What is a Sphere? Metapatterns and Scale-transcending Functional Principles

Tyler Volk

What is a sphere? Answering this question is a way to summarize what I have called metapatterns, or scale-transcending functional principles.

Emphasis is on the word functional. This focus makes my analysis somewhat different from the common way to think about scale-transcending principles, which tends toward the more mathematical patterns. To be sure, metapatterns have mathematical descriptions or at least allusions to math in a number of cases. But they are also inherently functional, unlike mathematical objects. This is a key point that hopefully will become clearer.

The functional aspect of metapatterns was present in the book,[1] but was only explicit in a few parts and therefore much too implicit. But the issue of function and how it relates to multi-scale evolution was made explicit in three recent papers.[2]

Point 1. All is pattern.

This seems obvious, but I highlight it to start because this short statement is potentially a way to think about a unified science, in other words, a science of everything. What would be the subject matter of such a science? Well, because everything is pattern then a science of everything has to be a science of patterns.

Consider a simple sphere, such as a grape or a soap bubble. It is a system made of parts. It is not made of π, πr^2, $(4/3)\pi r^3$ (for the volume) or πD. These are strange though useful numbers that came out the heads of mathematicians. But π is not the way that nature builds a sphere. A sphere in nature is a pattern of parts in a certain geometric arrangement.

Point 2. There exists what I think of as two great realms.

I am not sure what to call these—perhaps existential zones or domains. I am open to suggestions. But here is the point, despite the challenge with terminology: consider the soap bubble sphere (or a natural bubble in a turbulent stream). That sphere is formed from physical and chemical interactions (forces), resulting in a minimal energy system. The shape turns out to have a minimal surface area, because surface area or tension/energy is minimized and this is also the configuration of maximum volume. This process and the result are fairly well understood (there still is science going on with soap films in the literature).

Now let us turn to a biological sphere. A grape, perhaps. The grape is not like a soap bubble because it is perfectly possible to cut the grape in half and have each half remain as a half sphere, all by itself in space. A bubble of half the mass would either burst or re-form into a smaller bubble. The grape is formed not only from the interaction of physical forces, though the grape is indeed physical. A good way to think about this is the fact that the genes in the cells of the grape itself are the same as the genes in the grape leaves. Different genes have been turned on or off inside the cells in the different plant organs, but the genome of each cell is the same. So the grape vine did not form the grape as sphere in the same way that the soap bubble was formed. The grape as sphere was a biological choice (anthropomorphizing an evolutionary process). The same genes could have formed a leaf, the function of which is to capture solar energy. In contrast, the grape, like many but not all fruits, is spherical because this shape is a good way to conserve water while the seeds are developing inside. So the grape vine is using in a sense the same idea (a minimization) that is in the natural, physical bubble. But the biological sphere is a choice because of a function that is being fulfilled by the geometric properties.

This consideration shows why I see two fundamentally different realms out there: (1) the pre-life of the physical, chemical, geological, and astrophysical; and (2) the post-origin-of-life, in which I will include culture (which I'll go into shortly). The post-origin-of-life consists of all

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the systems that can seek out patterns and lock them into a place in the pageant of existence through evolutionary processes based upon the functions of those patterns.

Point 3. Within the realm of post-origin-of-life, which could be considered as one great evolutionary realm, are the sub-realms of biological and cultural evolution.

I always feel strange talking about evolution in this expanded sense because evolution is sometimes taken to imply biology. But many others have expanded the meaning of evolution to include the objects of culture as well.[3]

Consider a cultural sphere that is not exactly a sphere but close enough to it: the cathedral in Florence, with the amazing dome by Brunelleschi. There is a wonderful little book called *Brunelleschi's Dome* that recounts the events. Brunelleschi won the contest to design and construct the dome, over his long-term rival, Ghiberti. And so the final design was chosen not through biological evolution but through a cultural evolution. Brunelleschi and Ghiberti both had ideas on how to span the circular gap in the cathedral's transept that had been sitting there as a physical void, a wound to the pride of Florence. The two designers entered a competition. So they put forth variations. One of their designs (and only one of the designers) was selected. In culture, patterns are generated, at least in some cases by an evolution-like process. Cultural evolution works not by genes but though equivalent processes taking on a high level of generality. The philosopher Daniel Dennett, as just one prominent example, used the term algorithm to describe the evolutionary recipe: replication of themes, variation of those themes, and selection of those themes (winners). The result is that we get patterns that work in some important kind of sense. Sometimes the patterns do not work so well, but this is the marketplace. We are not talking about optimization in any sense in all cases; we are talking about making it out there into manifestation.

Point 4. Evolutionary convergence.

Convergence exists across the scales from narrow to transcendent. As far as I am aware, the term convergence comes out of the biological sciences. A most famous example involves the cacti of the deserts in the Americas versus the succulents in Africa. Both types of plants have spines to deter grazers. Although they are rarely perfectly spherical both are more spherical (as a metric) than flat leaves. Their thickening is useful because it saves water by reducing surface area relative to a given volume. Here is the important point: the cacti and succulents are not genetically related to each other. They did not come from a needle-bearing, bulbous plant. They both evolved from leafy plants in the distant past. So their separate genetic evolutionary lineages discovered their similar patterns independently. So there was a convergence of design.

It is straightforward to expand the term convergence beyond its usual confines to biological forms, say, within plants. I will first show how this expansion takes place within biology. The eggs of many birds and insects are also spherical, or nearly so. The fact that the grape is spherical and an egg is spherical has nothing to do with common ancestry. The facts of these two biological spheres are related to the functional fact that the sphere is a good way to conserve moisture. The sphere is a minimal surface and maximum volume. The sphere as functional principle was independently discovered, as shown by grape and bird egg, across the plant and animal scales, which expands the concept of convergence in a way not normally done in standard biological convergence.

Let's keep moving outward. Consider a crab, specifically its leg, not its round body, but just its leg. Also consider the antlers of an elk. Crab leg and elk antlers. Both are examples of what I call tubes in the language of metapatterns. One function of tubes is to create distance in space in a minimal kind of way, through a linear structure. Tubes have been independently discovered on different scales. For example, trees use structural space-spanning tubes. Even though trees, compared to crabs and elk, have very different genes and molecules in their cells, all have found and abundantly utilize the same forms. The tree's trunk lifts the leaves up to the sky in the same way that the legs of the elk lift the body off the ground, away from the surface.

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I now want to show you that these metapatterns are much more than the geometric shapes so far discussed as spheres and tubes. The metapatterns can be relational patterns as well.

The metapattern of alphabetic holarchies or combinatorial systems is convergent in both biological and cultural evolution. In biology, the four bases of DNA generate the codes for twenty-three-plus amino acids, and those amino acids in turn can generate hundreds of thousands, or truly, many millions of proteins. The result is what is basically an infinity of proteins, the result of alphabetic combinations of what are fundamentally four bases. Now the alphabets of cultural systems use more than four letters (though computer code is at its most fundamental a binary), but limited alphabets of a couple dozen or so letters (or a few dozen phonemes) of different cultures around the world can generate what is almost an infinity of words and then an even higher infinity of sentences, paragraphs, etc. These two alphabetic holarchies of the DNA code and the human alphabet generate combinatorial diversity. This relational metapattern was independently discovered by both biological and cultural evolution, and so there is something more fundamental behind the specific manifestations. There is the common functional idea that is being fulfilled.

Metapatterns are functional attractors at the scale that includes all evolutionary systems. Metapatterns are structures or relational principles that fulfill functions. They are not like the way that the soap bubbles minimize energy. Metapatterns are discovered for functional reasons, because evolutionary systems exist in contexts of organisms in ecosystems, or designed items within human cultures.

Point 5. Evolution itself is a metapattern.

Here is how. Once biological evolution began, systems that have replication, variation, and selection in them have been independently discovered many times (in other words, they have been selected for).

In biology, sex would be an example. Sex creates variation. So sex creates a mini-evolutionary system within evolution.

The immune system is another biological example. The immune system puts out variants. Whichever variant finds the bacterium or virus gets subsequently manufactured in expanding abundance.

For the brain, Gerald Edelman[4] has applied the term neural-Darwinism. According to Edelman the brain has at least three different levels of a kind of Darwinian selection.

It is within the evolutionary sub-realm of cultural evolution that I feel a great amount of work could be done in seeking examples of the replication, variation, and selection (RVS). For example, Stuart Kauffmann[5] has recently written how the evolution of human laws needs to be examined, and law is a variational and selectional pattern. The market itself is an RVS system, according to Adam Smith, who made conscious the power of the economic evolutionary algorithm as the best way to produce efficient patterns that can benefit everybody. Democracy itself is an RVS system. Evolution as RVS is itself a metapattern.

I am not sure what to call evolution as a general algorithm that itself is a metapattern. RVS sounds like a drugstore. But perhaps it's abstract and unique enough to do the job. Dennett[6] uses the term universal Darwinism to include memes and cultural evolution.

In summary: 1. All is pattern. 2. There are two great realms, that of physics-chemistry and that of the realm of all evolving systems that originated after the origin of life. 3. The realm of all evolving systems contains the sub-realms of biology and culture. (Note: I am not sure where to put cognition here, it might be pragmatically worthwhile to treat it as a third sub-realm, though clearly it is related to both biology and also to culture.) 4. Convergence occurs at different scales, and metapatterns are convergences at the all-inclusive scale of all evolving systems. 5. Evolution as RVS is a metapattern. These considerations lead to the intellectual research challenge to seek metapatterns, such as spheres, tubes, borders, binaries, centers, layers, arrows, breaks, cycles, and more[7/8] and then use them to explore the structure of all of reality in new ways and especially as ways to understand the self in quest that is similar to some of the goals and tools of general semantics.

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Tyler Volk is science director of environmental studies and a professor of biology at New York University. In his work and writing, he examines reasons for phenomena across a number of different scales, and is the author of a number of books, including *Metapatterns Across Space, Time, and Mind*, and the newly released *CO2 Rising: The World's Greatest Environmental Challenge*.