

BIOLOGY OF AN UNTHINKABLE WORLD

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Transposons, small DNA fragments or sometimes virus like particles are fascinating research objects in evolutionary and molecular biology. Due to their parasitic lifestyle they would present excellent material for science fiction stories, but they also actually constitute a big portion of how we evolved as a biological species and maybe – by modulating the genomes of single neurons in our brains – even of what we can sense, feel and think.

Transposons are probably an emerging property of complex, multicellular life. They provide raw material for evolution to work on, contribute to the regulation of genetic activity, help central nervous systems reaching higher complexities by orchestrating the diversity of neurons and help immune systems to become adaptive.¹⁻⁶ At the same time they are the ultimate molecular endo-parasites seemingly of direct bio-punk origin.⁷

Transposons, transposable elements, or jumping genes are short, mobile genetic elements that constitute most, if not all of the ‘dark matter’ of the genetic code that resides in humans and in almost all organisms that we can identify as animals, plants or fungi. In analogy to the cosmic ‘dark matter’ (scientifically non-describable so far), which contributes a much bigger portion of energy to our universe as ordinary matter, dark matter of the genome contributes most to the blueprint of the genetic code – in humans more than 90%! While transposons in contrast to dark matter seem to dwell within the realms of scientific evidence, they have so far resisted a coherent theory of why the genomes of complex organisms are full of them. Biologists started to believe that their high abundance is a necessary condition for allowing the evolution of multicellular complexity. However a small aquatic plant with yellow flowers and tiny elaborated traps that can catch tiny aquatic animals told them in 2013 that you can indeed evolve a happy and clean genome with hardly any transposons.⁸

Transposons are the ultimate selfish gene⁹ although many are not active anymore (they basically died) and slowly degrade leaving big portions of our genetic code as graveyards with millions of dead transposon bodies.

Living transposons however are sleeping, being carried along by the host for many generations. Only when the host feels weak or encounters stress they awaken, start producing proteins that help them to proliferate and start mutagenic, jumping activities on their genomic playgrounds.

Many living transposons try to proliferate in synchrony with the sexual machinery of their host. In

flies, mammals and plants the middle earth of transposon-attacks and cellular counter-attacks are the germ cells, which are the egg and the sperm cell.¹⁰⁻¹¹

What I would like to attempt in this short article is to add transposons to the list of horrors of why our scientific world becomes increasingly unthinkable, or as Eugene Thacker puts it in his book *In The Dust of This Planet*: ‘a world of planetary disaster, emerging pandemics, tectonic shifts, strange weather, oil-drenched seascapes, and the furtive, always-looming threat of extinction’.¹² Given the nature of transposons, it might have well been suited to investigate correspondingly the Horror Of Transposons and why they could be considered anti-biological and/or non-biological.

However, in the context of science fiction/horror fiction or Biopunk of Transposons connections could be drawn to themes like endo-parasitism, being possessed or remote-controlled, and the engineering of genetic chimaeras.

Richard Dawkins of course made eloquently the point in the ‘The Selfish Gene’⁹ that we (the multicellular organism) are basically not more than a housing for a string of genes that need to work together to be able to produce sexually competent cells. However transposons take that thinking one step further in transforming the genes themselves into a housing. The string of genes that forms the organism becomes a breeding ground for colonies of transposons. One of course has to further ask if there is an infinite amount of layers, that the transposons themselves carry parasites, which then can be parasitised again, etc. Thus, every cell division in us and every split of species in the phylogenetic tree becomes a split of a settlement of transposons.

Transposons also make the neat genetic world of Gregor Mendel unthinkable. Mendel’s laws of inheritance are still deeply imprinted in every biology student and even in most researchers of molecular biology. Unfortunately as elegant Mendel’s laws may be and as cemented as their scientific status is in genetics, evolutionary biology and medicine, they are nearly always wrong. Genes that follow Mendel’s laws are exceptions. The vast majority of genes are part of an entangled network far too complex to follow these simple laws. Transposons not only add additional layers of complexity to these networks but they are maybe the most important force to have generated these complex, multi-layered webbings⁶.

As a side note, transposons have been discovered for not following Mendel’s laws by Barbara McClintock who received the Nobel Prize for identifying ‘jumping genes’ in maize corns.¹³

Put under stress, the unfortunate genetic host can activate many Transposons and the activity of which becomes dangerous if the host is unable to counter attack and prevent transposons from proliferating.¹⁴ Recent results from sequencing human genomes suggest that active transposons are much more common in humans than anticipated. Transposons could be a major driver of cancer development¹⁵. And transposons can even be transferred between and be infectious in different species.^{16,17} Is it appropriate to expect a transposon outbreak that could eventually exterminate a whole species, humans included? What is the life cycle of a transposon? What is the typical life cycle of an endo-parasite?

If we want to encounter the *crème de la crème* of horror fiction inspiring endoparasites we have to move to the insect world. Some of the most diverse groups of the already incredible diverse insect world comprise of the families of parasitic wasps (e.g. the *Ichneumonidae*). Their lifestyle is in fact so horrific, that it added to the increasing doubts of Charles Darwin about the existence of a benevolent creator. In an 1860 letter Darwin wrote to the American naturalist Asa Gray, ‘I own that I cannot see as plainly as others do, and as I should wish to do, evidence of design and beneficence on all sides of us. There seems to me too much misery in the world. I cannot persuade myself that a beneficent and omnipotent God would have designedly created the *Ichneumonidae* with the expressed intention of their feeding within the living bodies of Caterpillars...’.¹⁸

Jean-Henri Fabre, one of the great naturalists of the nineteenth-century wrote a beautifully anthropomorphic account about the struggle of the victims of these wasps in his books *Insect Life* and *The Wonders of Instinct*.¹⁹

Ichneumonidae female wasps lay their eggs either on or inside their host, which are either insects or spiders. After hatching, the wasp larvae start feasting on the still living but paralysed, or from within the living and growing host, eating fat reserves and non-essential organs first. Only when the larvae are ready to pupate do they devour essential organs leaving only a blank shell of their tormented host.

Since there are at least 90,000 different species of parasitoidic wasps there are at least as many variations of this gruesome lifestyle; however one group is still managing to stand out – the polyembryonic wasps in the family of the *Encyrtidae*. Each single egg laid into the host – usually a caterpillar – develops into thousands of genetically identical, clonal embryos. Some of the embryos develop as expected

into adult larvae and pupate, however others develop into slim, elongated soldiers with enlarged fighting mandibles who die off together with the host and whose sole function is to defend the genetically identical ‘normal’ siblings from other intruding clones.²⁰

So here we have a situation in which a caterpillar is not simply the victim of feasting larvae, but where the caterpillar is an arena of a war between different genetic clones with thousands of individuals.

What parallels can we draw between the biology of transposons and *Encyrtidae*? Many transposons also inhabit their host genome. (However, there are many different kinds of genetic transposon clones – each of them sometimes in thousands of copies). That means, that there is probably a fight not only against the cellular counter-defence of the host (a group of proteins specialised in identifying and killing transposon activity) but also amongst them. This intra-transposon fight could confer a lot of protection to the host. As long as transposons fight a molecular war over genomic ground none of the single transposon clones would become too prolific to eventually kill the host or its reproductive cells. Although there is, so far, no direct evidence for this intra-transposon war, ironically one of the tools with which we could test such a hypothesis by selectively deleting transposons and engineering organisms with reduced transposon-burden, is in fact a transposon protein itself: Cas9, the genome editing protein in the CRISPR system.²¹ So one of the most powerful tools to engineer genetically modified organisms is given to us by a transposon. Let’s see where this transposon protein gets us.



Image by Ruben Gutzat.

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