On cosmological principles in natural sciences

Cosmological principles are believed to be authoritative in the natural sciences. I challenge such beliefs and contend that they result in systematic errors and false beliefs about the powers of natural sciences and about possibilities for development of new scientific systems. The results of the errors and false beliefs are especially serious in investigating the question, "How do brains work?" I have developed an "alternative approach" to that question that does not rely on cosmological principles.

A cosmological principle (as I use the term) is a principle that is declared to be true in all situations and under all circumstances. An original cosmological principle was Newton's Law of Universal Gravitation. Its descendants – Einstein's principles of space, time, mass and gravity – are the most powerful current cosmological principles. I affirm the validity of Einstein's cosmological principles but deny other popular cosmological principles. The reasons for such affirmation, on the one hand, and denials, on the other hand, make up the subject matter of this essay.

I hold that human intelligence is not strong enough to state cosmological principles applicable to important conditions and activities of material bodies. For example, we cannot provide a satisfactory "explanation" of "why" water turns into ice when the temperature falls below 0 °C at ordinary pressure. There are "explanations" available but they are far from satisfactory. This state of affairs is stated by physicist, David Ruelle, in *Chance and Chaos* (1991) at 122-124 as follows:

> "One puzzling phenomenon is the boiling of water, and the freezing of water is no less mysterious. If we take a liter of water and lower the temperature, it is not unreasonable that it should become more and more viscous. We may guess that at low enough temperature it will be so viscous, so stiff, as to appear quite solid. This guess about the solidification of water is wrong. As we cool water we see that at a certain temperature it changes to ice in a completely abrupt manner. Similarly, if we heat water it will boil at a certain temperature, i.e., it will undergo a discontinuous change from liquid to water vapor. The freezing and boiling of water are familiar examples of *phase transitions*. These phenomena are in fact so familiar that we may miss the fact that they are strange indeed, and require an explanation. ... So here is a problem for theoretical physicists: prove that as you raise or lower the temperature of water you have phase transitions to water vapor or ice. Now that's a tall order! We are far from having such a proof. In fact, there is not a single atom or molecule for which we can mathematically prove that it should crystallize at low temperatures. These problems are just too hard for us." (Emphasis in original.)

False cosmological principles include the following:

1. "All things are made of atoms." (*The Feynman Lectures on Physics*, Vol. I, at 1-2 or Chapter 1, page 2.) There are, in fact, very few "atoms" in our lives. Real material bodies are not "made of atoms." It is impossible to "make" a piece of wood out of chemical reagents. A

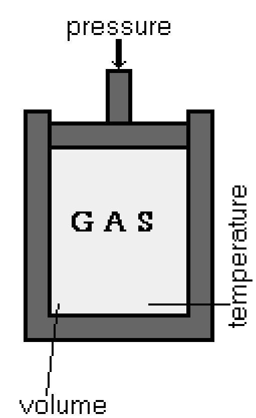
piece of metal, like iron, is made up, not of atoms, but of "grains." In a grain, atomic nuclei are arranged in a regular geometric pattern like a three-dimensional wallpaper pattern; but the chief properties of the piece of iron are based on negative electronic charge that is distributed throughout the iron and that is described, to a crude first approximation, as a "Fermi sea." Magnetism is a collective property of iron and can be changed through a collective phase transition that operates on principles very different from those governing "atoms" and that are illustrative of my alternative approach to brains.

2. The Universal Turing Machine (a computer) is supposed by some computer scientists and brain researchers to apply to all reasoning. Many current brain researchers base their approaches on computational systems.

3. "Darwinism" is elevated to a cosmological principle that supposedly applies not only to biological species but also to brains, as in Neural Darwinism proposed by Nobel Laureate and brain researcher Gerald M. Edelman, or the "Darwin Machines" proposed by other researchers that supposedly show how brains work.

I have different answers to the question of "how do brains work." My answer is not based on universal or cosmological principles, but rather on *idealized* models that apply exactly at a point or center and with decreasing exactitude as conditions depart from the center. Hence my rejection of cosmological principles is a basis for my alternative approach of constructing idealized working models of brains.

An example of an idealized model is the Ideal Gas Law, $pV=nRT$, where p stands for the pressure of the gas, V stands for the volume of the gas, T stands for the temperature, n stands for a measure of volume (the number of "moles" of the gas) and R is a constant that is the same for all gases. Applied to a quantity of a real gas in a closed container with an adjustable volume, the Ideal Gas Law applies with greater exactitude as the pressure decreases and the temperature increases and, conversely, with decreasing exactitude as the pressure increases and/or the temperature decreases. If a real gas is subjected to a sufficiently high pressure and a sufficiently low temperature, it will cease to be a gas and become a liquid or solid, where the Ideal Gas Law does not apply at all.



Another idealized model is the Ideal Reversible Heat Engine developed by Sadi Carnot (1796-1832). Such an idealized model is, in my opinion, an appropriate way to investigate conditions and activities of matter (including the activities of brains) while cosmological principles are a wrongheaded approach. This opinion follows from the principle that our intelligence is not strong enough to state cosmological principles applicable to the internal activities of matter, especially matter organized in living beings.

It is, however, a fact of the human condition that we crave cosmological principles. Finding a useful principle in an idealized model, we want to elevate that principle into something cosmological, hoping to use it to discover new knowledge. Such hopes are often somewhat realized even if the cosmological principle is erroneous. As Goethe wrote: "A wrong hypothesis is better than none at all." (Please see W. Kaufmann, *Discovering the Mind: Goethe, Kant and Hegel* (1980).)

The chief cosmological principle that I challenge is the principle that a Universal Turing Machine, a computer, applies to all reasoning and is the key to "artificial intelligence." Proponents even declare that "robots will have superhuman powers of reasoning." I have presented a counter-argument using an idealized system, with an essay and a web page titled "Timing Devices or why brains are ***not*** computers." Please see: http://www.quadnets.com/timingdevices.html

My investigations propose an explanation for the incapacity of human intelligence to state cosmological principles applicable to internal conditions and activities of matter. That is, my idealized models show (in a limited way) "how brains work" that the "workings" constitute a specialized and limited set of skills and capacities. The most important capacity is a capacity to ***exercise freedom***. A person exercises freedom while playing a game or sport. (I hold that the enjoyment of freedom is the chief reason for playing games and sports.). A person exercises freedom while making a choice about a purchase in a market. A judge or jury exercises freedom while deciding a civil lawsuit. Please see: http://www.embodiment-of-freedom.com/

In my models, brains work by generating multiple activity patterns that all belong to a ***family*** of such patterns. The activity patterns in such a family are related through ***resemblances***. Through an exercise of freedom, a person can select one activity pattern from the family. I hold that our intelligence is not strong enough to penetrate the actual exercise of freedom (or the workings of consciousness) but that we can gain partial knowledge through idealized models and by identifying the families and the resemblances.

As an example of such brain workings (without freedom), consider an automobile driver waiting at a traffic signal that is "red." "Waiting" is one activity pattern. When the signal changes to "green," the driver will change the activity pattern to one that starts moving the vehicle forward. While waiting, the person's brain generates a family of activity patterns consisting of two possible activity patterns, "wait on red" and "go on green." Such generations will occur repetitively in a cyclical way. If, during such a cycle, the person sees that the signal is "red," the person will realize the activity pattern "wait on red." If the person sees that the signal is "green," the person will realize the activity pattern "go on green." Realizing one activity pattern or the other constitutes a ***selection***. The selection is made consciously. A person requires consciousness to start moving his or her vehicle when the traffic signal changes.

The selection at the traffic signal is controlled by the traffic signal and there is no exercise of freedom involved. Selections can be free during sports and games, in markets and in courts of law, as discussed in the website noted above.

I suggest that such general workings of brains operate during the construction of scientific theories. The "best" resemblances show exact duplication. The strongest foundations for natural science are ***invariants***, matters that are duplicated exactly, such as the speed of light and the structure of an individual's DNA. Successful families of resemblances in natural science are organized by principles of ***symmetry***, ***continuity*** and ***reversibility***. In spatial symmetries, one part of a pattern closely or exactly resembles other parts, although with distinctions based on location, rotation, mirroring and the like. During continuous processes, there is a sequence of conditions that closely resemble each other; the mathematics of calculus enables families of resemblances to be compared and organized. In reversibility, a prior pattern can be achieved by "running the film backwards" and a "reversible" scientific principle such as conservation of energy works as well going backwards as going forwards. A chief test of a scientific principle is that a later researcher can successfully ***reproduce*** an experiment of a prior researcher, with results of the two experiments closely resembling each other.

Idealized systems support such principles of symmetry, continuity, reversibility and reproducibility. Such systems provide useful scientific knowledge. Unfortunately for those who crave cosmological principles, reality is, in general, unsymmetrical, discontinuous, irreversible and non-reproducible. When resemblances fail to apply to phenomena under consideration, scientific knowledge likewise fails to be effective.

Einstein's principles of space, time, mass and gravity are formulated for application in a ***void*** that is highly symmetrical by default. The symmetries support the principle of conservation of momentum and other conservation principles. Dynamical laws (based on Newton's original Three Laws) are further organized by principles of continuity and time-reversibility. The invariants include the speed of light and the cosmological constant. In the void, these principles are successfully generalized into Einstein's cosmological principles.

Real material bodies, on the other hand, go through phase transitions discussed above. Physicist Lev Landau "emphasized that the continuity of state between liquid and gas at sufficiently high temperatures is possible only because the liquid and gas phases have the same symmetry. A transition between two phases of different symmetry [e.g., between liquid water and ice] cannot be continuous; elements of symmetry are either present or absent and no intermediate case is possible." (C. Domb, *The Critical Point* (1996) at 122.) During a Critical Point transition, symmetry is ***broken***. Symmetry is also broken, I contend, when a person exercises freedom. Critical Point phase transitions are of central importance in my proposed models of idealized brains. Because of symmetry-breaking, an exercise of freedom cannot be comprehended by a scientific theory. Moreover, in real brains, phase transitions are often discontinuous and irreversible. My idealized models provide a way of approaching the question "how do brains work" without purporting to arrive at a definitive answer and without invoking cosmological principles.