Darwinism is discredited but was Darwin right?

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Keith Baverstock
Department of Environmental and Biological Sciences
University of Eastern Finland
Kuopio. Finland

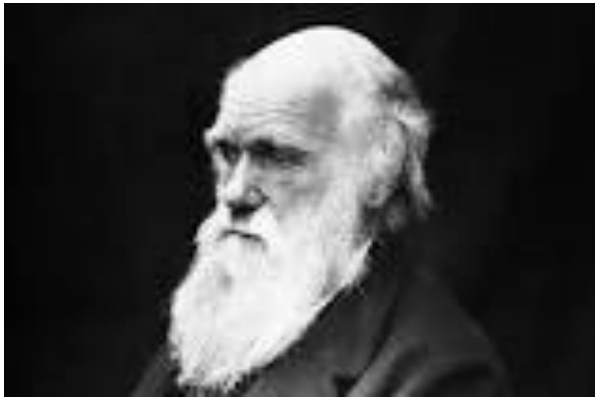
INTRODUCTION

Some scientific theories serve as a template for a "World order" and none more so than Darwin's theory of evolution. In the title of his book, the "*On the Origin of Species*", Darwin includes the phrase "*Struggle for Life*" in the sub-title and the title of the third chapter of the book is "*Struggle for Existence*". Nature is seen as red in tooth and claw and for many creatures life is almost entirely about avoiding death by predators.

Darwin's theory of evolution by natural selection dominates the way we view the natural world through the Modern Synthesis or Neo-Darwinism. This interpretation of Darwin's ideas was founded in the 1930s and is governed by strong scientific beliefs. Three are particularly important: that the process of evolution is *gradual* and organisms are *passive* in the process; that genes reside in the nucleus of the cell and constitute the unit of inheritance discovered by Mendel; that genes determine the phenotype exhibited by organisms, including us, and our behavioural characteristics.

All three of these foundational beliefs have been questioned by evidence acquired in the last few decades. In this talk I want to discuss whether it is time for a serious revolution in evolutionary thinking.

Charles Robert Darwin FRS 1809-1882



Naturalist and experimentalist and author of: "On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life".

This book is beyond doubt a great work of literature and is regarded by some as one of only two or three books that have had a really profound influence on the way the world order is viewed.

"There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

Gregor Johann Mendel 1822-1884

Czech Friar and Abbott and experimentalist who famously grew pea plants and kept bees in the garden of the St Thomas Abby in Brno. He discovered the "unit of inheritance" from one generation to the next. His work remained undiscovered for many years and Darwin was unaware of it.

"This development [of the organism by cell formation] proceeds in accordance with a constant law, which is grounded in the *material* constitution and arrangement of the elements which achieved vivifying union in the cell."

Darwin and Mendel are the central characters in the foundations of the Modern Synthesis. Neither Darwin nor Mendel had the concept we have today of the gene. It would be more than 50 years before DNA was identified as the “material" referred to by Mendel.

Neither did Darwin know very clearly what he meant by natural selection. Selective breeders were able to produce organisms with unique properties, artificial selection: Darwin assumed there was a comparable natural process in the natural world to produce the diverse species that we see today and those we know of from the fossil record. He understood that in any natural population there was variation of characteristics: selective breeders combined certain characteristics to produce new forms.

In 1930 the mathematician Ronald A Fisher developed a theory of natural selection based on a statistical measure of that natural variation called “variance”.

Fisher's theory of natural selection is fundamental to the Modern Synthesis and in my view is one of its major problems now.

Fisher was a statistician and he had no idea in physical terms of what he was referring to when he spoke of “variance in genes”.

But there was an alternative which he either overlooked or deliberately ignored. The feature of living organisms that distinguishes them definitively from non-living objects is that they are continuously dissipating energy which they obtain by metabolising nutrients available in their environments. They do this for themselves: they do not need external intervention.

By 1930 the physics of energy dissipation was well developed and it seems to me extraordinary that it did not apparently occur to Fisher that here was something of great relevance to biology.

THE PRINCIPLE OF LEAST ACTION

Pierre Louis Moreau de Maupertuis 1698-1759

French mathematician who formulated the principle of least action, an equation that determines the path followed by a system as it evolves.

Essentially the principle says that the system will evolve by the route of least resistance (and in the shortest time) given the prevailing conditions.

"The laws of *movement* and of rest deduced from this principle [of least action] being precisely the same as those observed in nature, we can admire the application of it to all phenomena. The movement of animals, the vegetative growth of plants... are only its consequences; and the spectacle of the universe becomes so much the grander, so much more beautiful, the worthier of its Author, when one knows that a small number of laws, most wisely established, suffice for all movements."

In this principle of least action we see the foundations of two of the greatest laws of physics, namely Newton's second law of motion and the second law of thermodynamics.

I want to concentrate here on the second law of thermodynamics, THE second law. Heat will flow from hotter objects to cooler objects and not the other way round. A block of ice contains enough heat to boil a kettle of water, but that will not happen spontaneously. But if we stand a kettle of boiling water on a block of ice it will melt it.

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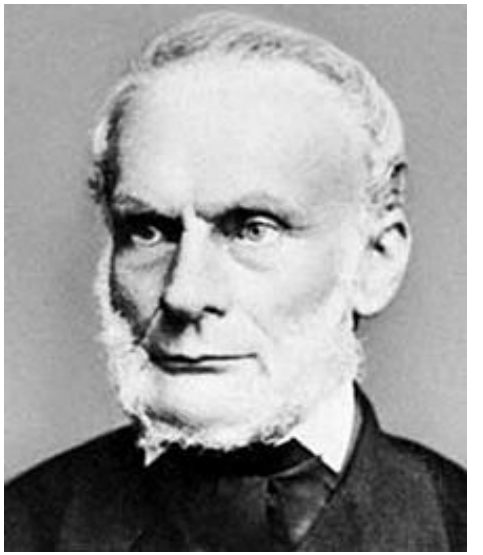
There are two forms of energy, one able to do work (or melt ice) which we call **free energy** and a second which is in the ice but unable to do work, which we call **entropy**.

Living organisms are in the business of converting free energy to entropy by consuming nutrients.

Rudolf Julius Emanuel Clausius 1822-1888 German physicist who stated the 2nd law of thermodynamics.

His objective was to explain why there is a limit to the efficiency with which engines could convert free energy to work.



"The energy of the universe is constant (energy cannot be destroyed or created), but the entropy of the universe tends to a maximum."

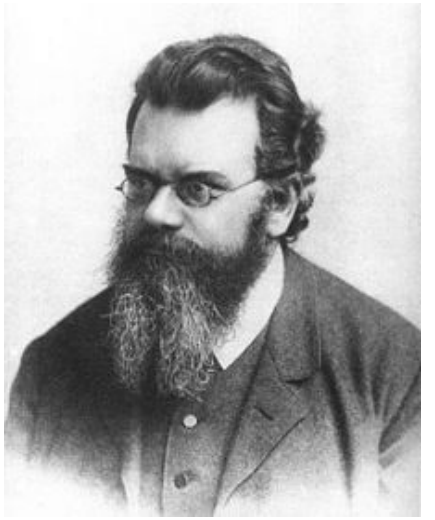
This means that any process that consumes or dissipates free energy produces entropy – useful energy produces work or growth and entropy that is unable to produce work.

Life produces entropy.

Entropy is something of a mystery. It is not directly measurable in situations where it is actually being generated as is, for example, temperature. If we use energy to heat a kettle we can measure the energy used and the temperature increase, but not the entropy produced. We have to infer that from other measurements.

After Clausius framed the second law as the maximisation of entropy, physicists began to enquire what was the nature of this curious form of energy and Ludwig Boltzmann provided an answer in 1875.

Ludwig Eduard Boltzmann 1844-1906



An Austrian physicist and mathematician who developed the molecular interpretation of entropy. He was an atomist (believed that matter was composed of invisible atoms), a view that was largely rejected by his fellow scientists at that time.

Boltzmann's equation:

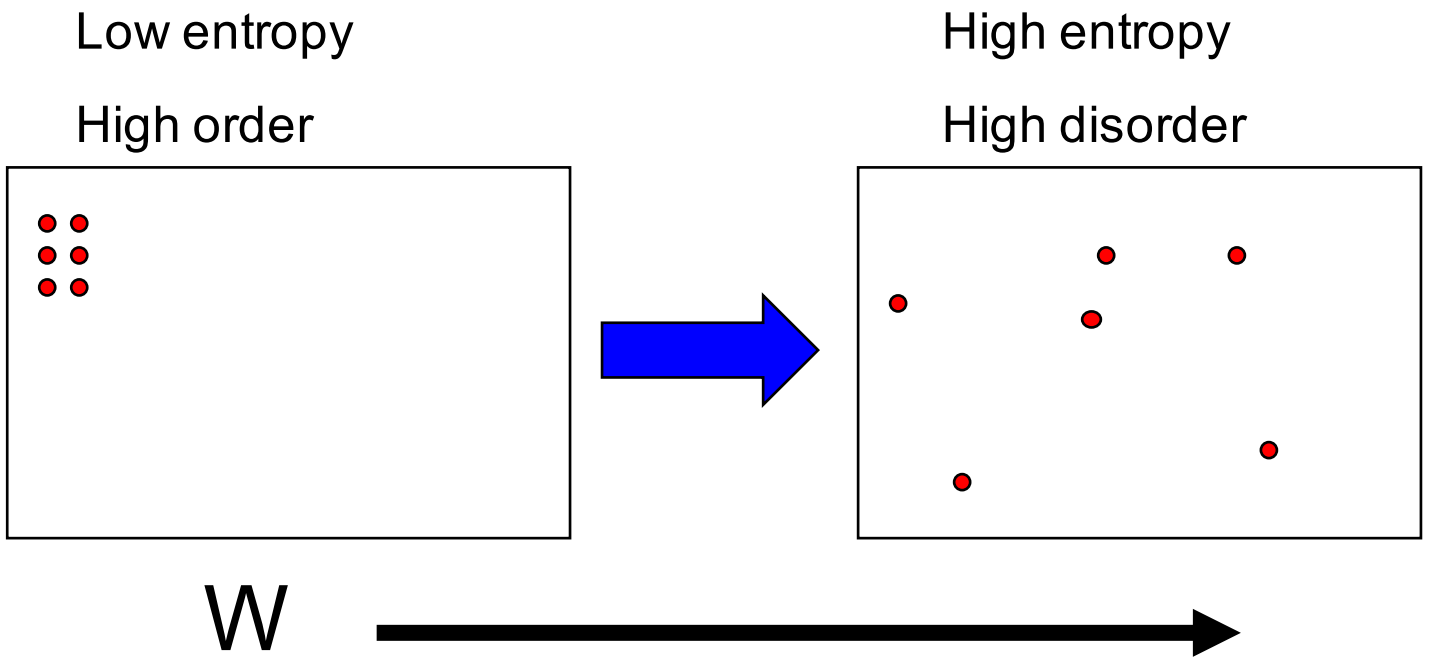
$$S = k_B \ln W$$

Where S = entropy; k_B = Boltzmann's constant and W = the probability of a specific state (this equation is carved on his tombstone in Vienna).

In this equation S increases as W increases and in a molecular system the most probable state is one of complete disorder.

Boltzmann's molecules in a closed box

(no energy allowed in or out of the box)



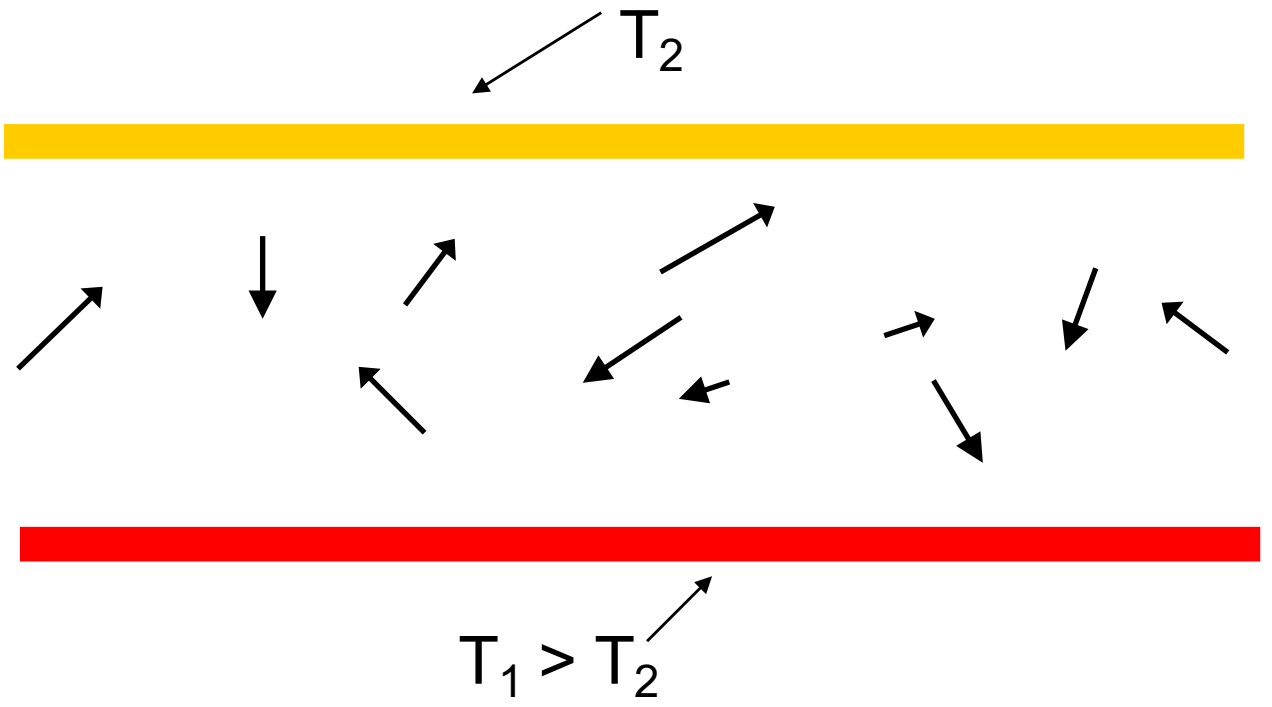
The implication here is that systems **naturally** move from highly ordered, low entropy states, to highly disordered high entropy states.

But this result worried even Boltzmann. Living systems produced entropy and should, therefore, be producing disorder. Darwin's work showed that evolution was a process in which order was increasing. Boltzmann was unable to rationalise his result with what he clearly saw in the real world and understood from Darwin. His life ended in suicide in Italy.

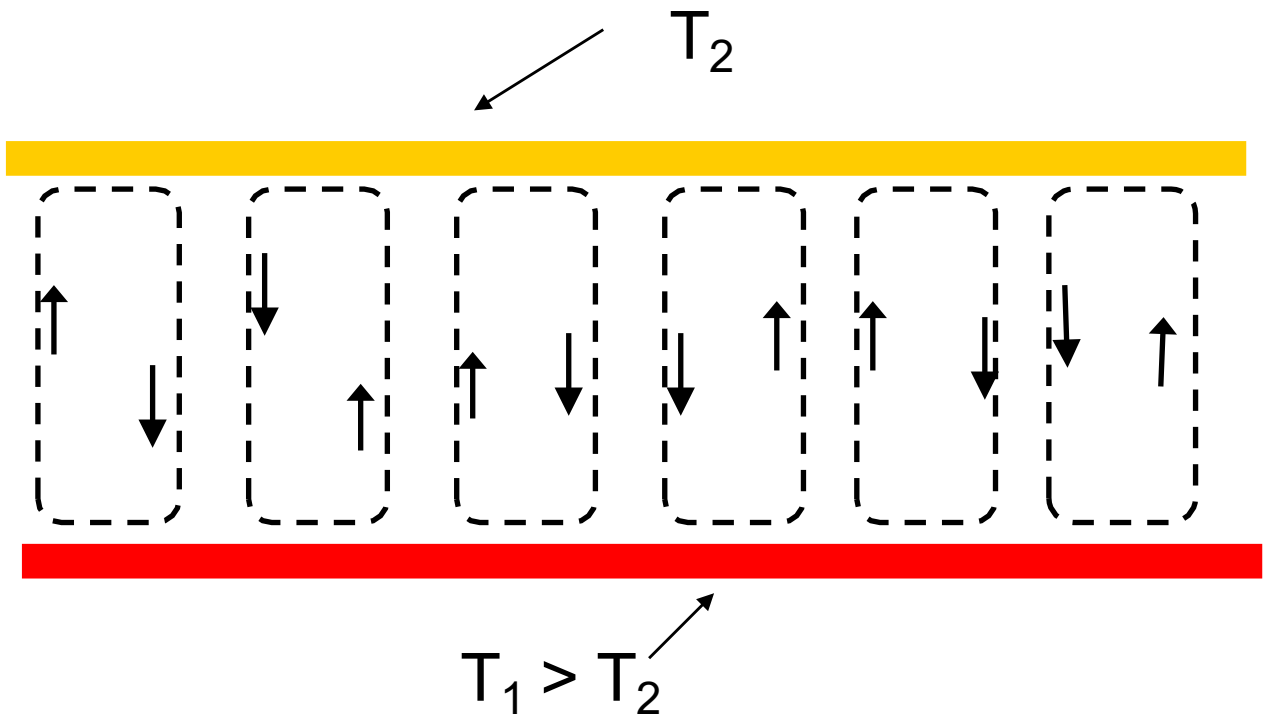
If we rely on Boltzmann's interpretation of entropy it does indeed seem that the supreme law of physics, THE second law, is at odds with a very real phenomenon of evolution.

One, at least, Boltzmann's theory or Darwin's theory, must be wrong.

Consider a fluid layer being heated evenly from below so that the lower surface is warmer than the upper surface. Molecules in fluid are randomly distributed and they are transferring the heat by a process of **conduction**: heat transfer from random collisions of molecules



In 1900 the French chemist Henri Bénard carried out this experiment. At a critical temperature gradient the randomly ordered molecules adopted an ordered state in which the process of **convection** increased the rate of transfer of heat across the liquid.



The ordered convection state is of higher entropy (because energy dissipation is increased) than the previous state where there was no convection.

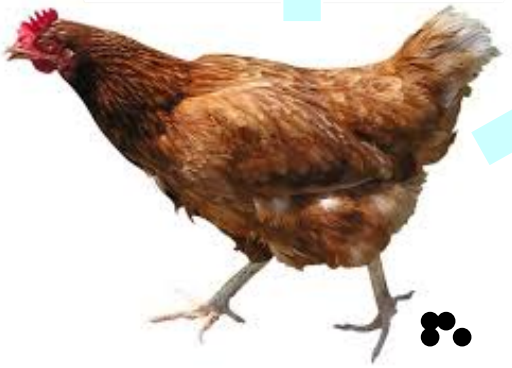
Conclusion: increasing entropy can mean increasing order or increasing disorder depending on the system. Entropy is not necessarily the disorder in the system.

In 2007 the Finnish physicist Arto Annila showed categorically that for systems that were open to the exchange of energy with their environments, order is as likely as disorder as entropy increased. Annila overturned more than 125 years of scientific belief. Boltzmann was wrong.

Consider a chicken feeding on corn. Part of the entropy is in its waste products, all less "ordered" than the corn, It emits low grade heat (body heat). Work has been produced (the chicken runs around). But we can eat the chicken for lunch: it is also entropy in the form of **stored energy**. So the energy in the corn is converted to entropy in more than one way.

Life is sustained by consuming free energy, ultimately from the sun, and converting it to stored energy that will be used by other organisms in the ecosystem.

Corn = free energy



body heat = entropy

Stored energy
= entropy

Waste = entropy

Chicken produces WORK

There is no conflict between the second law of thermodynamics and the evolution of life: life is a response to the principle of least action. Before life appeared the only way the free energy from the sun falling upon the planet surface could be dissipated was through generating climate and emission of low-grade heat to outer space.

Life dissipates, via chemistry, the Sun's energy. Initially bacteria, then simple single celled organisms, then plants, then fish and ultimately animals, emerged through chemistry from simple molecules. These molecules arrived on the planet from comets and meteorites, which were the products of the chemistry that goes on in stars. This process is called. These life-forms are the entropy of the abiogenesis.

In this view of life we can see that the process of natural selection is not so much based on genes (so far we have not needed to invoke the concept of a gene), but on how effectively an organism can obtain nutrient.

So Fisher was wrong as well.

British naturalist Edward Blyth some 20 years before Darwin published On The Origin said:

"……. *among animals which procure their food by means of their agility, strength, or delicacy of sense, the one best organized must always obtain the greatest quantity; and must, therefore, become physically the strongest, and be thus enabled, by routing its opponents, to transmit its superior qualities to a greater number of offspring*."

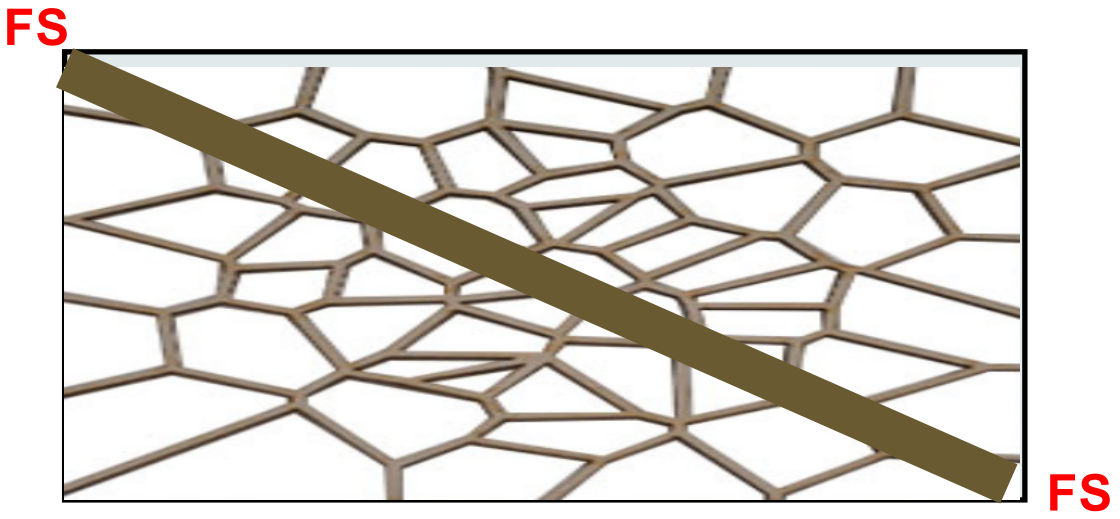
The principle of least action has driven the evolutionary process. But as nutrient sources are dependent on that same evolutionary process (stored energy in other organisms), how organisms evolve is dependent on the ecosystem in which they live: to use the words of my colleague Arto Annila, everything depends on everything else.

We are here today because for 3.7 billion years there have been ecosystems from which our ancestors derived nutrient.

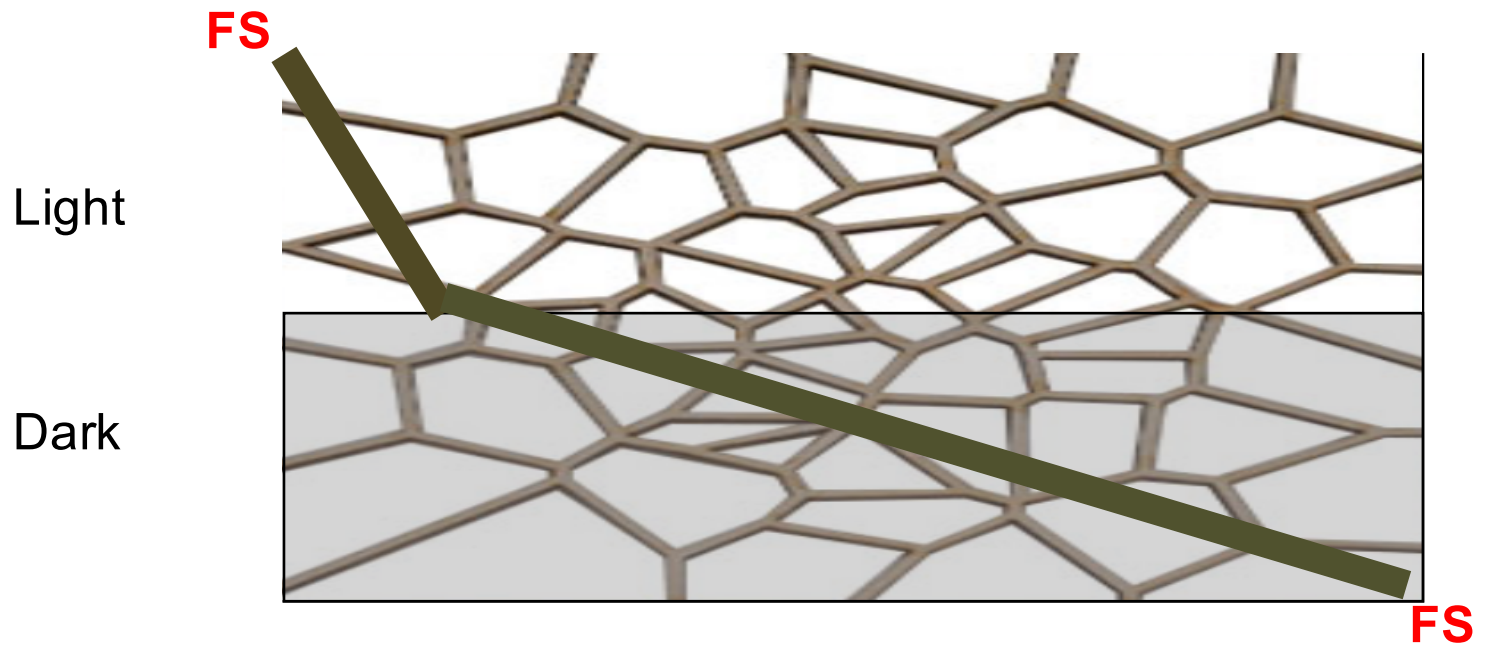
“Delicacy of sense". What did Blyth mean by this?

Consider some experiments carried out here in Japan using one of the most primitive organisms, a slime mould. Slime moulds are single celled organisms with rather peculiar properties. Placed on a rectangular agar plate with no nutrient it will spread itself out into a network of microtubules and cover the whole surface. This is its strategy to find food.

If nutrient (FS) is placed at diametrically opposite corners of the plate, the slime mould will transform to a thick tube diagonally across the plate connecting the two food sources. This we can regard as a direct demonstration of the principle of least action: the organism is consuming the nutrient as efficiently as possible.



Light is toxic for slime moulds, so these experiments are usually carried out in near darkness. If half of the plate is illuminated then the organism still connects to both food sources, but it minimises the amount of exposure it gets to the light.



Minimum-Risk Path Finding by an Adaptive Amoebal Network Nakagaki et al Physical Review Letters (2007)

In the part illuminated plate the pathway adopted appears less efficient (is longer): the organism has been able to trade-off the benefit of the nutrient against the toxicity risk of being exposed to light. This is quite remarkable for such a primitive organism.

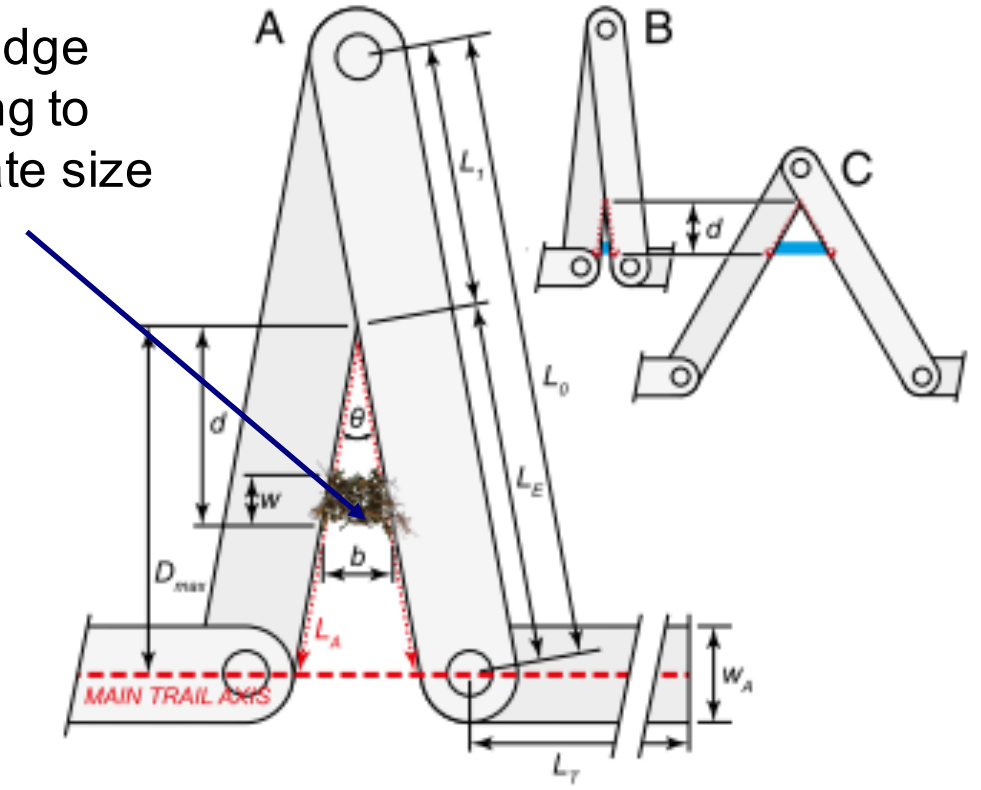
It illustrates a universal feature of living systems, namely that they have a form of *consciousness* or *awareness* and are able to make simple decisions that aid their survival.

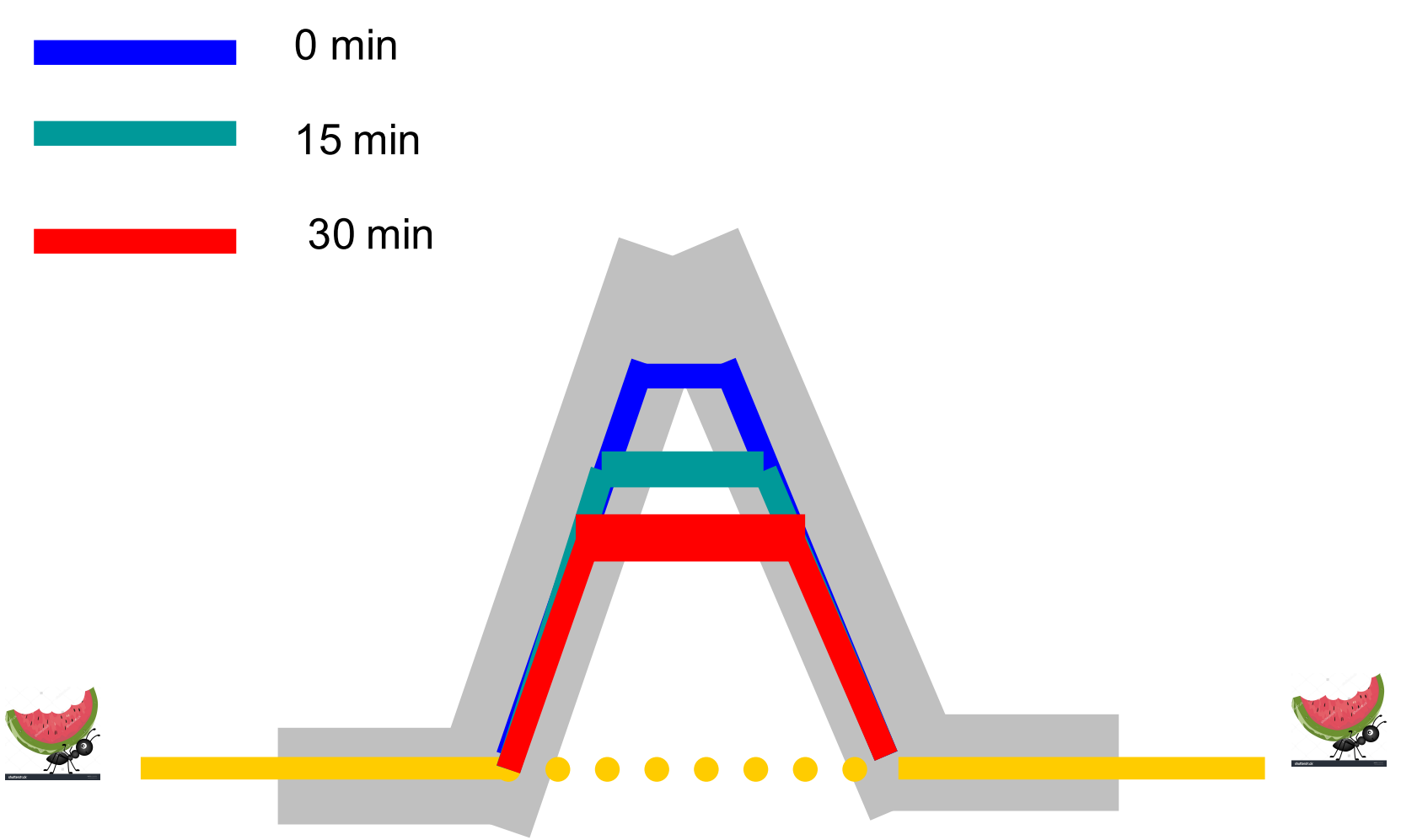
Life could not have evolved without this feature: an unconscious organism is helpless in a hostile environment. In 2009 Frantisek Baluska published a paper entitled "*Deep evolutionary origins of neurobiology* ". He gives many examples of what appears to be brain activity in micro-organisms and plants, life forms that we generally do not regard as having brains.

Even the most primitive organisms are not passive where their survival is concerned.

The Army ant (*Eciton*) has the ability to form ant bridges over obstacles in the way of the foraging ants bringing food to the colony. In a field experiment researchers contrived apparatus to place an obstacle of varying size on the route of the foraging ants.

Ant bridge drawing to Illustrate size





The researchers concluded that the ants adopted the optimum balance between using ants to forage and using ants to form the ant bridge.

Each individual ant has its own genotype and conventional theory would dictate that the expression of that genotype would determine the ant's behaviour, i.e., whether it forages or contributes to the bridge. Plasticity has been observed in that different castes of ants are to some degree interchangeable, even some may become Queens.

The beneficiary of this behaviour is the whole colony, yet it seems that individual ants are making the decision as to how to optimise the foraging process.

Are we observing complex cognitive behaviour or are we seeing the principle of least action in operation? I favour the latter.

In the slime mould we saw that principle clearly when the plate was uniformly in darkness. In the half illuminated plate a "decision" was made to find the optimum access to food while minimising the exposure to light. In the case of the ant colony we see the optimum deployment of ants to optimise the nutrient supply – seems we are observing a law.

Let us now move to consider some interesting behaviour by plants, specifically their roots. Baluska and colleagues have shown that if a root is forced to grow, under laboratory conditions, along a horizontal tube it periodically tries to turn downwards (exploratory behaviour). If a millimetre or two of the root tip is removed this behaviour is no longer observed.

Darwin was in fact aware of this and in his 2nd to last book on plants, that he wrote with his son Francis *The Power of Movement of Plants* he says this:

"It is hardly an exaggeration to say that the tip of the radicle thus endowed [with sensitivity] and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements."

Is Darwin observing the principle of least action?

These, and many other similar observations in organisms that do not have brains, force us to the conclusion that conscious and cognitive behaviour is not confined to the organ that we refer to as the brain. The empirical evidence is compelling and cannot be ignored.

Organisms could not have survived in a hostile environment without this property that enabled them to take meaningful decisions to aid their survival. We have to accept they have "cognitive" abilities and these played at least some role in the process of evolution

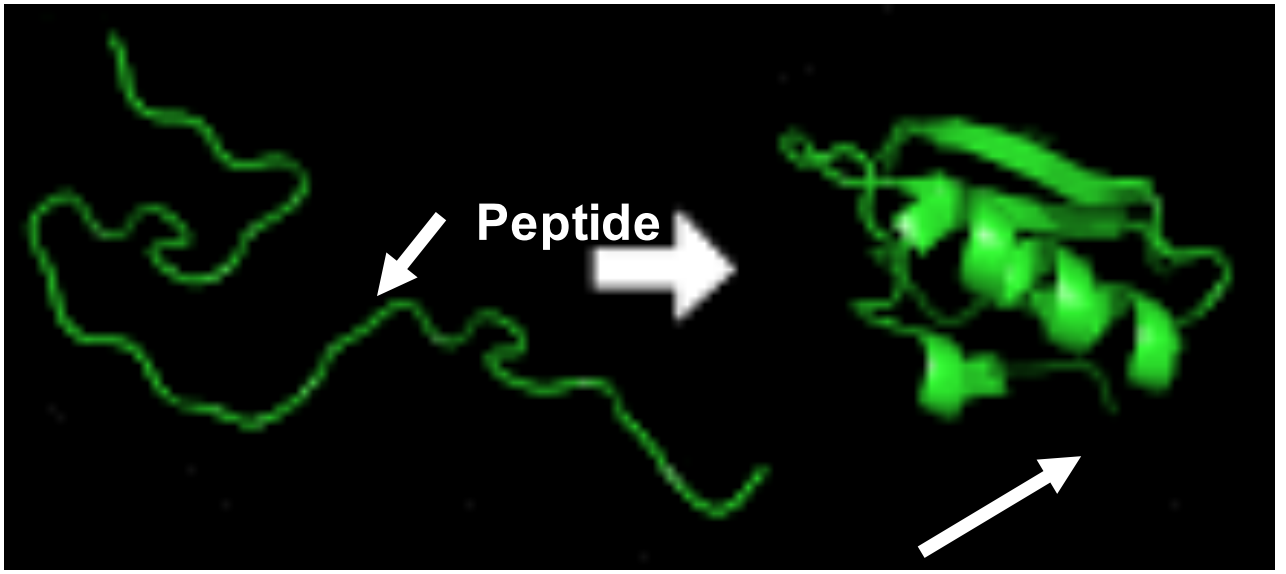
Darwinists believe that better genes increase survival and the propagation of those genes to future generations and that is the driving force for evolution.

Could it not equally well be that those with cognitive abilities that enabled them to survive in a hostile environment are those that drove evolution?

An active and not a passive process

But this raises the question where does this ability lie in the organism if not the brain and how is it passed to future generations. Surely it has to be in the DNA which has to be Mendel's unit of inheritance.

Not so. DNA is not a working molecule: it plays a passive role in the nucleus as a database to enable the cell to produce a specific set of peptides on cell division. Those peptides are then folded into proteins.



And the proteins do the work and produce the phenotype.

There are more proteins than there have been seconds since the universe formed over 14 billion years ago. They undergo a multitude of reactions with each other and with other molecules. And out of that chemistry I believe comes the living world.

The cell supports this chemistry by providing the environment. The properties of life are contingent on both. Two properties above all, consciousness and cognisance, separate out the living from the non-living.

As far as we know proteins are unique among the chemicals we know in being able to produce life.

That life has succeeded in colonising almost every environmental nook and cranny of the planet that was accessible to free energy and has been around for 3.7 billion years.

That by any standards is success and we should have respect for it.

So Darwinism is discredited, but was Darwin right?

I think his emphasis on the struggle for life was wrong. Evolutionists have constantly been puzzled by altruism. It is, in fact, not uncommon in the natural world, but it proved a 'hard nut to crack' in conventional Darwinian theory. Furthermore, there is a lot of cooperation (symbiosis) as well as competition. Thinking in the long term one sees the need for cooperation, even altruism, whereas in the short term these properties are not so obvious.

Darwin spoke of the "proportional numbers" of species in an ecosystem. If, in some cases, one species is eliminated the ecosystem collapses and over time a new and different one replaces it. Many species are displaced. It seems to me that the inhabitants of the ecosystem are also cognisant of need to maintain the proportional numbers and they have evolved to do so by balancing competition with cooperation.

So in conclusion I think that Mother Nature is a kinder and more "intelligent" entity than Darwin would have us believe.

I gratefully acknowledge my collaborators:

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Dr Mauno Rönkko, University of Eastern Finland

THANK YOU FOR YOUR KIND ATTENTION

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Specifically the essay entitled “Genes without prominence”