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Why Philosophy of Science Matters

Peking University
National School of Development
Public Policy Forum International

April 12th, 2019

Revised, April 16, 2019

Let me start with two quotes
from Albert Einstein:

“I fully agree with you [Robert Thorton] about the significance and educational value of methodology as well as history and philosophy of science. So many people today - and even professional scientists - seem to me like somebody who has seen thousands of trees but has never seen a forest.

A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering.

This independence created by philosophical insight is - in my opinion - the mark of distinction between a mere artisan or specialist and a real seeker after truth.”

Albert Einstein, 1944

"How does it happen that a properly endowed natural scientist comes to concern himself with epistemology? Is there no more valuable work in his specialty? I hear many of my colleagues saying, and I sense it from many more, that they feel this way. I cannot share this sentiment. When I think about the ablest students whom I have encountered in my teaching, that is, those who distinguish themselves by their independence of judgment and not merely their quick-wittedness, I can affirm that they had a vigorous interest in epistemology. They happily began discussions about the goals and methods of science, and they showed unequivocally, through their tenacity in defending their views, that the subject seemed important to them. Indeed, one should not be surprised at this."

Albert Einstein, 1916

Were you professional scientists, I could limit myself
to comment these two statements by Einstein

But you are not scientists! Or you are not only scientists.
You will be decision makers, in the private as well as in the public sectors. You will be policy makers, at national and at international level. So what I will try to show is that philosophy of science is relevant for you.

Philosophy of science is a complex discipline. What I do mean by this? Think to algebra. Algebra is not a complex discipline. Is simple, and very difficult! Algebra is made by algebra! Philosophy of science, on the contrary, is a discipline composed by the union of different disciplines. The most relevant are: mathematical logic; history of science; linguistics; and, obviously, a knowledge of the scientific research in the different fields.

As it was well said by one of the greatest philosophers of science of our age, Karl Popper, in any field of knowledge the focus are problems, not disciplines. As Popper suggested, disciplines were invented by university deans in order to organize the academic curricula!

The progress of knowledge means solving problems. And the advancements of knowledge does not consist in looking after certainty. This is an illusory objective. The advancement of knowledge consists in moving from more simple problems to more complex and deep problems.

So I shall illustrate what are the problems/questions that are at the center of the philosophy of science.

Here are the main questions addressed by philosophy of science:

First question:

What is science? Is there one thing that constitutes science, or are there many different kinds or fields of inquiry that are different but are nevertheless called sciences?

Second question:

Is science an universal enterprise, or there are different sciences for different cultures and different countries?

Third question:

How is genuine science to be distinguished from non-science or pseudo-science?
Which criteria can be established for separating science from non-science?

Fourth question:

Is there any such thing as a scientific method? If there is, what are the types of reasoning used to arrive at conclusions and the formulation of it?

Fifth question:

What are the implications of scientific methods and models for the larger society, including for the sciences themselves?

Sixth question:

How the growth of science can be defined and measured?
Is the growth of science cumulative or revolutionary?
Has science a direction towards a clearly definable objective?

Seventh question:

For a new scientific theory, can one say it is "nearer to the truth," and, if so, how?

Eight question:

How does science explain, predict and, through technology, harness nature?

Ninth question:

What is a law of nature?
Are there any in non-physical sciences like biology and social sciences?

At this point, you need a crash course in philosophy of science!

All you need is to understand and to retain two main concepts:

1. What is the structure of a law of nature;
2. What is a valid scientific explanation.

Newton's Law of Universal Gravitation

The force of gravity, F_g, is given by

$$F_g = \frac{G\, m_1 m_2}{R^2}$$

where,

G = gravitational constant = 6.668×10^{-8} dynes $cm^3\ g^{-2}$
m_1 = mass of object #1
m_2 = mass of object #2
R = distance between the objects

Newton's Laws

1. A body will remain at rest, or moving at a constant velocity, unless it is acted on by an unbalanced force.

2. The force experienced by an object is proportional to its mass times the acceleration it experiences:

$$\vec{F} = m\vec{a}$$

3. If two bodies exert a force on one another, the forces are equal in magnitude, but opposite in direction:

$$\vec{F}_{12} = -\vec{F}_{21}$$

$$E = h\nu$$

$$E = energy$$

$$h = Planck's\ constant$$

$$\nu = frequency\ of\ light$$

and

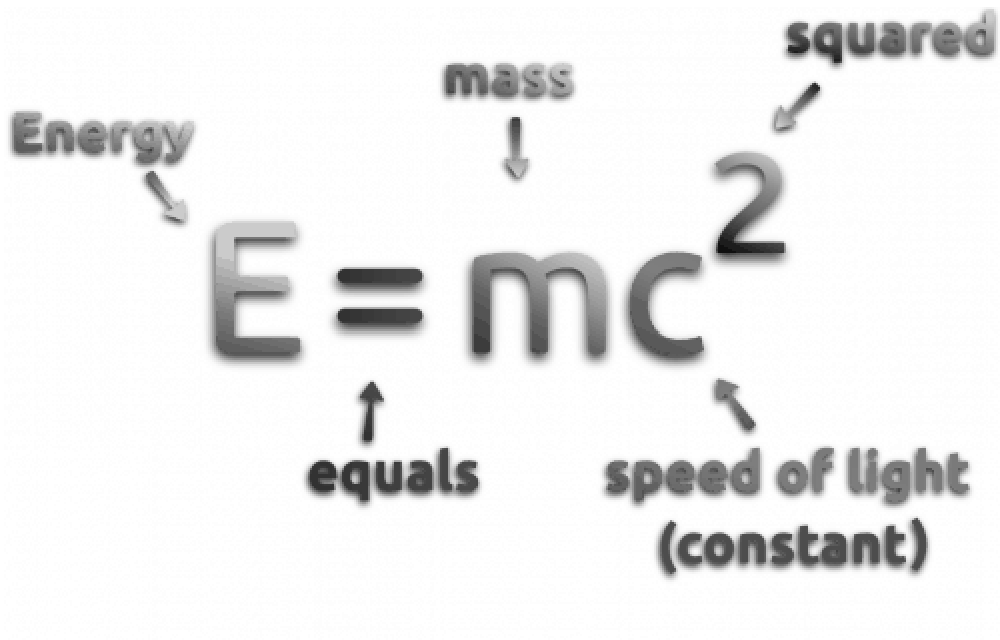
$$E = \frac{hc}{\lambda}$$

$$E = energy$$

$$h = Planck's\ constant$$

$$c = speed\ of\ light$$

$$\lambda = wavelength$$


squared
mass
Energy
E = mc2
equals
speed of light
(constant)

Universal laws take the following logical form:

$$(x)\ (Px > Qx)$$

This can be translated as: for all x, if x has the property P then x will have the property Q.

“If ‘x’ stands for any material body, then the law states that, for any material body x, if x has the property P, it also has the property Q.”

Why laws of nature are crucial?
Because without these laws there can be no sound explanation and – ever more important – no sound prediction of phenomena.

Here is how laws of nature are used for explaing and predicting phenomena:

Deterministic Explanation

[We can costruct] an explanation as a deductive argument of this form:

(D)

$$\frac{\begin{array}{c}C1, C2, ..., ck \\ L1, L2, ..., Lr\end{array}}{\mathbf{E}}$$

Here, C_1, C_2, …, C_k are statements describing the particular facts invoked; L_1, L2, ..., Lr are general laws: jointly, these statements will be said to form the explanans.The conclusion E is a statement describing the explanandum
event; let me call it the explanandum-statement, and let me use the word "explanandum" to refer to either E or to the event described by it.
The kind of explanation thus characterized I will call *deductive nomological explanation;* for it amounts to a deductive subsumption of the explanandum under principles which have the character of general laws: it answers the question *"Why* did the explanandum event occur?" by showing that the event resulted from the particular circumstances specified in C_1, C_2,…,C_k in accordance with the laws L_1, L_2, …, L_r.
This conception of explanation, as exhibited in schema (D), has therefore been referred to as the covering law model, or as the deductive model, of explanation.

C.G Hempel

Probabilistic Explanation

This kind of explanation, too, is nomological, i.e., it accounts for a given phenomenon by reference to general laws or theoretical principles; but some or all of these are of *probabilistic-statistical form,* i.e., they are, generally speaking, assertions to the effect that if certain specified conditions are realized, then an occurrence of such and such a kind will come about with such and such a statistical probability.

C.G Hempel

For example, the subsiding of a violent attack of hay fever in a given case might well be attributed to, and thus explained by reference to, the adminis tration of 8 milligrams of chlor-trimeton. But if we wish to connect this antecedent event with the explanandum, and thus to establish its explanatory significance for the latter, we cannot invoke a universal law to the effect that the administration of 8 milligrams of that antihistamine will invariably terminate a hay fever attack: this simply is not so.
What can be asserted is only a generalization to the effect that administration of the drug will be followed by relief with high statistical probability, i.e., roughly speaking, with a high relative frequency in the long run.
The resulting explanans will thus be of the following type:

John Doe had a hay fever attack and took 8 milligrams of chlortrimeton.
The probability for subsidence of a hay fever attack upon administration of 8 milligrams of chlor-trimeton is high.

C.G Hempel

Clearly, this explanans does not deductively imply the explanandum, "John Doe's hay fever attack subsided"; the truth of the explanans makes the truth of the explanandum not certain (as it does in a deductive nomological explanation) but only more or less likely or, perhaps "practically" certain.

C.G Hempel

Reduced to its simplest essentials, a probabilistic explanation thus takes the following form:

$$(P)\quad \frac{Fi \quad p(O, F) \text{ is very high}}{Oi} \Big\} \text{ makes very likely}$$

The explanandum, expressed by the statement "Oi," consists in the fact that in the particular instance under consideration, here called i (e.g., John Doe's allergic attack), an outcome of kind O (subsidence) occurred. This is explained by means of two explanans-statements. The first of these, "Fi," corresponds to $C_1, C_2, \ldots,$ Ck in (D); it states that in case i, the factors F (which may be more or less complex) were realized. The second expresses a law of probabilistic form, to the effect that the statistical probability for outcome O to occur in cases where F is realized is very high (close to 1).

C.G Hempel

In contrast to the case of deductive-nomological explanation, the explanans does not logically imply the explanandum, but only confers a high likelihood upon it.

The concept of likelihood here referred to must be clearly distinguished from that of statistical probability, symbolized by "p" in our schema.

A statistical probability is, roughly speaking, the long-run relative frequency with which an occurrence of a given kind (say, F) is accompanied by an "outcome" of a specified kind (say, O). Our likelihood, on the other hand, is a relation (capable of gradations) not between kinds of occurrences, but between statements.

C.G Hempel

The likelihood referred to in (P) may be characterized as the strength of the inductive support, or the degree of rational credibility, which the explanans confers upon the explanandum; or, […], as the *logical,* or *inductive,* (in contrast to statistical) *probability* which the explanandum possesses relative to the explanans.

C.G Hempel

If you understood the basic concepts that I exposed since now, then you will be able to understand why philosophy of science matters not only for natural (and social) scientists, *but also for any public and private decision maker.*

Here are the fields of decision were you need to know and to apply the basic concepts of philosophy of science, if you want to take rational decisions for the benefit of your public institutions, communities or companies.

Public policies: How should be allocated public resources for scientific research? Which criteria should be followed?

Should public money finance pure research or applied research?

From: Stanford Encyclopedia of Philosophy

Healthcare: Medical science develops and evaluates treatments according to evidence of their effectiveness. Pseudoscientific activities in this area give rise to ineffective and sometimes dangerous interventions. Healthcare providers, insurers, government authorities and – most importantly – patients need guidance on how to distinguish between medical science and medical pseudoscience.

Environmental policies: In order to be on the safe side against potential disasters it may be legitimate to take preventive measures when there is valid but yet insufficient evidence of an environmental hazard. This must be distinguished from taking measures against an alleged hazard for which there is no valid evidence at all. Therefore, decision-makers in environmental policy must be able to distinguish between scientific and pseudoscientific claims.

Science education: The promoters of some pseudosciences (notably creationism) try to introduce their teachings in school curricula. Teachers and school authorities need to have clear criteria of inclusion that protect students against unreliable and disproved teachings.

Journalism: When there is scientific uncertainty, or relevant disagreement in the scientific community, this should be covered and explained in media reports on the issues in question. Equally importantly, differences of opinion between on the one hand legitimate scientific experts and on the other hand proponents of scientifically unsubstantiated claims should be described as what they are. Public understanding of topics such as climate change and vaccination has been considerably hampered by organised campaigns that succeeded in making media portray standpoints that have been thoroughly disproved in science as legitimate scientific standpoints . The media need tools and practices to distinguish between legitimate scientific controversies and attempts to peddle pseudoscientific claims as science.

Expert testimony: It is essential for the rule of law that courts get the facts right. The reliability of different types of evidence must be correctly determined, and expert testimony must be based on the best available knowledge. Sometimes it is in the interest of litigants to present non-scientific claims as solid science. Therefore courts must be able to distinguish between science and pseudoscience.

Philosophers have often had prominent roles in the defence of science against pseudoscience in such contexts.

MY FINAL POINT

What is the relationship between science and religion and science and ethics?

What is the relationship between science and politics?

Is there an ethics of science?

Let us start from the issue if there is an ethics of science.

The best description of the ethics of science was given by the great American sociologist Robert Merton.

Robert Merton/1

Science is characterized by an “ethos”, i.e. spirit, that can be summarized as four sets of institutional imperatives.

The first imperative, *universalism*, asserts that whatever their origins, truth claims should be subjected to preestablished, impersonal criteria. This implies that the acceptance or rejection of claims should not depend on the personal or social qualities of their protagonists.

Robert Merton/2

The second imperative, *communism*, says that the substantive findings of science are the products of social collaboration and therefore belong to the community, rather than being owned by individuals or groups. This is, as Merton pointed out, incompatible with patents that reserve exclusive rights of use to inventors and discoverers.

Robert Merton/3

The third imperative, *disinterestedness*, imposes a pattern of institutional control that is intended to curb the effects of personal or ideological motives that individual scientists may have.

The fourth imperative, *organized scepticism*, implies that science allows detached scrutiny of beliefs that are dearly held by other institutions. This is what sometimes brings science into conflicts with religions and other ideologies.

Let us come now at the relationships between science and politics.
This has become a very hot issue today, especially in the US.

The first element to be highlighted is that science is not a democratic endeavor. A scientific statement is not true because a majority, even a vast majority of the relevant scientists, holds that is true. In science the dissent is as important as consensus is. Without dissent we would have had none of the great scientific advancements and revolutions that shaped modern science. The Copernican Revolution, the Darwinian Revolution, the Quantum Revolution, the Relativistic Revolution, were all promoted by a very limited number of scientist, against the beliefs of the waste majority of the scientists of their time.

This means that there can be no true science if any single scientist is not let to be free to follow his point of view, and to propose it freely to all other scientists. In turn, this means that in science there should be no organized trusts or cartels aiming at imposing a specific point of view by means of a control over academic and laboratory life.

The second element to be highlighted is that science is a “spontaneous order”. As a matter of fact, there are two kinds of orders in the social world.

The first kind of orders are *constructed orders*.

These are the result of a deliberate act by a single man or by a restricted number of people. Their existence is due to the fact that all the elements of the order obey commands that specify what each of them must do in all specific circumstances.

Constructed orders are developed to attain a specific aim, which is common to all members of the order itself. The complexity of these orders will not exceed what can be mastered by a single person or by a limited number of persons. We may sometimes call this kind of order an "organization". Such an order's efficiency rests upon the fact that the organizing principles are clear, internally consistent, and properly executed. An army, or a commercial company, are examples of constructed orders. But the machinery of the state is also an example of a constructed order.

The second kind of orders are *spontaneous orders*. They are not planned by any single mind or group of minds, but emerge from the meeting of intentions and actions of a plurality of individuals, each pursuing his or her own aim. Their existence rests upon the fact that their elements follow rules that avoid interference with other people's aims and behavior. These rules are therefore a prohibition of unjust conduct. In this sense, they can be called "orders of freedom". Individuals in spontaneous orders are "free" in the sense of Isaiah Berlin's "negative freedom. Spontaneous or self-generating orders can be very complex since they do not rest upon the knowledge possessed by a limited number of individuals – e.g., legislators, or the government. They are non-hierarchical. Since they do not serve any pre-determined aim, they can evolve in relation to changing internal and external conditions without dissolving entirely. The market and language are two major examples of spontaneous orders. Despite the fact that they are the result of innumerable purposive and rational actions, their general configuration at any moment in time is not decided by a single individual or set of individuals.

Science is obviously a “spontaneous order”, made up by the interaction of a great number of scientist, and their free judgement about what is true or false about theories, observations, experimental results. As a consequence, if one tries to impose upon science any specific purpose, he destroys the very mechanism by means of which science progresses towards a deep knowledge of nature.

From this fact it follows that political institutions, be they representative institutions or institutions of other kind, should never play any role in deciding what scientist should consider as true or false. Furthermore, political institutions should never decide the direction of the research that the different branches of science have to take. Doing the contrary would destroy or severely harm science.

All this does not mean at all that political institutions should have no responsibility in the regards of science. As a matter of fact, there are two main functions that political institutions have in the regards of scientific research.

The first function is to decide how many public resources should be allocated in the different fields of research. This is an eminently political decision. As a consequence, political institutions have the duty of verifying how public resources were employed, which results were reached, and therefore the degree of effectiveness/efficiency of the research institutions. International comparison here matters mostly.

The second function of political institutions is to make sure that scientific research, and especially experimental research, in conducted in the full respect of the ethical principles that are prevalent in any country. Freedom of research should never be an absolute value but, as all freedoms, should be made compatible with all others moral principles and individual and social rights that are prevalent in any country.

This last point is obviously particularly relevant for the biomedical research. This is why the discipline of bioethics has so strongly emerged in the last 30 years, and why a sound bioethics, taking seriously the specific moral and cultural values of several countries, is one of the most important instrument for fostering biomedical research.

Readings

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