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EDITORIAL

The genetic self

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Life is sustained in a subtle balance between reproduction and innovation. The elegant mechanism, by which a nucleotide strand induces a mirror image of itself, along with the ability of all cells to split into symmetrical copies of themselves, efficiently amplifies that what has been proven to be successful. Reproduction is a conservative business, though—if it were not accompanied by ongoing change, life would never have made it beyond some germinal states. Sophisticated processes, such as sexuality, meiosis, or transposons, actively increase variation and have been powerful driving forces for biological innovation. These considerations lead to the question, how these obviously antagonistic activities are integrated into a functional genetic self. The alternative that there is not such a thing as genetic integrity would imply that genetic damages just proceed and in case that the result is not any longer viable will be eliminated by selection. Although the impact of selection should not be denied here, it is clear on the other hand that most organisms actively maintain their genetic self by constraining or repairing genetic perturbances, or by eliminating damaged cells by apoptotic cell death. One of the many indications of an actively maintained genetic identity is the observation that mutations in germ cells are orders of magnitude more rare than in somatic cells. Thus, while individuals age, species remain forever young (Seidel 2015). But what happens with the genetic self, either when organisms lack a clear separation of soma and germ line, or when they propagate clonally (either as part of their natural development or in consequence of human manipulation)? Three contributions to the current issue highlight different aspects of the genetic self in animals and plants.

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The genetic self of prokaryotes is circular—the DNA is forming a ring. In contrast, eukaryotic DNA is organised in linear units, which is probably tribute to the larger amounts of information that have to be processed and copied, but makes it more difficult to defend genetic integrity. In fact, double-strand breaks can lead to a situation, where smaller fragments of DNA are religated into small ring chromosomes. These are the topic of a review by *Pristyazhnyuk and Menzorov* (2018) in the current issue. Even if this genetic material is not lost during mitosis, such ring chromosomes can lead to drastic consequences for genetic integrity, because they are followed by considerable rearrangements of the remaining chromosomes. The authors address the causes for this phenomenon, the biological responses evoked by ring chromosomes, the medical implications of ring chromosomes, and the clinical aspects of ring chromosome syndromes. They also discuss the interesting possibility, whether the genetic reshuffling triggered by the presence of artificial ring chromosomes might be therapeutically exploited to cure large chromosomal aberrations.

While the genetic self is challenged to a certain extent during each event of sexual propagation, hybridisation between two species represents a very drastic perturbation of genetic identity. While in animals such events lead to early abortion of the hybrid, hybridisation is a common event in plant evolution, giving rise to numerous novel species that often are even more successful than their parents. A contribution by *Majka et al.* (2018) deals with hybrids from two forage grasses, *Festuca pratensis* × *Lolium perenne*. Since the parental species harbour complementary traits, these hybrids are of economic relevance. The parental species are sufficiently different, such that genome reorganisation can be followed using fluorescent in situ probes. Virulent hotspots for reshuffling are fragile sites that had been linked with the 35S rDNA regions, which was also found for one of the parental species, *Lolium perenne* (Rocha et al. 2015). This would mean that due to their functionality, certain regions of the genome are more prone for breakage. In their contribution, the authors now show that not the 35S rDNA regions, but a different type of fragile sites, the interstitial telomeric sequences, account for most rearrangements taking place in these

allopolyploid hybrids. These sites are discussed as hotspots for genome instability derived from repair events in the DNA or from expansion of microsatellites. While the authors conclude that the interstitial telomeric sequences are not the only factor underlying chromosome rearrangement, their findings indicate that the genetic self is rescued here, by allowing for predefined points where modular recombination is permitted, while other regions are robustly protected from interruptive events.

Genetic integrity as active process becomes manifest most explicitly during sexual reproduction. However, even in somatic cells, it has to be sustained, because otherwise the individual would soon die from dysfunctionality, as can be seen from genetic disorders like progeria (Werner-syndrome), where the failure to repair DNA damage due to a missing helicase leads to precocious ageing in humans. But still, the somatic genetic self seems to be less rigorously sustained as compared to the germ line (Seidel 2015), and this should impact cases, where propagation proceeds asexually. Asexual propagation in animals, although existing, is the exception, not the rule, while in plants, somatic embryogenesis is very common and also of biotechnological relevance. In their contribution, *Mamedes-Rodrigues et al.* (2018) investigate to what extent the ability to regenerate an embryo is perpetuated during clonal propagation of non-differentiated cells in the model cereal *Brachypodium*. The regenerative ability of these cells can be maintained only over a few months and then declines. This might indicate that genetic integrity deteriorates, which would impair the ability to form an embryo. However, when authors assessed the maintenance of ploidy levels using flow cytometry, they found that genetic integrity was not linked with the age of the callus. They were then using a metabolomic approach to detect metabolic hallmarks linked with regeneration ability. In fact, they found that accumulation of certain amino acids was a predictor for embryogenic competence, while accumulation of monolignols, such as cinnamic or ferulic acid, marked the decrease of embryogenic competence. This would mean that even under clonal propagation, it is the channelling towards differentiation rather than the loss of genetic integrity that limits totipotency of a cell.

What can we extract from these three glimpses into genetic integrity? Despite the specificities of the respective models and phenomena, a genome seems to be more than the mere sum of its genes, but exhibits certain holistic properties that are actively maintained, repaired, and restored. The intellectual challenge of a genetic self is to be seen in the question, how the information on the target situation is stored and relayed in a situation, where genetic integrity is perturbed. In case of single-strand repair, the answer is evident—the integrity comes from the template provided by the antisense strand and the chemical rules of base pairing. In case of supergenic organisation within a genome, there is no evident template. While there might be structural components, such as the pairing of entire chromosomes in the synaptonemal complex during the first meiotic prophase, the genetic self might also be "embodied" in cybernetic processes rather than in static structures.

Compliance with ethical standards

Conflict of interest The author declares that there is no conflict of interest.

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