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Opinion

Life has No Blueprint. Cells are Pixels in a Living Jumbotron

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Opinion

In recent years we have been facing an incredible increase in the range of applications of high throughput analyses of genetic material. Whether you are interested in soil microbial communities or the spread of weeds or maybe the basics of plant development and the limitations it exerts on organ size and plant productivity, the key to almost any biological and in fact agricultural question seems to be hidden in the sequences of nucleic acids, or to use the more colloquial expression, the details of the blueprints of life. To tell you the truth, I hate the last expression. Maybe it is just a matter of a name, that nobody takes too seriously but my point is that words can sometimes help us grasp the reality, but they can also lead us astray and this second case applies in my opinion to DNA seen as a blueprint.

This idea might sound impudent if not insane – a simple Google query brings over 83 million documents on "blueprint of life", so it seems to be beyond any doubt that there is some kind of design hidden in the DNA of every living cell, and so there is a plan, a sketch of the object as if observed from above or from the distance. However, if you look into the genome of any organism, you will not see definitions of any of its major building modules. There is no stretch of DNA defining plant root, leaf, or flower. Instead, there are lots of instructions on how to build a cell, or actually, its simplest subsystems and how they should respond to various stimuli. The large scale organization of any living being (be it a human or a bean seedling or an assembly of fungi or even bacteria) seems to result from the massively repetitive execution of responses at the most basic, subcellular, level. None of the components of such complex system (with the partial exception perhaps of us, humans) has any desire to build the high level structure. High level complexity is formed absolutely spontaneously and non-intentionally. It was well described in the case of spatial patterns like formation flights of migrating birds, swarms of insects or schools of fish. The later system for instance was described in the following way : "Schools are highly structured with coordinated movements and a common direction [A] school does not need to act together, instead every individual needs to coordinate with nearby individuals. In a coordinated school, one fish turns, then it's neighbors turn, then their neighbors turn, etc., all in the blink of an eye. A massive coordinated school is thousands of individual movements that make up one overarching movement" [1]. This behaviour is sometimes so complex, elegant and so perfectly concerted that the term swarm intelligence was introduced and defined as: "(SI) the collective behavior of decentralized, self-organized systems, natural or artificial. SI systems are typically made up of a population of simple agents interacting locally with one another and with their environment. The inspiration often comes from nature, especially biological systems. The agents follow very simple rules, and although there is no centralized control structure dictating how individual agents should behave, local, and to a certain degree random, interactions between such agents lead to the emergence of "intelligent" global behavior, unknown to the individual agents" [2].

We may and probably should imagine the same principle of self-organization to apply not only to spatial but also functional, chemical, or biological patterns. To get the complete appreciation of this type of complex pattern formation through very simple interactions it turned out for me very helpful to reflect on my teenage experience of once playing the role of a pixel in a human jumbotron. The word 'jumbotron' refers of course to a gigantic display used sometimes during mass events on the stadiums to show the same image to a huge crowd of spectators seated on the tribunes. Normally it involves advanced electronic technology, however there is also quite another implementation of a jumbotron concept, and it used to be very popular and perfectly mastered in North Korea, I think – the concept of a human jumbotron. I have never been to North Korea but years ago my country was not so much different, and the authorities sometimes requested the human jumbotrons to be formed, may be not very refined, but rather simple and crude. So hundreds of pupils were equipped with coloured flags and seated in a predefined sequence on the tribune. They were obliged to observe carefully a guy standing discretely on the roof of a nearby building and holding a large cardboard tag with some kind of number on it, visible from distance if you knew where to look. The numbers changed from time to time. We were requested to prepare a flag with the proper colour depending on the number we were shown. This colour might have been different for neighbouring students responding to the same number/signal. So for example if I saw number 10 I should have prepared a red flag and if it was 33 the colour should have been green. Another signal was used to trigger the immediate display of the flags we had just prepared. Sometimes different signals resulted in the same response of a specific student, who was thus playing the role of a pixel in a gigantic image formed on a tribune. Of course, we were given instructions on how we should behave, specifications of numbers and the corresponding colours. I would not call them blueprints, we called them cheat sheets. They did not tell us what kind of pattern we formed. During rehearsals we asked our teachers to go at some distance and tell us what kind of impressive patterns we were displaying. So I think this is the way complex tissue arrangements are formed by individual cells, only the poor cells have no teachers and none of them knows what it forms (nor does it care about it). The analogy has of course a limited applicability. In a multicellular system there is not a single source of signals and the cells do not respond to just one signal at a time. For instance, the experiments have shown that to induce tracheid formation in a plant from the mesophyll cell, both auxin and cytokinin are needed. Moreover, not only the type of signal counts, but also its intensity, how clear it is, how distant is the responsive cell from the signal source [3]. Often the signal is sent from the sender cell to the recipient cell through the agency of some other cells, like a message, propagated in a form of a gossip, rather than an official announcement. The reactions, though very basic and elementary, are no doubt much more complicated than exposing a colour flag. They often include expression of a large array of genes and each of these responses is quite complex and contains many regulatory points.

Moreover, if we wanted to make the jumbotron model even more similar to the way a multicellular organism behaves, we would have to kindly request some of the "pixels" to commit suicide in response to specific signals, like tracheid or some secretory cells tend to do (entering the apoptosis route).

With all these limitations, I think the jumbotron composed of pixels equipped with simple cheat-sheets is a much better analogy of a multicellular organism, than an army of microscopic dwarfs keeping blueprints in their pockets. And importantly, the jumbotron model makes it easier to evade the question "if there is a design, then who could possibly be the designer ?" which cannot be answered within any evidence-based science.

Acknowledgement

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Conflict of Interest

No conflict of interest.

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