interventions to limit such relations and retain experimental control.

Though other closely related types are also in use today, the Bristol N2 was the original reference organism. A reference organism is basically needed to generate mutations and compare them to the original worm; and to make comparison possible between different laboratories. Only a highly standardized and controlled organism can become a model organism. A model worm is a worm that behaves properly.

Standardization and controllability are achieved by heavily modifying the worm with respect to its natural counterpart. One laboratory protocol, known as "bleaching," clears the worm of its microbiota in the gut and the cuticle. The worm is then fed one specific bacterial strain (*Escherichia coli*) which is itself standardized. The standardization of the worm and its food source create a reference strain, which allows comparison with other strains and across different labs.

Like other widely used model organisms such as the fruit fly, the worm is logistically interesting for genetics research: it is small and easy to store in freezers; easy to feed; and it has a rapid reproductive cycle—3 days from egg to egg—allowing the generation and tracking of mutations over several generations in a small amount of time. Furthermore, the worm has one unique physiological property: it is transparent. Through a microscope, one can see its internal anatomy and individual cells, which makes it an ideal organism to observe biological phenomena in real time. Combined with its small size, it became possible to observe and map all its cells and neurons. Perhaps more than any other model organism, *C. elegans* embodies the metaphor that seeing is knowing. A primer on *C. elegans* as a model organism calls the worm "a transparent window into biology" (Corsi *et al*, 2015). As a highly standardized organism it also came to embody the criteria of a science that wanted to see and describe whole systems. If the worm was introduced as a model of something, it was not of humans or a specific biological problem, but of a new approach to biology.

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A story of salvation

A bestselling book about *C. elegans* is entitled: *In the beginning was the worm* (Brown, 2003). The Biblical overtones of that title turn the worm into the first exemplar of greater work to come: the mapping and sequencing of the human genome after the sequencing of the worm genome was completed in 1998. And as with the worm, or so the story goes, once we have cracked the human genome, we will possess the grammar and syntax of disease and human behavior; and we will be able to control it. Francis Collins, the Human Genome Project's Director at NIH, put it more mildly in the early 2000s and—again—in Biblical terms: we will be able to read the Book of Life. This conviction spurred massive investments to bring together scientists and sequencing machines. In 2003, the human genome was sequenced: not a specific person, but a mosaicism of different individuals representing a genomic "blueprint" that all humans were claimed to share.

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Meanwhile, biologists kept tinkering with worms, regardless of the human genome or anything concerning humans at all. These biologists see a unique organism and will tell you that other model systems such as fruit flies or zebra fish have very little to do with worms. In fact, biologists are divided as to what model organisms are a model for, and whether they should rather be called "experimental organisms"—organisms to experiment with. In such discussions, and in their passion for the particularism of the worm, they are implicitly or explicitly contesting the scalar promises of the *C. elegans* salvation story: if we can crack the worm code, we can do it for humans, and if we have one code, we can rule—pardon—understand them all.

However, scalability is not a natural property but a technological and political strategy to make things scalable by isolating an organism from its broader ecological relations, including the process of bleaching described above (Tsing, 2012). With scalability, it is not the organism that counts, it is the approach, applied indifferently to several species. And that approach is no longer a biological one (Gilbert, 2018). Biologist and sociologist Jenny Reardon documents how the human genome project evolved from gathering data about "life" into the life of data. We are today submerged with genomic data, even up to the personal level, but we do not know what all these data mean. We are very far from understanding this "book of Life" that we sequenced, and we realize that it' is not a book at all: it is biochemistry. And the ones who have benefited most from the competition to crack the genomic code are the makers of the sequencing machines (Reardon, 2017).

I was surprised to see how little interest the biologists I worked with had in such leaps across species barriers and techno-economic scales. Their passion was definitely not about solving humanity's problems. They know what it takes just to keep this one animal still: to continually intervene so that it remains a standardized model that makes controlled experiments possible in the first place. Model organisms are organisms to work on but they are also worked organisms: artificial animals with respect to their wild cousins. Keeping some parameters stable allows the scientists to tinker with other parameters and identify biological mechanisms and how these vary under different circumstances. But the biologists know very well that their worms are not as simple as that, precisely because a lot of their time goes into disciplining the worms through reagents, temperature regulation, and food. Until someone changes the food and weird things happen. The drama of this is not to be underestimated: genetically identical worms may develop different biological traits because *E. coli* was replaced by another bacterium.

And our nematode friend is a sneaky one: the genome of the Bristol N2 reference worm has changed over time, despite—or because of—its domestication (Weber *et al*, 2010). Now consider the fact that all laboratory worms have been cleansed from their symbiotic relations with bacteria, in order for them to be reliable partners in science. Compared to the sequencing of genomes, nematode life on the rotting apple in your organic waste bin is quantum physics in nine-dimensional space.

My point is not to criticize model organism research in terms of its limitations—as if it were not sophisticated enough. On the contrary: my aim—or wager—is to honor that complexity in a different way: as an occasion that provides a deeper philosophical and political sense to the unexpected, unknown, and weird.

Figure 1. "j-UNC" by artist d lynch made of saw blades and discarded laboratory materials.
Caenorhabditis elegans is known for its "elegant" S-shaped movement (top saw blade), while "UNC" is an abbreviation for mutants that display uncoordinated movement (saw blade at bottom). The top blade "[. . .] suspends and is contained by the construction much like the way scientific dialogue can become bound by the knowledge it has already produced" (d lynch, see: https://scijust.ucsc.edu/2018/04/03/celegans-junc/). With permission by d lynch.

Weirdness and freedom

Caenorhabditis elegans is a protagonist in a research infrastructure that was originally designed to keep weirdness under control. Fig 1 is an artistic representation of that infrastructure, emphasizing its fragility and the linear vision on scientific progress that gave shape to it. Fragility, because the nematode is an unruly fellow once you relax the disciplinary measures to maintain the animal's genomic identity—and that goes for all model organisms. The little worm literally embodies the historical expectations of a solution-driven anthropocentric take on biology on the one hand, and the mysteries and wonders of life that drives biologists to go to their labs every day on the other hand.

Biologists talk admiringly about the organisms they study, and they insist on surprises, unexpected findings and things deemed impossible until they happened. And yet many of them seem to be plagued by the question of societal relevance, which often includes the promise of technological solutions and financial gains.

It is the enduring power of solutionist and utilitarian expectations that prompts me to propose the statement "Keep biology weird" as a corollary to similar slogans and stickers. The term "weird" is important and its history and connotations might offer insights to defend the importance of biological research questions on non-utilitarian grounds.

In fiction, the "weird" long represented the monstrous and the unnatural. The weird was very much like the darkness in the dictum *scientia vincere tenebras*. The horror literature of HP Lovecraft, for example, played with the deepest fears and racism of 19–20th century Europe and America: the intrusion of things and people that threaten to bring chaos in a society where the moral and political order is based on what is deemed "natural". Fueled by the climate crisis as a worldwide anthropogenic transformation of the biosphere, recent "new weird" fiction and scholarly work takes a different stance: nature and society are, and have always been, caught in mutually transformative relations (Turnbull *et al*, 2022). The horror of the unnatural loses its edge if unruly worms, mutating viruses and microbiotic communities inside and around us are the rule. Some biologists and philosophers have directly addressed this by saying that "we have never been individuals" (Gilbert *et al*, 2012). Life is fundamentally weird as it constantly defies our classifications.

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In this sense, biology cannot become a "social weapon" because you cannot forge weapons out of weirdness. Weirdness, in its contemporary meaning, questions the norms nature is supposed to conform to. As such, weirdness stimulates curiosity and the imagination. Just like the stickers to keep Portland or Santa Cruz or whatever community weird, "Keep biology weird" is a statement that is funny, playful and deeply political. The statement is not against the societal relevance of science, but in favor of a more imaginative discussion as to what "societal relevance" may mean, and what "society" is made of in the first place (without forgetting nematodes, cnidarians, and viruses for example).

Finally, "keep biology weird" invokes something of fundamental importance that relates to all the above considerations about research questions, openness to nonconformity, the unexpected, rethinking society. It is something that I registered when the biologists I worked with talk about their cherished objects of research. It had to do with joy of some kind: a joy that emerges at the encounter between life's inventiveness and the scientists' imagination.

You could call it the joy of "discovery" but what is it, then, that makes discovery so exciting? Like "societal relevance," discovery is a term available from our stock of unseasoned notions that does a perfect job in making extraordinary events sound mildly entertaining and without unnecessary provocation, such as elevator music. But when a biologist laughs out loud when an organism happily breaks the rules of "normal development," this laughter is more indicative of the deeper sense of this experience than the fact of having discovered something new. Newly discovered facts do not necessarily provoke joy or laughter. Perhaps they only do so when the facts tell us that we need to accommodate to a reality that is weirder than we thought? Might it be a sense of *freedom* that accompanies that kind of discovery?

Perhaps my own and many scientists' irritation with the notion of "societal relevance" is nourished by the fear of losing the possibility to encounter weirdness and wonder: the experience of a larger reality that demands a larger imagination to understand it. Is the possibility to encounter that larger reality and to try and meet its demands not precisely what scientific freedom is about?

> *"Perhaps my own and many scientists' irritation with the notion of 'societal relevance' is nourished by the fear of losing the possibility to encounter weirdness and wonder..."*

Keep biology weird is a slogan, an encouragement, a commitment to science, and a way of living on Earth that is not destined to prevail over any designated "darkness" but geared to encounter the possibility of freedom within life itself.

Expanded View for this article is available online.

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