Some considerations for what it means to be "fundamental"

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The nature of the question

"Read this examination in its entirety before answering any questions." A number of questions follow, the 20th one being "Ignore questions 1-19. Then, "place your name in the upper right-hand corner of this paper, and turn in the exam." The figurative question 20 for the Foundational Questions Institute (FXQI) contest for "what it means to be 'fundamental'" asks - after all the introductory material on its https://fqxi.org/ website - for a "fresh" or "new" perspective on "what 'fundamental' means." Too, as any scholar should ask, let us look at the question, who is asking it, and why it is being asked. Chances are that the answers here will help characterize a response as being "correct" or not. This author wants to read questions 1 through 19 before proceeding. My plethora of quotes here sets the stage for the examination of the container of metalanguage and the objects that is the content.

The following brief essay parses the answer first by looking at what is being asked. The second is the type of answer that is sought and ones that can be given. Here, one subsumes the rubrics for assessing what answer is desired. The third is researching what has been said, both as "public" versions and the version proffered by the one asking the question. The fourth aspect of the inquiry is presenting a response. Last is asking about how the one making the inquiry will respond. One also can question the motivation of the questioner.

I detect both a contradiction between the type of answer FXQI wants and a reflexivity in the question, itself. Whatever generates a description of the meaning of "fundamental" would have to be "fundamental", as it would be manifested in all the examples used to generate the meaning. What does it mean to be anything? A word is infused with meaning because of the examples. The wider variety of examples correspondingly widens the scope of the meaning.

The standards by which the answer is to be judged must itself be or least incorporate the meaning of the word. That is, the judges already have some idea. On the contrary, they do not know and truly are seeking an answer for themselves, as well. How they judge the answer is comparable to finding out the answer to any other problem. Now, if there is no satisfactory answer, but only a "best answer", the question remains. If "the" answer is presented (as in the judges having an "epiphany" because of it), the whole purpose of FXQI searching for the rubric by which to find that which is "fundamental" disappears. It then only would remain the task to locate those "fundamental" things.

Too, and we'll get to it in a while, the criteria for establishing rubrics to judge who the winner of this contest perforce and by logic would have to subsume some idea of what "fundamental" means. I am not convinced that any level of detail will reveal the nature of "fundamental", save, for, perhaps this being an exercise of fractal description.

To analogize, we are not identifying what "organic" is but what criteria would be used to say that something is "organic". That is, what does "organic" mean? Numerous philosophers of sociology, from Herbert Spencer to Emile Durkheim throughout the 19th century discussed whether they thought societies were "organic", ranging from their being analogously so to their actually being organisms. Underpinning "organic", giving it full force and effect is the idea of what "life" is. What holds up "organic"? If identifying what "organic" means depends upon that entity having "life", perforce, we must know what "life" is in order for that entity to be "organic". We have to know what we are looking for in order to be

able to search for it. One needs to know what they are talking about before talking about it (loosely speaking, object language of "life"- metalanguage of "organic").

For another example, if I am looking for the meaning of a "horse" I indeed would have to have some idea of what one looks like in order to spot one. "What does it mean to be a 'horse' [fundamental]"? Here, I must know what each component would look like, as well as the configuration of those components. In turn, I would have to be able to identify the meaning of the words naming the components and the words describing them. This takes us on a quick journey about the fabric and dynamism of language, itself. The "leg" means an "appendage that extends and is used to support ...". What is the meaning of "extend", and so forth? Language is like this, consisting of a web of meaning. Each word in a word is dependent upon the others for substance. Yet, that meaning is contextually-driven. That is, not only is the meaning of a word dynamic but because all the words are interrelated, dependent upon each other for meaning, perforce the whole language is dynamic. One might argue that language, itself, is "organic".

As in statistics, an exercise in logical induction, the larger the sample, presumably the closer one is to identifying the "whole". In passing, each response may differ radically from the next. Suffice it to say there is a difference in responses, there being no "absolute" response but, perhaps only that "statistical" one. Otherwise stated, the two basic types of response would be "absolute" and relative (contextual). Whether there exists "THE truth" or single definition of what it means to be "fundamental", it is then logically the case that it is relative, or contextual.

For FXQI's part the answer at this stage of the inquiry is contextual. Building blocks would not be a satisfactory universal answer to the question, as the FXQI website states. Neither are things physically smaller, as in "if inflation is correct, quanta of the inflaton field are as large as the observable universe". Then,

> Are 'less fundamental' things made out of 'more fundamental' ones? Perhaps – but while a cell is indeed 'made of' atoms, it is perhaps more so 'made of' structural and genetic information that is part of a long historical and evolutionary process. Is that process more fundamental than the cell? Does a "more fundamental" description uniquely specify a "less fundamental" one? Not in many cases: consider string theory, with its landscape of 10500 or more low-energy limits. And the same laws of statistical mechanics can apply to many types of statistically described constituents.

Yet, as we will see below, scientists do not seem to be worried about adopting these concepts, but they do so contextually, or for restricted purposes, none claiming they have a universal meaning applicable to all fields of inquiry. These very differences suggest that "fundamental" is context driven – what is fundamental in one domain may not be in another.

The consequences of answering the question

One of the first questions that struck me when first reading the description of this contest was "Are you really serious that someone is actually going to come up with THE answer?"

It often is helpful to turn a question on its head. It is somewhat like the Yale student who reputedly answered "why not" in response to the question in the philosophy class, "why?" The scope of the FXQI question is on par with this. However, I doubt if the contest judges will think this all that humorous or much in depth. Let's try another approach. Polya in his *How to Solve It* thought it helpful to work it backwards. Let me try it here, with a question that is on the back of what I have left of a mind, "Does this essay contest mean the end of FXQI?" That is, "the" answer accepted by the Foundational Questions Institute at least on the surface would appear to mean "well, that settles it; we all can go home now."

This is somewhat like the ancient lawyer's paradox, where I come before Protagoras dressed as FXQI. If I win, FXQI loses, as I have the "correct" answer.

“What is fundamental?” FXQI shifts the focus from “foundational” to “fundamental” in saying that it bears some “relation it holds to “fundamental” as a term describing some branches of physics.” By collecting or sampling what scientists think “fundamental” means perhaps might lead to an overall idea of what “foundational” is. We'll stick with “fundamental” for a while and come back to “foundational” later.

Method of inquiry

I am going to use the language-meta language approach because FXQI starts out this way, that is,

> This contest does not ask for new proposals about what some "fundamental" constituents of the universe are [object]. Rather, it addresses what 'fundamental' means [metalanguage], and invites interesting and compelling explorations, from detailed worked examples through thoughtful rumination, of the different levels at which nature can be described, and the relations between them.

In essence we are addressing the philosophy of meaning, more explicitly in philosophy departments, the philosophy of language.

To find out what has been said about what the meaning(s) of “fundamental”, requires cross disciplinary, research, giving a nod to – among and illustrated by various fields - linguistics, psychology, sociology, history, some of the major areas of scientific exploration, and philosophy.

It is understandable that some readers of this essay might sympathize with scientists like Hawking and are exasperated with such discussions, as in “... almost all of us must sometimes wonder: Why are we here? Where do we come from? Traditionally, these are questions for philosophy, but philosophy is dead. Philosophers have not kept up with modern developments in science. Particularly physics (Hawking, 2017)”. Hilary Putnam said, “I do not believe mathematics either has or needs ‘foundations’ . . . that the various systems of mathematical philosophy, without exception, need not be taken seriously” (Putnam, 2017, p. 2).

Richard Feynman wrote, “Philosophers say a great deal about what is absolutely necessary for science, and it is always, so far as one can see, rather naive, and probably wrong” (Feynman, pp. 2-6, 2010). “Fundamental” may imply that regularity in science, that the same experiment will always produce the same result - i.e., uniformity, but surely experimentalist do not get uniform results, as a search for “replication crisis” will indicate. “Science has an inside secret: we fail all the time” (Zaringhalam, 2016). One scientist even goes so far as saying in the title of her article “Most Clinical Research Is Not Useful” (Ioannidis, 2016).

Then, it is not certain that there is “the” methodology of science. In other words, like Church's Theorem that says there is no algorithm for doing logic proofs; there is no set method for arriving at new discoveries, as Feyerabend wrote in his *Against Method*.

History, I think, will justify a focus on philosophy, not as mere idle speculation, but from the tradition of the “natural philosophers”, from the pre-Socratics through Johannes Kepler through James Renwick and on to many in FXQI , itself. These are the scholars who not only identified a discovery but how and why it was so, an emphasis being on the “why”.

Yet, it is encouraging that FXQI does entertain “the philosophy of physics” at least as an “opener”. Moreover, FXQI is an organization with its whole history, purpose, and familiarity with “fundamental”, i.e., .concerned with “scientific disciplines fundamental to a deep understanding of reality”).

If “reality” is not a core of philosophy, then my decades in the field have been for naught. Others asking the same question about what “fundamental” means apparently want to go beyond definition and jargon, as one questioner in a physics forum asked:

> Most of the books on science tell that quantum theory and general relativity are the fundamental theories in science. This has always sparked a question in my mind. What does it mean to be "fundamental"? is it depended on your philosophical view (reductionistic or holistic)? If possible, I would like some philosophy involved in the answer.
>
> (Physics Stack Exchange, 2017)

I am not a scholar per se simultaneously in linguistics, the "hard" sciences, psychology, nor in most areas – as is the case with most individuals not being scholars in such a wide range of areas. Hence, mostly anyone, including "hard" scientists, themselves, will be on the same footing as I (in philosophy) in being able to give a perspective reflective of their own discipline better and more completely than others. However, it is hard to imagine anyone at this level of competence being able to do "...from detailed worked examples through thoughtful rumination, of the different levels at which nature can be described, and the relations between them" and "...essays should be sure to touch on issues in physics and cosmology, or closely related fields, such as astrophysics, biophysics, mathematics, complexity and emergence, and the philosophy of physics..." as FXQI wants. Perforce, to obtain a universal idea of the meaning of "fundamental" will require an input from numerous scholars in diverse fields. However, as will be seen below, philosophy is quite capable of doing this in a way different than description from a "techne", or mechanical, point of view.

In this essay I am using a special method of inquiry. Rather than simply finding out what the meaning might be – the answer as an object (what it is) – I am also seeing that how we arrive at the answer is critical. That is, the process is just as much an object as the object, itself. There is the second-order cybernetic aspect, that the observer or one answering the question must be a part of the answer, i.e., the answer necessarily being infused with bias. So goes it with all the answers submitted to FXQI. I submit that such dialectics is not a common method of response in Western discourse, hence giving at least a "fresh perspective".

There are two aspects that may be regarded as definitional ("a priori" and logical) and empirical (from the senses and experiential). This latter contains what scientists say, both inside and outside of FXQI. The following few examples illustrate this point, that the method for arriving at what it means to be "fundamental" is of this statistical nature. After these examples I will give some perspectives from philosophy.

Where does one go to find answers? It is to an oracle, of course, in our case Google, Yahoo, etc. to see "what is out there", from astounding to zany. The degree to which general definitions carry over into the disciplines is observed by how scientists use them.

Definitional

There are two ways of looking at the definition – absolutist or as a modifier. The first few persons would aver, as this is regarded as "the" truth. This means that the meanings of "fundamental" are varied. First, the word is used as a modifier of a set of elements, as in laws, forces, theorems, and so forth. A second is the way definitions have been brought into the field by considering what the science is about, as in biology. The subject matter, itself, is foundational, or fundamental to the field, as in "the study of life", the common definition found in numerous dictionaries and with which few of those in the field probably would disagree. Oxford English Dictionary says:

> Forming a necessary base or core; of central importance.
>
> Affecting or relating to the essential nature of something or the crucial point about an issue.
>
> So basic as to be hard to alter, resolve, or overcome.

From Merriam's:

> a **:** serving as a basis supporting existence or determining essential structure or function **:** basic
> b **:** serving as an original or generating source **:** primary
>
> 2 a **:** of or relating to essential structure, function, or facts **:** radical ; ; also **:** of or dealing with general principles rather than practical application
>
> b **:** adhering to fundamentalism
>
> 3 **:** of central importance **:** principal
>
> 4 **:** belonging to one's innate or ingrained characteristics **:** deep-rooted
>
> 5 **:** of, relating to, or produced by the lowest component of a complex vibration (see vibration 1)

Then there is the American Heritage dictionary:

> **a.** Of or relating to the foundation or base; elementary: the fundamental laws of the universe.
>
> **b.** Forming or Fundamental - Serving as an essential component of a system or structure; central: an example that was fundamental to the argument.
> **c.** Of great significance or entailing major change: a book that underwent fundamental revision.
> **2.** Of or relating to the lowest possible frequency or the lowest frequency component of a vibrating element, system, periodic wave, or quantity: a fundamental chord.
> *Music* Having the root in the bass: a fundamental chord.

We should be reminded that with all these definitions that each word, itself, has a definition composed of words that also have definitions, such that we have a web of meaning. As was observed above, that each word has an etymology, context, and mode of usage (being an adjective) makes the meaning of "fundamental" dynamic, even possibly "organic".

Etymologically, the word "fundamental" provides an idea of the word's meaning, i.e., the context, or history, that is, from Oxford's On-Line Etymology Dictionary:

> mid-15c., "primary, original, pertaining to a foundation," modeled on Late Latin fundamentalis "of the foundation," from Latin fundamentum "foundation" (see fundament). In music (1732) it refers to the lowest note of a chord. Fundamentals (n.) "primary principles or rules" of anything is from 1630s. (

From some main disciplines

What scientists say about "fundamental" in the main science branches of physics, chemistry, and biology often percolates down to the specialty areas. The following briefly illustrates the types of answers.

One post-doc astrophysicist says that the meaning of "fundamental" is perspectival, i.e., "depends on our point of view" (Zhang, 2014).

Another physicist argues that "...what I mean by "fundamental" is what Lange means by 'real'. This suggests that there is at least one construable of the word 'real' that tracks fundamental existence, though certainly our pedestrian attributions of 'real' apply to both fundamental and derivative existents. (Kutach, p. 31, 2013)

In astrophysics, there is reference to "fundamental physics" - "nature of", "existence" (VanDenBroeck. 2014)

Fundamental cosmology is about: origin, what exists, how and why it exists, and the nature of things (Freeberg, 2013).

This idea carries over into chemistry (2008), where the meaning of "fundamental" is "fundamental *[fʌndəˈmɛnt(ə)l] Adjective* forming a necessary base or core; of central importance".

For biologists, “unifying principles form the foundation of modern biology” (Science Daily, 2018).

From what FXQI says.

At least since 2009 FXQI conferences have been wrestling with the same question about what “fundamental” means.

Theoretical physicist Sabine Hossenfelder (2018) reports a focus on:

> A theory is fundamental if it cannot be derived from another, more complete, theory. More complete means the theory is applicable to a larger range. Note that a fundamental theory can be derivable from another theory if both are equivalent to each other (though one could plausibly argue then one should consider both the same theory).

However,

> ...there are different reasons for why we may not be able to derive it: It might not be possible in principle, it might not be possible in practice, or we might not yet have the sufficient knowledge to do it. In general, we do not know which case we are dealing with.

… with the caution,

> Misjudgement of the situation can waste a lot of time and hinder progress. If we wrongly believe a property is not fundamental, we risk searching forever for a more fundamental explanation that doesn't exist. On the other hand, if we believe something is fundamental even though it isn't, our understanding of Nature will remain limited.
>
> (Hossenfelder, 2009)

At the risk of taking quotes out of context, I at least can illustrate that there seems to be support for a more broadly based approach to answering what is “fundamental” than simply providing some examples.

Max Tegmark, himself, one of the founders of FXQI seems already to have arrived at the answer that mathematics is what is “fundamental”, this referring to a hierarchal arrangement of “Theories ...crudely organized into a family tree where each might, at least in principle, be derivable from more fundamental ones” (Tegmark, p. 2, 2007). In essence, Tegmark refers to “fundamental” in terms of “laws”, that existing for all times and places (Ibid., p. 9)”, or that which is irreducible (Ibid., p. 24, *passim*). His work clearly is philosophical, “that mathematical existence and physical existence are equivalent, so that all mathematical structures have the same ontological [that which exists] status. This can be viewed as a form of radical Platonism, ...” (Ibid., p. 16). Here and clearly “fundamental” means that on which other things depend for their existence, his purpose being to discern the nature of “ultimate reality” (Ibid., p. 26). In all honesty, though I personally agree with him, answering the question about the meaning of “fundamental” is on par with that of identifying the “unmoved mover”, an age-old philosophical conundrum.

Nick Bostrom says there is “reasonable disagreement” about “What features of the human condition are fundamental and important” (Bostrom, 2007). Gregory Chaitin reveals his sympathy for “an idealistic as opposed to a materialist conception of nature”, realizing the value of epistemology and even starting with metaphysics to “to measure the conceptual complexity of a theory in terms of its algorithmic information content” (Chaitin, 2018).

David Chalmers surely is no stranger to philosophy with his Ph.D. in philosophy and cognitive science. My memory of his being an integral part of the *Towards a Science of Conscious* conferences (which I help start -Horne, 2008) is that the whole question about what “fundamental” means is about philosophy.

We have observed that a number of answers refer to “existence”, “reality”, ontology, and so forth. These all sound like philosophy questions to me. Indeed, FXQI's reference to the “philosophy of physics” in its “essay rules” points to the Enlightenment – onward, the natural philosophers. But why not philosophy, itself? Physics, after all, is an instantiation of the more general, philosophy – natural philosophers. Such leads this writer to muse that it is the search for what is “fundamental”, “foundational”, or what have you that is the one of the *raison d'etre* of philosophy, itself. The John Templeton Foundation (JTF) which helped get the FXQI going, seeks to find a common ground between religion and science. Here, one should refer to the Latin roots of “religion” - to cohere, or bind. In essence and to my personal delight, FXQI is a philosophy institute!

From the queen of sciences

Now, from a philosophical perspective, I will proceed to give a meaning of “fundamental”, keeping in mind that the manner in which I arrive at the answer is just as much an answer as the answer, itself. I do not think iterating as many instances as possible of what various scientists think is “fundamental” is going to get us any closer to its meaning, save, perhaps statistically, and that is unlikely to be done by one person in a single or so disciplines and in this limited space. That each use of the word seems to have equal status with the other and that each use of the word “fundamental” is usually in adjectival form implies that the meaning is contextual and no absolutist meaning either exists or is agreed upon, as was discussed above.

I will show that not only the answers above are contextual but why any answer we give has to be so and not absolute. We can start “blaming” Rene Descartes for putting us on the road to our current investigational predicaments.

Descartes and his reference "....to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution. ...by showing that we cannot conceive body unless as divisible.” (Descartes, R. (1641/1984). Repeated subdivision sends us to Planck scale (6×10^{-35} m), where particles are “flicking in an out of existence" (Hawking, 2017). In this world we are faced with uncertainty, as in not getting the same result measuring position before momentum or after it. If the character of the micro world percolates to the macro world, as JJC Smart asserts in his *Problems of Space and Tim*e, then we must question the issue of boundary and include those involving any property, such as dimension and physical characteristics, including that of color. A simple exercise will reveal the problem, that of discerning shading and when one identified color transitions to another. Even identification by Angstrom unit fails on the measurement problem. That is, one faces granularity, i.e., how finely cut is the measurement unit (Angstrom). Indeed, the whole idea of integral calculus centers on our determining limit. It is not only sociology, Berger and Luckman style in their *The Social Construction of Reality,* but indeed (from what we know now) that of Heisenberg and the Copenhagen interpretation of the double slit experiment and the wave particle duality problem, although Tegmark's mathematics may supplant uncertainty.

What, then, is common to these fields of exploration? Here is where the philosophy of philosophies enters. The search for what “fundamental” means was subsumed by Aristotle in searching for a “substratum”, that which exists from which all other existence comes, perhaps the mathematics of Tegmark. It is that “substratum” of Aristotle's (Aristotle, 1984, 192a25-192a34, p. 455/18)[Note the Bekker references.] in his *Categories*, “…the underlying nature to substance, i.e. the ‘this’ or existent” (Ibid., 191a9-191a12, p. 453/15).

Now – we are getting closer - philosophy of physics. We are trapped within ourselves; it is we, ourselves, who are the linchpins of what is the most fundamental. We are the most basic, not derivable anything else, unique, and all of that. Philosophers refer to the “fishbowl” in which we live, and we only can see ourselves (and our world) only through ourselves.

Conclusion

"FQXI catalyzes, supports, and disseminates research on questions at the foundations of physics and cosmology", but it is curious that until now the unspoken question of "what is the meaning of foundational", or "fundamental".

Inasmuch as there are many versions of what "fundamental means", there is the common thread or focus on age-old questions about what reality is, origins, space, time, and so forth. It is highly unlikely that FXQI will fill the "foundational" vessel with the content gleaned from the "fundamental" one for a number of reasons, not the least of are issues in absolutism, bias, judgement rubrics, etc. That is, the same problems with giving meaning to "fundamental" carry over to "foundational" if a fixed meaning is sought.

That FXQI exists and has throughout the years persisted in asking the question of "fundamental" is worthy in and of itself. To that end, I hope mine is not the "correct" one to cause FXQI to go out of existence. On the other hand, I doubt if mine is the "correct" one, and I fully expect the quest to continue.

What is the upshot of all this? On a personal level, if mine is the "correct" answer and wins the contest, I can take the proceeds and provide what I think the answer is – process, i.e., advancing the study of philosophy, making it a mandated part of the core curriculum in every school in which student has the appreciation and capacity to learn and apply. That is, students learn that "foundation" means the dialectic of episteme and techne, each owing its existence to the other. The dialectic of the Cartesian reductionism towards the deductive infinitesimal of Planck scale with the inductive infinite of the cosmos provides the content of "fundamental" to fill the foundational vessel. It then is up to us be the limit or the limitless, the dialectic in that second order cybernetic fashion then being within us.

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