# The Character of Natural Law

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## 1 Introduction

Our world is complicated but not all arbitrary. We do recognize rules and regularities across all scales of natural hierarchy. Scale-free patterns, most notably skewed distributions that accumulate along sigmoid curves, and hence display mostly as straight lines on log-log plots, i.e., comply with power laws make no distinction between animate and inanimate. For example, lengths of genes distribute in the same skew, nearly lognormal manner as lengths of words. Animal and plant populations, irrespective of a species, spread out on terrestrial and marine environments in the same manner as economic wealth, irrespective of assets, spreads out in diverse societies. Chemical reactions and economic transactions proceed at times in an oscillatory manner toward stationary cycles such as citric acid cycle in a cell and annual cycles of agricultural production. Also a cyclone whirls in a temperature gradient in the same way as a galaxy spirals in the universal density. Logarithmic spirals appear in many other familiar forms as well.

Moreover, ecological succession proceeds in the same way as technological progress, that is, from one innovation to another along a sigmoid curve. Production of goods branches out just as phylogenic tree of species fans out. Furthermore, neural activity recorded from cortex displays a power-law pattern just as seismic activity recorded from Earth's mantle. A metabolic network across a cell displays the same degree distribution of intersections as the nodes of a transportation network across a city or the communication network World Wide Web across the Globe as well as the network of galaxies across the Universe. And so on, and so on. These universalities present compelling evidence to me that there is a natural law that encompasses everything.

## 2 Perspective

For long man has sought for complete comprehension of nature. However, today the quest for the theory of everything no longer entails everything in physicists' attempt to construct a theory that would unite fundamental forces. As the quantum theory of gravity remains elusive, many a physicist have began to belittle the anticipated breakthrough by reminding us that the ultimate unification may not, as such, guarantee prediction of an outcome of any conceivable experiment. Instead laws governing complex, notably living systems may well emerge independent of the low-level, microscopic laws.

In historical perspective this now attained narrowing in the quest of complete comprehension to the unification of forces follows the overall trend of ever deeper specialization. In the old days, at the turn of 1600 and 1700 hundreds when natural philosophy had not yet diverged to disciplines, the quest for the complete comprehension was not regarded as an awesome aim attainable first by an impressive scientific industry, rather it was considered merely as a rational task with inevitable resolution.

Newton began Principia by saying that *Rational Mechanics will be the science of motions resulting from any forces whatsoever, and of the forces required to produce any motions,…* In other words, Newton did not focus only on gravity rather he regarded gravity as any other force. Moreover, Newton acknowledged that everything depends on everything else by saying that motions results from forces and vice versa. Also Leibniz promoted holistic worldview by announcing that *among all conceivable worlds the one, in which we live, is the most probable*. Leibniz spoke about variations and about natural selection for the most probable paths. Few decades later the variational principle took its firm mathematical form in Maupertuis' writings. Nonetheless, by today we have largely abandoned both Newton's and Maupertuis' forms of the equation of motion for natural processes as being either imprecise or incommensurate with modern constructs of thinking. Here, I wish to explain why we walked away from the rational way of thinking, and I wish to reappraise the early understanding as an accurate comprehension of everything.

## 3 Notion of everything

When we wish to speak about everything, we need the most general concepts and the most impeccable logic, not the most exhaustive catalogues of genes or surveys of galaxies and not the most detailed charts of metabolic pathways or communication networks. Indeed Newton, Leibniz and Maupertuis did not talk about particular particles and certain fields, but about variation in motional paths in general and about the universal criterion of natural selection among alternative paths irrespective of gravitational, electromagnetic, nuclear or other forces that merely power natural processes. Likewise Darwin did not talk specifically about mutations and ensuing expressions as altered phenotypes, but in general terms about variation and natural selection irrespective of genetic, metabolic, behavioral or other means that are merely in the service of evolution.

Darwin was a generalist, but not general enough to promote that evolution entails everything, not only animates. The ubiquitous patterns prove processes of life no different by principle from processes of abiotic, technological, economic, social or any other systems. Therefore it is not enough to study living to understand life, but we must place life in a general, cross-disciplinary context to learn what it is all about. Likewise, it is not enough to study elementary particles or quantized fields to learn fundamentals, but we must express everything in general, scale-free terms.

* Figures: http://prezi.com/40b8asird5yr/the-law/

## 4 The problem of physics

As I speak for physics to provide us with the most general concepts and the most solid logic to make sense of nature, surely some of you doubt whether physics is able to explain life or other forms of complexity and emergence. And you are right in the sense that physics as a discipline the way we know it today, cannot, but physics as we should know it, can.

Let me make my point by reminding you of Newton's 2nd law of motion. When I ask physics students to state Newton's 2nd law, they will almost always declare $\mathbf{F} = m\mathbf{a}$. However, Newton wrote that a force causes a change in momentum, [i.e., $\mathbf{F} = d_t\mathbf{p}$]. Hence the differential [of momentum $\mathbf{p} = m\mathbf{v}$] respect to time yields not one but two terms, namely $\mathbf{F} = m\mathbf{a} + \mathbf{v}d_tm$. The change in mass can be converted to a change in energy by another familiar formula of physics due to du Châtelet but made known by Einstein, namely $E = mc^2$. The 2nd term of Newton's law should not surprise you because any chemical reaction will either emit heat or absorb heat. The heat originates from the change in mass. In a nuclear reaction the change in mass is unmistakable as its tremendous output powers activities of our society. In a chemical reaction the change in mass per a broken covalent bond is not more than one per mill of the mass of an electron, but it is still ample enough to power processes of life. Since the change in mass is inherent in any change of state, it should be also written down in our equations of how nature works.

All this is very trivial, and hence very important. Newton's law says, for example, that a bacterium is forced to swim up along a concentration gradient of sugar to metabolize the associated free energy. If the second term were omitted, that description would be without metabolism, that is, without changes of whatsoever. But biology is all about changes; about evolution, development, differentiation, proliferation, adaptation, learning and so on. And so are also all other processes that are embedded in evolution of the entire Universe. Therefore physics, the way it is taught today, cannot account for life and not even for evolving inanimate, but the way Newton, Maupertuis and few others knew physics centuries ago, may well account for everything.

As you see, it takes only to divide Newton's law by momentum to recognize the ubiquitous power law, that is, the straight line on a log-log plot that follows from the fact that a system will move along the resultant force, that is, along the steepest gradient of energy.

## 5 Wishes and verity

You must be now somewhat puzzled by the thought that if dissipation in the form of change in mass is so vital, as I argue, why it is then omitted from teaching physics. The reason is simple but selfish. Namely, the equation of motion including the change in mass cannot be solved.

The non-determinism manifests itself, for example, when a rock rolls down from a hill top to the bottom of a valley. During the process the hill top will obviously become little lower and the valley will become little higher. In other words motion is consuming its driving forces, here the height difference, and hence variables cannot be separated to solve the differential equation of motion. Likewise when limits of integration, in this case the height levels, change during integration, the value of a definite integral cannot be calculated precisely. Our inability to predict precisely does not follow from complexity of a system or from our incomplete knowledge of the system, but non-determinism and emergence are innate characters of natural processes due to net flux of quanta from the evolving system to its surroundings or vice versa, all embodied in the changes in mass.

It is obvious to any biologist that a growing population will invariably cause changes in its surrounding ecosystem, just as it is evident to any economist that an expanding enterprise will inescapably put adjacent competitors in plight. Yet, many a physicist does ignore these indisputable consequences imposed by the evolving system on its housing surroundings or vice versa to keep his equations computable. Apparently it was the intellectual challenge to calculate outcomes that superseded profound comprehension and misled us away from the early accurate account of nature to devise approximate models of data.

I am not only blaming contemporary physics for lack of common sense, I am also claiming that modern biology voices more like our wishes about a tractable nature than the verity about the intractable character of nature. The trouble is not that we would not know enough, the trouble is, as the late Stephen Jay Gould said, we wish that, when changing one aspect, all other things would remain equal, but they never do. *Ceteris paribus* principle does not hold. It is not only that *we* cannot solve the equation of evolving nature – nobody can. When everything depends on everything else only by trial and error nature varies its courses and makes the natural selection for the least-time free energy consumption.

Yet we should not mistake non-determinism for indeterminism. Paths of evolution do vary, but the tracks are not all arbitrary. The natural bias points along the resultant force, and hence diverse processes do direct along their least-time paths and give rise to the rules and regularities we see everywhere. But too often we mistake these trends as outcomes of some special mechanisms or as being consequences of some discipline specific laws or doctrines whereas in fact they are manifestations of the supreme law of nature that spans across all schools and scales.

## 6 The resolution of physics

It takes only to multiply Newton's law with velocity to display explicitly the least-time flows of energy. This form,

*Figures: http://prezi.com/40b8asird5yr/the-law/

given first by Maupertuis, is known as the principle of least action. It sums all evolution as changes in kinetic energy. The term does not only denote, for instance, the kinetic energy of a rolling rock but also the accompanying changes in the landscape as the hill top becomes lower and the valley fills up little bit as well as the dissipated quanta. Therefore the total kinetic energy is not $½mv^2$ but $mv^2$ *vis viva* as Leibniz new it.

In thermodynamic terms the change in kinetic energy is equal to the change in entropy multiplied by temperature. The change is financed by energy that is bound, for example, in numerous chemical potentials of food and by energy that is in free propagation as light which will, for example, raise fodder. It is only a trivial mathematical task to show that the equation accounts for the ubiquitous patterns, skewed distributions with long tails which sum up along sigmoid curves, and hence follow mostly straight lines on log-log plots, that is, comply with power laws. Alike analysis reveals that logarithmic spirals and branching trees and networks are natural consequences of least-time free energy consumption. So Newton's $2^{nd}$ law, the principle of least action, as given by Maupertuis as well as the $2^{nd}$ law of thermodynamics, as given by Carnot, are one and the same law, the supreme law of nature.

Thus, the proper physical portrayal of nature is not convoluted, weird or mysterious but simple and familiar to us from our everyday experience. Quandaries of quantum mechanics and curved space-time of general relativity are among many eerie ideas of modern physics that merely articulate our own aspirations of a computable nature rather than expressing true comprehension of the non-deterministic character of evolving nature.

## 7 Examples of all-inclusive impetus

We look for various causes of changes, but it is always the superior surroundings that has the say whether a system will change or not. A chemical reaction, proliferation, development, differentiation or any other process did happen in the past and will happen also in future to abolish energy differences between the system and its surroundings. Biota appeared and covered the Earth by diverse species to consume the free energy contained in the hot sunlight relative to the cold space. Likewise economies emerged and are now enveloping the Globe to consume energy differences between rich natural resources and the cold space by many means, mines, factories and other industrial machinery. Also galaxies housing stars and other powerful mechanisms of combustion formed and spread across the Universe to consume energy differences between matter and the sparse energy density of space.

Free energy in various forms is consumed in changes of various kinds. Diverse mechanisms, however, merely channel flows of energy when proteins fold, cells differentiate and plants grow, or when inventions are made, products are sold and business is flourishing, or when stars shine, galaxies mature and the Universe is expanding. Natural processes, despite their many names, do not differ from each other by principle, only by their mechanisms.

Since there is no qualitative difference between animate and inanimate, it is also meaningless to ask how life originated. Admittedly the vital machinery has perfected itself over eons in the free energy consumption, so that today's biotic faculty may seem rather different from pioneering abiotic mechanisms, but the operational principle is still the same. This resolution, however, does not relinquish all reasoning of abiogenesis futile. Metabolism first hypothesis makes sense, but first when it includes also abiotic processes such as a stirring breeze of wind over a warm pond. Also the advocated role of RNA is justified, but not solely by its hereditary properties but primarily by its ability to catch light. It is no coincidence that nucleic acids are energetically expensive molecules because they were initially recruited to the free energy consumption due to their energetic value as such and only later became to embody free energy in forms of information. Likewise, our alphabet evolved from pictorial presentations of those things we valued. For example, the letter A stands for an ox and the letter B for a house and only later they became to embody the free energy in the form of information. Thus, information is not abstract but physical, and hence also complies with the supreme law of nature.

The chirality consensus we see among natural amino acids and sugar moieties of nucleic acids is also a result of natural selection for the least-time free energy consumption. Molecular standardization facilitates energy transduction in the same way as, for example, the transportation convention to drive on the right hand side. Accordingly cellular synthesis revolves around with a comparatively small number of conceivable organic molecules, just as modern manufacturing consumes comparatively few components. Biota's high-degree of standardization reflects a high-degree of global integration, just as the on-going standardization reflects an increasing economic integration of all countries.

The simple principle sheds light also on our complicated cognitive operations. Neural pathways are literarily the least-time paths for flows of energy as electric signals, just as metro lines are the least-time paths to go to work. We learn by building new paths and recall by running along established pathways. Conversely, when one ought to revise affirmed impressions, energetic costs will be greatly higher than when acquiring accurate understanding in the first place. These costs we sense as aversion toward unconventional thinking, for example, that evolution by natural selection entails everything and that the old law of nature in fact explains everything.

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However, when in doubt one should at least challenge the least-time imperative, for example, when it accounts for type 1A supernovae data without dark energy and when it accounts for bending of light just as for rotational curves of galaxies without dark matter. Also when in doubt about the natural law one ought to argue against the old a-tomic notion that everything is composed of quanta, when that tenet presents elementary particles as quantized actions. The least-time geodesics, for example, for electron, proton, neutron and common mesons yield charges, masses and magnetic moments by elementary calculations in accord with their measured values. Moreover, the a-tomic tenet regards space not as an abstract metric, but embodied by quanta. So gravity manifests itself, like any other force, simply as an energy density difference between the system of bodies and their surroundings. Gravity appears as an attractive force to us because the present-day surrounding vacuum's energy density is sparse, but gravity manifests itself as repulsion when the energy density of the surroundings supersedes that within the system of bodies such as distant galaxies. Likewise we are taught that opposite charges would attract each other, but clearly we see repulsion when salt is dissolved in water.

## 8 Conclusions

Newton's and Maupertuis' understanding of natural processes across all scales were once as breath-taking of a theory as it is today. What the pioneers discovered complies with reality, and hence with common sense. However, the equation of motion did not meet the expectations of delivering definite predictions, and hence the rational mechanics was abandoned. Later, when the discrepancy between the rational reality and the looked-for clockwork idealism grew indisputable, we did not go back to reconsider, if we had misunderstood the pioneers, instead we went on inventing oddities of modern physics. So today we expect exact solutions by approximate mathematical models of nature, whereas we should expect exact mathematical forms to give approximate solutions of intractable paths, yet perfect for providing us with complete comprehension of the innate non-deterministic character of nature.

Thank you for your interest.

[*]Figures: http://prezi.com/40b8asird5yr/the-law/