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Tug of war

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Commentary on
Damasco, A, Giuliani, A, 2017, "A resonance based model of biological evolution", *Physica A: Statistical Mechanics and its Applications*, Vol. 471, 2017, Pages 750-756, https://doi.org/10.1016/j.physa.2016.12.016.

What upsets the balance?

Let us imagine two perfectly equilibrated A and B teams, each made of a dozen of very strong young men, involved in a tug-of-war contest. The play is going on since twenty minutes, the rope is incredibly tense and no team is still prevailing. We could imagine the contest to last for an indeterminate time, at least until when both the teams will collapse for the fatigue. But the tug-of-war game does not admit a parity, soon or later, something will happen and in few seconds team A (or B) will prevail and the players of the B (or A) team will slide to the 'threshold line' with apparently no special additional effort by team A.

This very vivid metaphor of phase transition comes from the excellent book written by physics Nobel Prize Robert Laughlin (Laughlin 2005) and allows us to understand the major pitfall hidden in the something will happen statement.

We are forced to think in terms of cause-effect chains.

If the two teams are identical as for strength and ability, the only way the equilibrium situation can be broken should be ascribed to an external perturbation, even 'minor' (like a transient loss of postural equilibrium of a player of team B due to a small irregularity of the field, like a bump).

Obviously, we might also imagine different occurrences, like a sudden player's failure. What matters is the fact that the equilibrium is lost when a minor 'catastrophic' event occurs.

This kind of reasoning is correct but, in the end, makes us to forget that, the really interesting issue is not the bump in the terrain (that can be substituted by any other perturbation), but the equilibrium condition and the 'catastrophic' character of the transition. How is it possible that a contest that was in perfect equilibrium for long time, arrives at a 'terminal' fate in few seconds? If, instead of address our minds on these two 'general facts', we get stuck into the enumeration of all the possible 'apparently small but crucial' contingent causes like bumps, sweat on the hands, a wind blow and so forth, we could go ahead at infinite. This is exactly what is happening to molecular biology whit the rise and the fall of dozens of 'real and definitive master genes (or pathways)' for cancer.

The same kind of reasoning is implicit in the neo-Darwinian view of evolution. Soon or later, something will happen (a mutation that, instead of being deleterious provokes a huge increase in fitness in that particular contingent situation) and a given individual will have an advantage in the 'struggle-of-life'.

This 'lucky contingency' will be fixed by heredity in the descents that in turn will be the recipients of other 'lucky contingencies' and, if physically separated by the bulk of their population so to prevent the dilution of such accumulation of 'positive changes', they are in a good position to give rise to a brand-new species.

Damasco and Giuliani do not oppose this way of reasoning, simply they think it could be much more relevant, in order to understand biological evolution, to focus on the equilibrium and transition issues.

The fact biological species are in equilibrium for very long times is a trivial fact (that curiously enough is almost completely underestimated by biologists).

Not only we should be very scared looking at our dog delivering five beautiful kittens, but also there are animal species that are here, practically identical, since millions of years.

This implies that a species (in terms of the ensemble of all the individual animals) occupies a given region of the phenotypic space for very long time: a very long tug-of-war, indeed!

Inside the phenotypic 'closed area' that allows us to immediately discriminate a cow from a horse, the 'allelic frequencies' of the species are not fixed but oscillate (any system constrained in a finite space oscillates).

Now the consequence the authors derive from this simple fact is 'there is only one way in order to make a STABLE system that oscillates inside a closed space to be convinced to go out from its comfort zone and make a jump outside: apply an external oscillator that resonates with the equilibrium frequency'.

The resonance phenomenon amplifies the effect of a relatively minor environmental constraint making the evolution possible. The authors do not look for microscopic mechanisms (they are not interested in bumps and sweat) but for giving the 'general conditions for something to happen', this is of crucial importance (not only in evolution but also for any effect exerted by the environment on biological systems). Damasco and Giuliani provide the reader with relatively simple formulas to experimentally test their conjecture and some interesting links between major environmental cycles (e.g. temperature fluctuations) and evolution rate are starting to emerge, on another heading, the proposed model allows to get rid of sudden (non gradualist) transitions in macroevolution that puzzle evolutionary biologists.

References

Laughlin, R, 2005, *A Different Universe: Reinventing Physics from the Bottom Down*. Basic Books