Philosophy of science – reduction of the manifest image of man-in-the-world to the scientific image

"Manifest" and "scientific" images: Wifrid Sellars: see "Philosophy and the Scientific Image of Man", https://www.ditext.com/sellars/psim.html .

"Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe? The usual approach of science of constructing a mathematical model cannot answer the questions of why there should be a universe for the model to describe. Why does the universe go to all the bother of existing?" S. Hawking.

1. Introduction

Philosophy of science is an academic subject with a vast literature, often strenously technical, but with substantial consequences outside the academy. For example, in the courtroom, in health policy, in education, and in climate warming debates.

Major current themes include:

"The demarcation problem" - what distinguishes science from pseudoscience? The philosopher John Searle remarked: *"Science has become something of an honorific term, and all sorts of disciplines that are quite unlike physics or chemistry are eager to call themselves 'sciences'".* This suggests, and I tend to agree, that physics and chemistry are the gold standard of what can be genuinely called science, with molecular biology finally bringing biology into the category of genuine sciences in the 1930s (due to M. Delbrück).

Causality: For example, does causation imply *necessary connection* between events? Or merely regular patterns? Causation at the quantum mechanical level? ("Quantum": the size scale where the exceedingly small Planck constant, $6.62607015 \times 10^{-34}$ m^2kg/s, becomes consequential).

Scientific method: is there one unified scientific method ("*The* scientific method" – e.g., the "observe, hypothesize, test and conclude" method) or are there many context-dependent methods? The "contexts" of, say, chemistry, or zoology. The concept of *scientific pluralism* as against *unified science* (the latter was attempted by the logical positivists for example, and versions of the unity-of-science thesis are still supported by many contemporary philosophers of science. Ideally, the reduction of all scientific terms to the terms of physics, and this is the thesis defended in this essay.)

Statistical reasoning: Is experimental or observational evidence strong enough to support a hypothesis? This is not only a mathematical question concerning the probability theorems but also a question of value judgement about acceptable risks and errors.

Realism, and anti-realism or instrumentalism: Realism*: "the traditional view that science is capable of giving us true accounts of the world and that the entities that play a role in our best scientific theories actually exist independent of our conceptual frameworks."* (J. Lawhead). The scientific enterprise uncovers the *metaphysical* truth about reality. I, and most scientists, are realists in this sense. In particular, the "no-miracles" argument is put forward by realists.

Scientific anti-realism, also called scientific instrumentalism**:** the claim that we cannot know whether science gives us an accurate picture of a real world. Anti-realists argue that science ought not to be concerned with metaphysics.

All these topics, and many more, are highly involved issues, and I won't consider them in detail today.

Instead, I invite you to keep them in mind as we jump into the main theme: the reduction of the manifest image (the "humanist" image) to the scientific image.

2. The manifest image (or "humanistic" image)

How we naturally experience the world. The manifest image is *personalistic*, and *normative*. The world is defined by observable appearances, phenomenology, filled with things like tables, and plants and animals, and persons, mountains and lakes and air, and stars – solids and coloured, or liquids, and with social things like money and contracts, etc. Notions such as agency, values, meanings and intentions, free will, foresight, obligation, responsibility, are intrinsic to it.

The manifest image is "*fraught with ought*", as Tim Crane put it.

These notions are entirely absent in physics. Their integration into a physicalist world view is not at all obvious. There seems to be an "explanatory gap" or outright conflict. A philosophical dilemma.

3. The scientific image

The natural sciences are remarkably successful, and therefore must attest to some connection to an underlying *objective* reality, the true metaphysics of reality.

The image is *atoms and the void:* there really exist only material atoms moving around in an otherwise empty void. It is a dramatically different picture of reality and our place in it. One could say "*fraught with is*".

The scientific image is impersonal and objective, and entirely positive rather than normative. And it aims for completeness.

The slogan "Only atoms and the void" needs to be expanded to *"Only atoms and the void, and no design, no foresight, whatsoever"* to effect the reduction I am attempting.

4. Matter

"Matter" is anything that kicks back when you kick it (that is what an experiment is! The kicking may be very delicate and sophisticated, but it is still kicking!). We call such things "bodies" or "objects" or "things". Bodies possess inertia. Phenomena such as light and radio waves are also matter, in an exact sense. They have no rest mass but possesses momentum and energy.

Space, time, and motion are merely part of the way we systematically describe observations, and they provide no independent-of-material-bodies evidence to verify their independent existence. E.g., Einstein: *"In the first place we entirely shun the vague word "space", of which, we must honestly acknowledge, we cannot form the slightest conception, and we replace it by 'motion relative to a practically rigid body of reference'".*

Space (the void) does not kick back, nor does motion nor time. All that kicks back are bodies. The information they kick back to us leads us to assign to these bodies intrinsic properties such as mass, electric charge, and the various more exotic properties of things in modern physics such as spin, colour charge, baryon number, and so on.

The "rules" of behaviour of these properties are what we call "*laws*" – represented by equations of motion (e.g., $v^2 = u^2 + 2as$; a very, very simple example of an equation of motion concerning velocities and accelerations)

A mathematical procedure called *"point of view invariance",* or "*gauging the equations of motion*", discovered and developed in the 20th century, has proved extraordinarily fruitful:

Point of view invariance: The laws (the equations of motion) must remain the same (be invariant, not change), regardless of an observer's location, orientation, position in time, or motion (whether constant velocity or accelerating or rotating). This constraint is known as "*gauge invariance*".

The equations of the very forces of nature arise naturally from gauge invariance (often called gauge symmetry), as do the various *conserved* quantities such as electric charge, energy, momentum, etc: their conservation (invariance) through all the fluxes of motion, chemical reaction, etc, are foundational to our ability to perform predictive calculations of the "kickings". See footnotes 1-3 for a more technical account of "gauging the physics".

5. "**Atoms and the void**"

"Only atoms and the void" is ancient vision of reality:

Democritus (c. 460 – 370 BC) *"By convention sweet is sweet, bitter is bitter, hot is hot, cold is cold, colour is colour; but in truth there are only atoms and the void"*.

Epicurus (341 – 270 BC): "*Only atoms and void exist. Everything else is opinion*".

These philosophers had already discerned the problem of the relationship of the manifest image (*sweetness, bitterness, colour, opinion...)* to the scientific image (*only atoms and the void*).

Modern natural science, especially physics and chemistry, has hugely enriched this ancient picture, but it remains the basic scientific image.

One could equally say "*only fermions and bosons and the void*", or, "*only lots of stars and the void"* ("lots" being quite an understatement: in the visible universe the estimate is 100 billion trillion stars, or maybe up to100 times more, utterly unimaginable numbers).

[The edge of the observable universe is approximately 46.5 billion light-years away from Earth. This distance represents the limit of what we can see, as light from objects beyond this point has not had enough time to reach us since the beginning of the universe. Because of the accelerating expansion of the universe, regions beyond will eventually never be observable from the Earth. These "regions beyond" are likely monstrously vast in volume, or possibly infinite in extent. There is a "future visibility limit" beyond which objects will never enter the observable universe at any time in the future because light emitted by objects outside that limit could never reach the Earth. This future visibility limit is calculated to be 62 billion light-years from Earth.]

6. Reduction

This paper seeks to show that the correct relationship is that of *reduction*: to outline in some detail how we can completely reduce the manifest image, all its concepts and language, to the scientific image, and, furthermore, reduce the sciences themselves - biology, chemistry, geology, etc, and the social sciences - to *physics* (its equations of motion). Reduction in the sense I am using, is captured in the slogan "the whole is the sum of its parts". Nothing that is really new ontologically emerges in things that have many parts, no matter how complex the things are. The entirety of reality is composed of a limited, maybe very limited, set of fundamental entities – perhaps the current physics of fermions and bosons. Reductionism has been an extremely useful and versatile explanatory endeavour in the sciences.

Obviously, reduction and the metaphysical picture thereby arrived at has been met by sustained resistance though the centuries: it is incompatible with many (most?) religions such as the theistic ones, and indeed is resisted by many secular philosophers ("humanists") to this day. Furthermore, many biologists and some chemists try to resist the reduction of their sciences to physics. The essential technical term is "causal closure of the physical", where "physical" refers to the entities of physics.

7. Mechanism

We can flesh out the scientific image in (slightly!) less austere terms than "atoms and the void" or "material bodies moving in space through time" by the concept of a *mechanism*.

Mechanism: A machine is a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motion. (F. Reuleaux, 1876)

A mechanism is an entity that generates organised motion (= *work,* see footnote 4). However, we can use Reuleaux's conception without the requirement that the bodies be entirely resistant /rigid (Reuleaux was a mechanical engineer). For example, the bodies may be liquids or gases, or the complex mix of liquid and solid that constitutes a living organism ("soft solids").

8. Explanation

Many a long and painstaking book and philosophical paper have been written on the question of explanation in science. Does science (merely) *describe* things, or does it go to the deeper ontological level of the true explanation of them? For example, descriptive botany on the one hand (very important) and, on the other hand, the elucidation of the mechanisms embodied in the anatomical, physiological, and molecular structures and entities (proteins, DNA, carbohydrates, lipids, etc) that support the ongoing life cycle of a plant.

The gold standard for any explanation in the natural sciences is "*What is the mechanism?*" And nearly always some law(s) (Reuleaux's "*the mechanical forces of nature*") appear somewhere in the explanation.

Explanation of *what*? Of everything and anything that has any aspect of materiality (physicality) about it. Mountains, the weather, living organisms, light, heat, chemicals, stars, etc. As mentioned above, science aims for completeness.

And this essay defends the idea that nothing other than the physical exists.

<u>The social sciences</u>: Also, if we wish to reduce the social sciences to the natural sciences, and ultimately to physics, scientific completeness aims at explanation of *human behaviour* (psychology, sociology, economics, anthropology, etc). And this programme of reduction to (ultimately) physics is the programme of translating the manifest image (of man-in-the-world) fully and completely into the scientific image.

Exceptions: purely formal systems: logic, mathematics. We do not consider that mathematics has mechanisms! Mathematics is not a natural science; it is a formal and *a priori* science. Mathematics includes computer science (the formal study of computation)].

As an aside, there can be no such thing as an *ultimate* explanation: See an informal proof by J. Z. Bonilla, UNED, 2014, "*We cannot (ultimately) explain everything*". Footnote 5.

9. The metaphysical picture of the clockwork universe

Naturalism, or physicalism or materialism: The clockwork universe: an ancient intricate mechanism, made not by a deity or any intentional designer, but by its own unfolding in space and time. More precisely: Physics is *causally closed* and *causally complete*.

10.Thermodynamics: the dissipation of mechanisms

But there's a *crucial* modification to the strict clockwork image:

All individual mechanisms are *coupled* to other mechanisms (weakly or strongly coupled, as the case may be): e.g., a weak coupling of our solar system to nearby stars and to the galaxy as a whole, and a very strong coupling between the moon and the Earth, and between the vast number of molecular mechanisms within a living organism. Technically, the coupling is through *fields* with values everywhere in space, the "*compensation fields*" of gauged physics.

By coupling, is meant that mechanisms *do work*, on both their own internal parts, and on the external mechanisms they are coupled with.

As a result, over time, all mechanisms *dissipate* (sometimes extremely quickly, sometimes only over aeons of time), become disorganised, and thus eventually *can do no more work*. They "die" so to speak. Literally in the case of living organisms.

This is the process described by the famous four laws of thermodynamics. The most overarching and perhaps philosophically consequential of all the laws of nature.

One law, the First Law, is the conservation of energy: this puts a *restraint* on how *fast* things can change.

Another is the Second Law, the inexorable dissipation of any mechanism so that it no longer can do any work. (The other two laws are required for the technical-logical completion of thermodynamics).

But absolutely *all change* draws on the dissipation of the capacity to do work. This could be called the "positive" or constructive aspect of the Second Law – even though it remains inexorably the law of dissipation. Very briefly, any *local* increase in the capacity to do work (local decrease in entropy) must be "paid for" by an overall increase in the dissipation of the universe (global increase in entropy).

There is no "drive" or "will-to-change" in the scientific image, let alone a change towards some goal (there is no teleology and no foresight) - atoms merely *drift* aimlessly, "mindlessly", colliding with each other randomly, with whatever energy they happen to have, eventually ending up in the most probable configuration (most probable given the local constraints – the boundary conditions) – entirely dissipated. The measure of degree of dissipation (and loss of capacity to do any work) is "entropy" – a pure, dimensionless integer (albeit a truly colossal integer): the number of possible microscopic arrangements ("microstates") in a body. [Specifically, entropy $S = k_B \ln \Omega$, where Ω is the number of accessible microstates.]

11. No teleology, no foresight, no design

One of the most important of all metaphysical consequences of science, if we are to be consistent physicalists, is that there is *no teleology* of any sort, at any time, anywhere, not even in biology (including human biology, no teleology in our bodies).

Radically eschewing teleological (anthropomorphic, animistic) explanations is not only of philosophical importance.

Its pragmatic importance: If you are trying to usefully understand any natural science (in its own terms), then if you let teleology slip into your reasoning you are setting yourself up for endless errors: you will simply be *completely confused* about what's *actually* happening – which is simply the *aimless drifting* of particles (atoms, molecules, photons, or whatever). See footnote 6.

The aimless drifting of atoms is given a precise, quantitative expression (as is the normal standard for any natural science):

$\mathrm{d}G = -S\mathrm{d}T + V\,\mathrm{d}P + \mu\mathrm{d}N$, and the particles aimlessly drift around until $\mathrm{d}G = 0$. (G being the "Gibbs free energy". And you can calculate what the final configuration of particles is going to be; very useful in chemical manufacturing!)

At our human scale, events may appear to be extremely fast (e.g., chemical explosions, the biochemical events in our own bodies), but the characteristic timescale of chemical and other fundamental-particle events is the femtosecond and even very much faster. Femtosecond: one millionth of one billionth of a second (10^{-15} s).

All this applies to our bodies too. In fact, our bodies do an enormous amount of work per kilogram of body weight to control internal dissipation (otherwise death ensues). *Much* more work than the same mass in the sun. The sun generates about 0.0002 W/kg. The human body generates about 1.6 W/kg. Therefore, per kilogram, our body produces about 8,000 times more energy than the sun.

12.Explanation and prediction

So, as said, the ambition of science is to *explain everything*. The aim is not *prediction* as such. But prediction is the *evidence* that the explanation is true.

In epistemology successful prediction is actually rather weak evidence that an explanation is true. One can with logical consistency dream up all sorts of explanations, including for example "God is the explanation".

But *only* science gives genuine predictions ("risky predictions": predictions that are at risk of being falsified) – and indeed exact, quantitative predictions. As exact as the current state of any given science can be expected to give. Usually measured by statistical (probability theory) quantification, e.g., *p* values (R. A. Fisher, 1925).

Essentially, we are *betting* that "only atoms and the void" is the true image of the world, including of man-in-the-world. Cf. Pascal's Wager in theology.

"*The physicist's picture of the universe is the one on which all bets should be placed. The bets are not only that it's correct as far as it goes, but that it will eventually go all the way and be completely correct*" (A. Rosenberg, 2012).

Why accept this? Why accept any metaphysical conclusion for that matter?

One ultimately takes the bet that the mechanical universe is the truth, and all the truth. One could be wrong – but the bet on the physicist's picture of the universe seems to me to be the most rational way to manage inevitable permanent uncertainty.

This has genuine existential consequences for how one tends to live one's life.

For example, what is the nature of reality? What physics says it is.

Is there life after death? No.

Is there a soul? No.

What is the difference between right and wrong, good and bad? There is no moral difference between them.

Is there free will? No.

What is the purpose of the universe and of life? There is none.

(From A. Rosenberg, 2011, *The Atheist's Guide to Reality*).

Is this bleak, despairing, nihilism, or on the contrary, *libertas ex machina*?

I do not think it is automatically bleak and despairing, but it could be, in political practice. All that flows from the manifest image (the religious conceptions of man; resistance to totalitarianism, technocratic governance, etc; the possible entailments of treating people as "mere machinery" - *L'homme machine (Man a machine),* La Mettrie*,* 1747 - could in practice be very corrosive. The late English philosopher Roger Scruton has written eloquently and with melancholy on these real dangers.

On the other hand, one could think of Carlo Rovelli's "*serene and quiet physicalism*". A liberating nihilism: Because the universe is fundamentally mindless matter in motion, there is no inherent design, or grand purpose or God keeping a moral track of you, there is no Ultimate Judgement or ultimate responsibility. A freedom from cosmic anxiety; and the irrelevance of death (Epicurus: "*Death is nothing to us. When we exist, death is not; and when death exists, we are not*").

In the end, in the scientific image, you will dissipate, die. If you are experiencing pain, it is either temporary or finite. If the pain is severe, it will quicky end your life terminating any sensation (though modern medicine can draw out the period of severe pain despite palliative medicine).

13.Truth

The notion of truth generally accepted by scientists is quite a deflationary one. Not "*Ultimate Truth*" but truth in the sense that *the truth of a theory is the success of its predictions.*

What "matter really *is*, *in itself*" is unanswerable in science (the phrase "in itself" has never made any sense to me at any rate). Maybe it's "*really* spirit" or something we can have absolutely no conception of. So long as such "things" are mathematically isomorphic to the "kickings" of physics' "matter", it can make no difference to anything.

Prediction in science must be quantitative and precise (precision is achieved by analysis by means of probability theory: statistical analysis of the data obtained by measurement).

14.Implications of the scientific image

Materialism: A theory of reality: All facts are causally dependent upon physical processes, or reducible to them. The world consists entirely of matter. It denies the existence of immaterial things such as minds or explains them as motions of material things.

Reductionism: One theory or phenomenon is reducible to some other theory or phenomenon.

In practice: The claim that *all* sciences are reducible to physics.

Slogan of philosopher Alex Rosenberg: *"The physical facts fix all the facts*" (and the physical facts are the facts of fermions and bosons only).

Or: all phenomena (including mental phenomena like consciousness) are identical to physical phenomena.

Determinism: The metaphysical view that all events can occur only in one possible way. Determinism, in philosophy and science, is the thesis that all events in the universe, including human decisions and actions, are causally inevitable. More precisely: Causal determinism is the idea that every event is necessitated by antecedent events and conditions together with the laws of nature. More detailed information on determinism given in footnote 7.

15.Mechanism in biology, including human biology

"*My mother is a fish*" (William Faulkner):

The overarching mechanism in biology is evolution by means of *descent with modification*, and *natural selection* of descendants by means of passive filtration by the environment, in the thermodynamic noise of the environment. The original theory (*On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life,* C. Darwin, 1859) was written in English prose with supporting conceptual diagrams, but is nowadays being mathematicised.

"*Nothing in Biology Makes Sense Except in the Light of Evolution*" is a famous phrase by Theodosius Dobzhansky, ca 1960 (he was also a Christian theist).

The resulting biochemical structures, tissues, organs, physiological systems, etc, are very *jury-rigged*, just as would be predicted by the Second Law of thermodynamics. A great many, especially at the biochemical level, but also at the other levels such as anatomy, are extremely ancient geologically: ancient adaptions that remain permanently in our bodies to this day. We all know about this personally! Our bodies are jury-rigged, "good enough" in a quick-and-dirty way for average survival and reproductive success. We very easily get ill and die. "Good enough" adaptions are rare events and very expensive energetically, but the Earth's surface is a big place and has been around for 4.5 billion years – and apparently in a state that could support life for about 3.7 billion years – an unimaginable stretch of time.

16. Reduction of the manifest image's concepts of intentionality, meaning and purpose to physics

The manifest image is extremely rich in notions such as "meaning" and "purpose", "agency", "intentionality," "responsibility" and "free-will".

The basic idea of the reduction is that living things (mechanisms) are "about" continuing their existence (persistence) in the face of continuing, relentless dissipation - both inside their boundaries and in the face of relentless dissipating processes in their environment.

Notions such as "purpose", "meaning", "agency" and "intentionality" can be rigorously defined in (non-equilibrium) statistical mechanics, a purely physical scenario. And in particular "*meaningful information*" can be quantified in purely physical concepts (measured in bits). (Statistical mechanics is the mathematical theory of large aggregates of microscopic entities).

Key physicists and biologists in this application of non-equilibrium statistical physics include A. Kolchinsky and L. Wolpert (Santa Fe Institute) and C. Rovelli (Aix-Marseille University).

In this theory, although the universe teems with physical correlations ("couplings" in my terminology, above), only a subset of all correlations contributes to a mechanism's *continued existence*: these correlations are "*meaningful*" for a physical system.

In biology, "meaningful correlations" arose (and arise) through the mechanism of evolution by natural selection.

Darwin's key discovery is that we can legitimately reverse the causal relation between the existence of the mechanism (the organism) and its function. The fact that the mechanism exhibits a purpose—ultimately to maintain the organism alive and reproduce it—can be simply understood as an indirect consequence, not a *cause*, of its existence and its structure (after C. Rovelli, 2018). Thus, the fundamental, foresightless, aimless drifting of atoms (a-teleology) that underlies biology remains the ontology. There is no "original intentionality" in the nature of things - but there can be "derived intentionality": highly structured mechanisms that resist thermodynamic dissipation into their surroundings. We call them living entities. Needless to say, such structures are immensely, mind-bogglingly complicated: the chemistry of hydrocarbons readily allows such fantastical complexity.

In essence, some entities, including organisms, their cells, and sub-cellular molecular mechanisms, and, also, in the non-living domain, some advanced computing machines, are *thermodynamic observers* – and use such observations to maintain themselves in a very highly organised state (state of low entropy; they shed the entropy they necessarily generate into their environment as heat and waste). Should they fail to maintain meaningful correlations in this purely physical sense, they descend to thermodynamic equilibrium – which we know as death. See footnote 8 for more detail on thermodynamic observers.

See the papers *Semantic information, autonomous agency and non-equilibrium statistical physics*, A. Kolchinsky and D H Wolpert, The Royal Society, 2018 and *Meaning and intentionality = information + evolution wandering towards a goal,* C. Rovelli, 2018, CNRS France. However, these papers are very technical and mathematical.

See footnote 9 for further details about intentionality.

The definition of 'meaningful' considered here does not directly refer to anything *mental*. To have something mental you need a mind and to have a mind, in physicalism, you need a brain, and its rich capacity for elaborating and working with information. The question addressed is "what is the physical basis of the information that brains work with?". The answer is that it is just physical correlation between internal and external variables affecting survival either directly or, potentially, indirectly.

The idea being put forward is that what grounds all this is "direct meaningful information", namely strictly physical correlations between a living organism and the external environment that have survival and reproductive value. The semantic notions of information and meaning are ultimately tied to their Darwinian evolutionary origin.

The link is thus made between the purely physical world and the world, the manifest world, of meaning, purpose, intentionality and value. It bridges the apparent gap between the manifest and scientific images.

17.Consciousness

The fact of consciousness, its subjective "feeling", its *"what it is like*", its "*qualia*" is often given in defence of the claim that there is "something more" to reality than bodies moving in space through time. Many philosophies indeed claim that there *must* be "something more."

There is, it is alleged, a radical "explanatory gap" between the physical and the mental. This is supposed to be the "Hard Problem" of consciousness, the alleged problem of *experience* (D. Chalmers). Chalmers and many others claim that the mechanistic processes of the brain are conceptually "*easy*" (the "Easy Problems"), as they can be, and gradually are being, elucidated by physical neuroscience and cognitive science.

"The really hard problem of consciousness is the problem of experience. When we think and perceive, there is a whir of information-processing, but there is also a subjective aspect. As Nagel (1974) has put it, there is something it is like to be a conscious organism. This subjective aspect is experience. When we see, for example, we experience visual sensations: the felt quality of redness, the experience of dark and light, the quality of depth in a visual field. Other experiences go along with perception in different modalities: the sound of a clarinet, the smell of mothballs. Then there are bodily sensations, from pains to orgasms; mental images that are conjured up internally; the felt quality of emotion, and the experience of a stream of conscious thought. What unites all of these states is that there is something it is like to be in them. All of them are states of experience" (D. J. Chalmers, *Facing Up to the Problems of Consciousness, J. of Consciousness Studies*, 2, No 3, 1995).

However, if the *how* and the *why* questions of consciousness (the "Easy Problems" in Chalmer's definitions) have been answered, *what else is there to explain?* We have explained consciousness.

The *why* is given by the physical mechanism of evolution by natural selection. The *how* is given by brain tissues' mechanisms, by neurobiology: the anatomy, physiology, biochemistry and molecular biology of the (purely physical) brain.

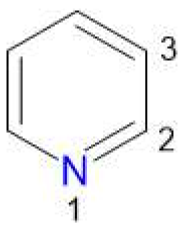
The very strong temptation is to persist and demand "something more": *"You still have not told us <u>what it is like</u> to be a conscious being".*

However, "what it is like" is an *experience* – which means that it makes no sense to ask *how* and *why* it is possible in any other senses than in the sense of mechanism.

Of course, an explanation isn't the same as an experience, but that's because the two are logically completely independent categories, like colours and lines. It makes no sense to speak of the colour of a line.

To demand that an explanation is also somehow to include the experience itself is incoherent (a category mistake) and is an invalid use of the word "explanation". An explanation of the chemistry of pyridine, its molecular structure, its reactivity and other properties, will not, cannot, give you the *experience* of smelling pyridine (very unpleasant!).

The molecular structure of pyridine:



You can't smell this!

In the same way, an explanation of the brain's mechanisms will not give you the experience of "what it is like" to be conscious.

Thus, consciousness does *not* represent a principled problem for reduction of the manifest image to the scientific image. See: *What Hard Problem?,* M Pigliucci, *Philosophy Now* magazine, 2013.

18.Free will

Schopenhauer: *"A man can do what he wants, but not want what he likes"*.

Our likes and dislikes are discovered, and they are shaped by our genes, upbringing and past experiences.

If we are not determined in all our thoughts, emotions and actions, are we then, instead, indeterministic? But is the problem of free will solved by positing a roulette wheel in our brain?

For these reasons, it might seem that the whole notion of free will is incoherent.

But there is a quandary: scientific experimentation itself seems to require that we (as experimenters) can *freely choose* which variables in the experiment we will allow to run their natural course, and which variables we will control by fixing some of the experimental parameters.

Free will, it is claimed, exists and is a metaphysical *prerequisite* to doing science.

"Superdeterminism" (or "super-determinism") has been proposed to obviate free will in scientific experimentation. It posits that the measurement apparatus, the experimenter making the choice, and the entity being experimented upon, are all deeply correlated. The term was introduced by physicist J. S. Bell in 1964, arising from his work on the foundations of quantum mechanics, but is applicable to any scientific experimentation and observation. It is really just plain old determinism, applied consistently to everything and everyone, including experimenters: Bell used "super" as an emphatic in the context of the controversies in quantum mechanics at the time (and to this day) - especially due to Einstein's view that quantum mechanics is an *incomplete* theory that should be superseded by a classical deterministic theory (that includes "realism" and "locality" in their technical meanings).

J. S. Bell, 1985: "*Suppose the world is super-deterministic, with not just inanimate nature running on behind-the-scenes clockwork, but with our behaviour, including our belief that we are free to choose to do one experiment rather than another, absolutely predetermined, including the "decision" by the experimenter to carry out one set of measurements rather than another, the difficulty disappears. There is no need for a faster than light signal to tell particle* A *what measurement has been carried out on particle* B*, because the universe, including particle* A*, already "knows" what that measurement, and its outcome, will be".*

According to A. Zeilinger (2010), if superdeterminism is true, some of its implications would bring into question the value of science itself by destroying falsifiability:

"We always implicitly assume the freedom of the experimentalist... This fundamental assumption is essential to doing science. If this were not true, then, I suggest, it would make no sense at all to ask nature questions in an experiment, since then nature could determine what our questions are, and that could guide our questions such that we arrive at a false picture of nature".

Evaluation of "superdeterminism" is of necessity very technical and very subtle. A good example is S. Hossenfelder and T Palmer, 2020, *"Rethinking Superdeterminism*", *Front. Phys.,* Vol. 8, 2020: https://www.frontiersin.org/journals/physics/articles/10.3389/fphy.2020.00139/full

Superdeterminism (or plain old determinism) if applied consistently would appear to turn the universe (and all scientific work) into a narrative script. Every event was predetermined at the Big Bang event itself.

As a consequence, superdeterminism is fundamentally untestable, as the correlations can be postulated to exist since the Big Bang, making, for example, the Bell loophole in the foundations of quantum mechanics impossible to eliminate.

However, were such a theory somehow proved to be true, it would – arguably - not invalidate science because science has allowed the discovery of relationships that have predictive power. Those predictions have already worked quite well, often extremely well, and we can bet that they will continue to work.

There's no reason why superdeterminism would be more likely to result in a breakdown in predictability than any other meta-theory might. If predictability suddenly started failing, it would not be because superdeterminism is true, but because superdeterminism is true *and* there's some wildly extravagant change in causality at some future point (assuming causality would still be a sensible notion in such a scenario).

One might also claim that the free will of the experimenter is irrelevant as to whether the experimental results corroborate or falsify a given theory of reality, which is all that is required from the experiment. Science does not give access to Ultimate Truth about nature (nor can any other endeavour), it just refines the ability to predict the result of a repeatable experiment.

And it works: planes fly, etc.

Let's imagine that superdeterminism is true and proven. Will planes start crashing, etc? The concept might imply something about our ability to interpret quantum mechanics (the origin of the concept) but science will continue to be very reliable.

END. 23 June 2026.

Footnotes

1. It is hypothesized that the known gauge symmetries of nature came from a larger primordial symmetry, *G* (so far unknown) and that this fundamental symmetry *G* "broke" as the universe cooled down after the Big Bang event: broke down into the symmetries we observe today].

2. A method of analysis in mathematical physics called "imposing gauge invariance on the motions of bodies", was discovered by H. Weyl, 1918 - *Eichinvarianz* ("gauge invariance"), an H. Weyl, V. A. Fock and F. W. London, 1927.]

3. "Gauging" physics: The discovery is that changing the gauge (any particular chosen mathematical "co-ordinate system") does not change the actual physical outcome.

The real power of this way of analysing motions is when the symmetry is made *local* rather than global. Even if one arbitrarily changes one's gauge from one tiny volume of space to the next (mathematically, infinitesimal volume elements), then if one wants the laws of nature to remain consistent, one must add a *compensation field.* We observe such compensation fields as the *fundamental forces of nature* (four in number): electromagnetism, the weak nuclear force, the strong nuclear force, and gravitation. Photons are the carriers of the electromagnetic field, W and Z bosons carry the weak nuclear force, and the gluon boson (g boson) carries the strong nuclear force.
The fourth fundamental force is gravity. Gravity is also a gauge theory, though different from the gauge theories of the other three forces (Yang-Mills, 1953). Gravity (e.g., in the general theory of relativity, A. Einstein, 1915) is invariant under local spacetime symmetries (the diffeomorphism group of symmetries): invariant no matter how one orients the coordinate grid in space and time. The gauge fields of the other three forces are "in" abstract spaces such as $U(1)$ or $SU(3)$, whereas the gauge field of gravity is "in" spacetime itself – its gauge transformations geometrically "curve" spacetime itself. (technically an intrinsic curvature is defined at every point in four-dimensional spacetime: spacetime is not "curved into" any higher embedding space).

The remarkable power of analysis of motion by gauging: the atomic bomb: A. Einstein: The principle of relativity (in the restricted sense): *"If, relative to* K, K*' is a uniformly moving co-ordinate system devoid of rotation, then natural phenomena run their course with respect to* K' *according to exactly the same general laws as with respect to* K*….The epoch-making theoretical investigations of H. A. Lorenz on the electrodynamical and optical phenomena connected with moving bodies show that experience in this domain leads conclusively to a theory of electromagnetic phenomena, of which the law of constancy of the velocity of light* in vacuo *(* c*) is a* *necessary consequence.....as a result of an analysis of the physical conceptions of time and space, it became evident that in reality there is not the least incompatibility between the principle of relativity and the law of propagation of light, and that by systematically holding fast to both these laws a logically rigid theory could be arrived at. This theory has been called the special theory of relativity…In accordance with the theory of relativity the kinetic energy of a material point of mass* m *is no longer given by the well-known expression* $m(v^2/2)$ *but by the expression* $mc^2/\sqrt{(1 - v^2/c^2)}$*….”* (A. Einstein, *Relativity – The Special and the General Theory*, 1916)

This expression, kinetic energy of a material point of mass m, $K = mc^2/\sqrt{(1 - v^2/c^2)}$, a result from Einstein’s armchair, proved the possibility of a nuclear bomb. Forty years later, on 16th July 1945 at 04:25 (11:25 GMT), “the gadget” was detonated at the Trinity site in the Jornada del Muerto desert of New Mexico. The “gadget” exploded with an energy equivalent to 24.8 kilotons of TNT. A mere 6 kg of plutonium yielded this colossal explosion.

4. *Work*: in the physical sense: the energy (measured in joules or horsepower-hour, or calories, or ergs, or kilowatt-hours, or foot-pounds, or litre-atmosphere, etc) transferred to or from an object via the application of force (measured in newtons or dynes or pounds, etc) along a displacement (measured in metres, feet, leagues, hands, light-years, etc).
   Your heart does about 1 joule of work at each heartbeat.
   Mathematical definition of work: $w = (m\mathrm{d}^2\boldsymbol{r}/\mathrm{d}t^2)\mathbf{r}$.

5. *“Imagine that we have been able to discover all the regularities that are true in the universe (this is impossible in practice, but suppose it is the case), and let* S *be the proposition asserting that all those regularities are true.*
   The fact is that there is no possible explanation of why S *is true. For: suppose there is a universal proposition* T *that can explain* S. *Since no proposition can explain itself,* T *cannot be contained in* S *if* T *is to be explanatory of* S. *But, by hypothesis,* S *contained all the laws that are true in the universe, and hence, if* S *follows from* T *(what must be the case, for we have assumed that* T *explains* S*),* T *must be false and cannot be the true explanation of why the universe is such that the regularities contained in* S *are true.* (KQ: A *reductio ad absurdum* argument).
   In conclusion, the question ‘why the laws of the universe are the ones they are, instead of other possible laws’*, is just a question that cannot be answered, at least with an answer which is true. Stated in other way: there is nothing like* ‘the ultimate

explanation of why the universe is the way it is'. *The notion of 'ultimate explanation' is just a logical impossibility, taking into account what 'explanation' is."*

6. Examples: You have probably encountered such anthropomorphism in situations such as describing pressures *trying* to equalize in gas flow. But, in fact, pressures don't *try* to do anything.
   If you were at school in the UK any time in the last 30 years, you almost certainly were taught chemistry between the ages of 14-16. And you were almost certainly told that the chemical elements bond to each other because their electrons are '*trying to get* a full outer shell' or '*like to* have a full outer shell'. In fact, there is no end of chemical situations in which (some of) the atoms do *not* have "full outer shells".
   And I'm certain that you were taught that acids "donate" protons: as if acids want to get shot of their protons! Whether a particular molecule is an acid, or a base or is amphoteric is entirely a matter of its environment.
   All that is ever happening (in physics, chemistry, biology, geology, meteorology, astronomy, engineering, etc.) is that atoms (or molecules, or whatever particles) aimlessly drift to a distribution in space that is (by far, *vastly*) the *most* probable configuration: it is no more mysterious than if you dumped a pile of feathers together in your garden: in due course, depending on how breezy (energetic) it is, the feathers will be all over your garden, and your neighbours' gardens).]

7. Determinism: Ideally, an explanation is presented as a set of differential equations, governing how physical magnitudes change with time, given their values at an initial time. Such a set of equations has a unique solution for future times, given the values at the initial time. Thus they are deterministic, with no random elements.

Examples of differential equations:

<u>Classical physics</u> – ca. 1680: I. Newton, R. Hooke, etc):

Oscillating lump on a spring:

$$\frac{d^2x}{dt^2} = -\frac{k}{m}x$$

<u>Quantum mechanics</u> (E. Schrodinger, 1926):

$$i\hbar\frac{\partial}{\partial t}\Psi(\vec{r},t) = \left[\frac{-\hbar^2}{2m}\nabla^2 + V(\vec{r},t)\right]\Psi(\vec{r},t)$$

General relativity (A. Einstein, 1917)

$$d^2x^\alpha/d\lambda^2 + \Gamma^\alpha_{\mu\nu}\ (dx^\mu/d\lambda . dx^\nu/d\lambda) = 0$$

Chemistry: The Schrodinger equation and classical and statistical thermodynamics: 19th and early 20th centuries (E. Schrodinger, W. Heitler, F. London, L. Pauling, J. C. Slater, F. Hund, R. S. Mulliken, G. Hess, W. Gibbs, W. Ostwald, W. Nernst, etc)

$$i\hbar\frac{\partial}{\partial t}\Psi(\vec{r},t) = \left[\frac{-\hbar^2}{2m}\nabla^2 + V(\vec{r},t)\right]\Psi(\vec{r},t)$$

$$\mathrm{d}U = T\,\mathrm{d}S + Y\,\mathrm{d}X + \mu\mathrm{d}N \text{ (reversable process)}$$

$$\mathrm{d}U < T\,\mathrm{d}S + Y\,\mathrm{d}X + \mu\mathrm{d}N \text{ (irreversible process)}$$

You'll note that the equation for quantum mechanics is a differential equation: quantum mechanics is *mechanics* and is *deterministic*. The popular idea that quantum mechanics implies that "everything is random, and nothing is certain" is highly misleading. In the "conventional" or "Copenhagen" interpretation of the physics, the exact outcome of a single event at the atomic and sub-atomic scales cannot be predicted (is random). The Schrodinger equation is used to deterministically calculate the probabilities of the spectrum of results. In repeated experiments or measurements, for any given fixed initial situation (e.g., experimental set-up) the outcomes will always lie in a specific envelope (probability distribution). This is probabilistic determinism. There are also entirely classically deterministic interpretations of the physics, e.g., De Broglie-Bohm quantum mechanics and the famous "many worlds" interpretation. Apart from these considerations, in most situations of interest (e.g., chemistry, metallurgy, fluid mechanics, or the biochemistry/molecular biology of cells and entire organisms) we are dealing with enormous numbers of atoms and molecules, and the probabilities (if we are adhering to the Copenhagen interpretation) associated with individual atomic events average out into highly predictable, determined outcomes (classical determinism). Even in a picogram sample undergoing a chemical reaction (an incredibly tiny amount of material) the outcomes are entirely determined (picogram= 10^{-12} gram, one-thousandth of one billionth of a gram. Indeed, even in a femtogram, one millionth of a billionth of a gram, entirely classical determinism obtains). See *Probabilistic* Determinism: https://www.southampton.ac.uk/~doug/quantum_physics/determinism.pdf .

All these considerations concerning quantum physics are a different matter to *chaos*: many kinds of physical systems in nature show chaotic behaviour. Strict determinism still holds: deterministic chaos. Natural examples include weather patterns, ecosystems, fluid dynamics, planetary orbits, and many phenomena in physiology and cellular activity: heart rates, neural activities in brains, respiratory patterns, hormone fluctuations, blood flow, immune system activation, bacterial stress responses, genetic restructuring in cancers.

8. Thermodynamic observers: A physical system that acquires, stores, and processes meaningful information about its environment to make decisions. It is an information engine.

Such observers are defined by their continuous need to extract "free energy" (Gibbs free energy, G) from their surroundings to process data. If they fail to acquire "meaningful information" to avoid hazard, they quickly succumb to thermal equilibrium – die. A cadaver is not a thermodynamic observer.

The major source of Gibbs free energy on this planet is sunlight. Another significant source is geothermal heat.

9. Intentionality is built into the definition of "meaningful information". The information here is information that the system A has about the variable y of the system B. It is, by definition, information "about something external". It refers to a physical configuration of A (namely the value of its variable x), insofar as this variable is correlated to something external (it 'knows' something external).

The definition separates correlations of two kinds: accidental correlations that are ubiquitous in nature and have no effect on living beings, no role in semantics, no use, and correlations that contribute to survival. The notion of meaningful correlation captures the fact that information can have "value" in a Darwinian sense. The value is defined here *a posteriori* as the increase of survival chances. It is a "value" only in the sense that it increases these chances.

Not any manifestation of meaning, purpose, intentionality or value is directly meaningful, according to the definition. Reading today's newspaper is not likely to directly enhance my or my genes' survival probabilities.

This is the sense of the distinction between *'direct'* meaningful information and meaningful information. The second includes all relative information which in turn increases the probability of acquiring meaningful information. This opens the door to recursive growth of meaningful information and arbitrary increase of semantic complexity. It is this secondary recursive growth that grounds the use of meaningful information in the brain. Starting with meaningful information in the sense defined here, we get something that looks more and more like the full notions of meaning we use in various contexts, by adding articulations and moving up to contexts where there is a brain, language, society, norms... C. Rovelli, 2018.

---------------- ----------------------- ---

Miscellaneous notes:

The scientific method: Describing and measuring (and thus observing) and doing experiments on any and all "phenomena" and coming up with explanations ("hypotheses") that can be tested experimentally. E.g., seagulls have an average flock size of 30 birds. An explanation could be that there's a trade off between survival benefits and costs of competition between individual gulls for food. This could in principle be tested experimentally.

The cornerstone of the scientific method is the postulate that reality (nature) is *objective*.

"The systematic denial that true knowledge can be reached by interpreting phenomena in terms of final causes – that is to say, of "purpose". An exact date may be given for the discovery of this canon. The formulation by Galileo and Descartes of the principle of inertia [KQ: ca. 1609] *laid the groundwork not only of mechanics but for the epistemology of modern science by abolishing Aristotelian physics and cosmology"* (J Monod, *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*, 1970)

Principle of inertia: A body removed sufficiently far from other bodies continues in a state of rest or of uniform motion in a straight line. This discovery is to my mind the true start of science in the modern sense.

Quantum mechanics and its numerous interpretations: The mathematical framework and the vast body of empirical data of quantum mechanics are entirely settled and work in every application that has been investigated. Quantum mechanics is a spectacularly successful theory of matter and light, and has withstood rigorous and extremely precise tests in an extraordinarily broad range of experiments, with flying colours.

This mathematical formalism is based in Hilbert spaces, abstract vector spaces equipped with the additional structure of inner products.

There has been and continue to be a great deal of philosophical speculation about what quantum mechanics "really means." Each offers different views on the nature of reality and of measurement. However, they are all empirically equivalent: no tests distinguish between them to allow a preferred "interpretation.

https://mjpuma.github.io/quantum_mechanics_guide.pdf https://uwaterloo.ca/institute-for-quantum-computing/sites/default/files/uploads/files/mathematics_qm_v23_qsys.pdf

“No miracles” argument (scientific realism):

P1. Our best science is very good at making successful predictions

P2. The best explanation for this success is that our methods are accurate, our theories are true, and the entities they describe exist

P3. Anything else would make our success seem miraculous

Conclusion: Therefore, scientific realism is true.

--------------- ---------------------- ----------------------------