Hypotheses and Opinions

Vol.3, 2 (December 2019)
ISSN: 2532-5876
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DOI: 10.13133/2532-5876_6.5

Why Basic concepts in Biology should be reframed
Is Etymology a useful tool for investigation in biology?

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Abstract
How do the words drive scientific investigation and the way we construct models? Here we want to sketch briefly how some biological concepts have changed over time, but that did not happen to the words we use to recognize them. Are we aware of the meaning of concepts we actually use as conceptual "tools" that shape our thoughts and experimental models? We want to investigate how this shift can affect the way science works, and how should etymology impact on the theoretical biology.

Keywords: etymology; biological process, biological system, organic, organic synthesis

Citation: Pensotti, A, 2019, "Why Basic concepts in Biology should be reframed. Is Etymology a useful tool for investigation in biology?", *Organisms. Journal of Biological Sciences*, vol. 3, no. 2, pp. 15-18. DOI: 10.13133/2532-5876_6.5

Introduction

One day an autistic friend, able to communicate by typing on a laptop, wrote "for me it is very difficult to put my thoughts into words. My thoughts only go into words by forcing them. My thoughts do not coincide with the meaning of words" (De Rosa, 2016).

Is there a similar problem with science? How nature's essence and laws fit inside concepts and words of science?

How do the words that we often use as crutches for our thoughts drive scientific investigation and the way we construct models?

Here we want to sketch briefly how some biological concepts have changed over time, but that did not happen to the words we use to recognize them. Are we aware of the meaning of concepts we actually use as conceptual "tools" that shape our thoughts and experimental models? We want to investigate how this shift can affect the way science works, and how should etymology impact on the theoretical biology.

Exploring basic concept in biology

The first problem we were facing was how to identify and classify basic concepts. Hence, we decided to begin the analysis from the most linear division: organic world/compounds and inorganic world/compounds.

Such partition is so deeply rooted in science that all curricula of scientific faculties contain, in the first year, an exam about organic and inorganic chemistry. Every student is told that all molecules containing carbon atoms (except for carbides, carbonates and simple oxides of carbon), are organic molecules, so that the expression *"is an organic molecule"* means that these molecules are the basic bricks of living organisms.

If we take a deeper look at the history of the words organic and inorganic, we realize that the concept underneath them has changed over the centuries. Before the XIX century, the main "paradigm" was Vitalism. Scientists believed that all the "organic matter" emerged because of special "vital forces" that characterized the living systems. For them "organic matter" meant all the compounds produced by living organisms. Their belief was that this kind of substances cannot be found in non-living organisms and that the organic compounds were characterized by some special "vital energy" (Greenwood, 1997).

Things changed in 1828, when Friedrich Wohler produced urea, an organic compound, starting from two inorganic substances (potassium cyanate e ammonium chloride) (Wöhler, 1828). That discovery is currently recognized as the starting point of modern organic chemistry. For the first time it was demonstrated that organic compounds can be produced without requiring "vital forces", and just from inorganic compounds (Ronald, 2015).

Later on, in 1845 Adolph Wilhelm Hermann Kolbe backed this new theory of organic compounds by synthesizing the acetic acid from carbon disulfide.

Therefore, the concept of *organic* changed but the word *organic* remained the same. If the previous idea was *"something produced by life through its vital forces"* the new definition abrogated the idea of vital forces, to endorse that of *"component of living systems"* (Ramberg 2000).

Furthermore, in 1858 Friedrich August Kekulé and Archibald Scott Couper independently developed the concept of chemical structure. The main idea was that tetravalent carbon atoms could link to other atoms and/or each other in a way that all the organic matter can be structured.

Starting from that moment the concept of *organic* was definitely reframed as *"carbon-based molecules that structure all biological entities"* (Streitwieser, 2017).

Notwithstanding this definition, carbon-based molecules are not all "organic", as epitomized by some metalorganic substances or by a few different carbon structures, such as diamond and graphene, not to mention the wide array of petroleum-derived molecules.

The etymology of word "organic"

From an etymological point of view *organic* is an adjective that means *serving as a means or instrument, from or characteristic of organised living beings, forming a whole with a systematic arrangement or coordination of parts*. Intriguingly, "organic" is a word strictly bound to "organ" and "organisms" lemmas (accidentally the name of this journal).

The word *organ* comes from the ancient Greek ὄργανον, "organon", primarily means *tool, that which performs some function*. This word is connected to the root ἔργον, "ergo", which means work, action. The word *energy*, which etymologically speaking means *effective, active*, derives also from the same root.

Therefore, if we forget scientific discoveries and definitions, by keeping our attention focused on the etymology of words we can deduce the following concept: organism and energy share the same root, which means "action". In some way, we can say that, etymologically speaking, *we cannot separate the concept of structure and the concept of energy from inside the word organic/organism*. From this point of view structuralism, by abolishing the idea of vital energy and giving the whole attention to the structure has eliminated the concept of energy from the word organic.

Such point is resurfacing nowadays. Nicholson (Nicholson, 2019) presents an example where he points out the inconsistency of the sole machine-model in describing living systems. Instead, he highlights the importance of the concept of *process* at the very basis of living organisms. If we look at the word *process* from an etymological point of view, we see that it comes from the ancient latin *processus*, *procedere* which means *advancement*, *progress*, *series of organized acts*. This etymology merges the concept of action/energy with the one of organization by introducing the concept of time.

The etymological contribution of the word "synthesis" to biological models

Another biology concept we want to discuss briefly here is that of *synthesis*. Such term was introduced in biological sciences just thanks to Adolph Wilhelm Hermann Kolbe who used the word *"synthesis"* for his work about the production of acetic acid from two inorganic molecules (Kolbe, 1845).

Currently this word is commonly used for describing something "not natural" like in synthetic life, synthetic drug, synthetic fiber, etc. With use this word is slowly shifting toward a meaning close to artificial.

Yet, also nature works with synthesis, which is the case of photosynthesis, synthesis of proteins, DNA synthesis, etc. Therefore we can generally affirm that such word has been pledged to identify the process of production of a new molecule or biological entity through the re-organization of other more basic substances.

Can we use etymology to discover other meaning of that word, which we can usefully apply to biology?

Synthesis comes from the ancient Greek σύνθεσις, which means *composition*, while the original root comes from συντίθημι, which means *to put together*. The general meaning is "*composition of elements with* *the goal to form a whole", a combination of parts into a whole*. That is a definition very near to the one of *organisms*. From a certain point of view, we can say that an organism is the result of a synthesis.

Moreover we have to consider that the words synthesis and system share the same root *syn-,* from the ancient Greek σὺν, which comes from the Indo-European *sem-* and means "with", "together". If we look at the etymology dictionary, we can find that they both share similar definitions. too: synthesis, as *"a combination of parts into a whole"*, system: *"organized whole, a whole compounded of parts"*. The difference lies in the desinence (ending): *hystanai* that means to *standby* and *thesis* that means *to put, to place*.

We can then say that the synthesis is the process, which puts together different parts into a system. Once a system finds a stability and acquires a property it can also be named organ because it is characterized by a special function.

It is also true that to synthesize is a function of a specific system, which opens the door to a circular or spiral mechanism that drive us toward a progressive magnification of the biological structures and their functions. Given that the development of structures requires that the system could span from lower (molecules) to higher (cells, tissues) levels, the "synthetic" process entails many different scales. Organism development is indeed a "scaling process".

Following this reasoning, we can say that synthetic processes are the way through which nature moves toward upper/bigger scales (Bizzarri, 2019).

Is it by chance that in English the verb deriving from the word synthesis is not "to synthetize" but "to synthesize" giving a crucial role to the word *size*? This advancement in size obviously happens along the time with dimension so, if we want to optimise the use of the words here analysed we can say that synthesis is the process that spatially and temporally organises the matter in a system. Unavoidably this system moves forward both in time and space, by raising size and by acquiring a history.

The simplification process and conclusions

We have then to introduce another word that having the same root as synthesis and system "*syn*-"(the same of): it is the case of *simple*. From the ancient latin word simple it is composed by *sim-/sin-* which stands for *sine*, which means *without*, and *-plico* which means *to fold*. From a first Latin etymology we can then extract the meaning of *without folds*, and *unique piece*. If we take a deeper look at the etymology of *sine*, we discover that the root *si-* comes from the Indo-European *sem-*, from which there derive both *si-*, and *syn-* which, as seen previously, means *together*. We can then say that to simplify means *to fold together (without leaving the signs of folds),* something folded in a way that appears just one thing. With a daring logical leap, we can remind the protein folding process and what it generates. The development of living structure implies that the space should be properly "structured", "organized", through subsequent and repeated "folding" organised in time. This aspect is indeed at the core of the DNA and chromatin structure.

Therefore, we can say that the words synthesis, system and simple shares the same root and, in some way, they are conceptually connected: all these terms are connected by the *goal to form a whole compounded of parts* that we can name organisms.

This is an embryonic method of conceptual investigation and should be better and deeper investigated. Can we draw new models or reinterpret certain data by using etymology analysis? Can this method be useful in the interdisciplinary transfer of knowledge?

These are some open questions that, from our point of view, should be investigated more deeply. Here we just wanted to show the potential of this etymologically based method in doing biological investigation.

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