COMMENTARY

Mosaicism and chimerism as components of intraorganismal genetic heterogeneity

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Traditionally, the occurrence of intraorganismal genetic variation has been considered as a rather exceptional condition. The pertinent information is rather dispersed, often in journals related to specific taxonomic groups (e.g. bryozoa, tunicates and red algae), and essentially similar biological processes are described and discussed with different terminologies and organisms. The review by Pineda-Krch & Lehtilä (2004) has the merit of assembling otherwise dispersed information on the occurrence and frequency of intraorganismal genetic variation in a diversity of plants and animals, terrestrial and marine. By merging ideas on mosaicism (e.g. Whitman & Slobodchikoff, 1981; Gill, 1986; Gill et al., 1995) with the processes of chimera formation (see Hughes, 2002 for a review), this study provides ample support to suggestions (Santelices, 1999; Rinkevich, 2000) that genetic homogeneity is rarer and genetic heterogeneity is more common than currently considered in different kinds of organisms.

In their analysis, however, Pineda-Krch & Lehtilä (2004) made few distinctions between mosaicism and chimerism, and most of them were restricted to their functional origin, relative frequency and magnitude of genetic change. Mosaicism originates by intrinsic genetic variations caused, among other processes, by somatic mutations, while chimerism originates from allogenic fusion or grafting. As such, chimerism is much rarer and involves a much larger genetic change than mosaicism. Nevertheless, there are additional differences not distinguished in the review and that eventually confuse the analysis of the respective costs and benefits of both processes. Mosaicism and chimerism also differ in the types of organisms most likely to show these processes, the mechanisms by which they are prevented, some of their respective costs and benefits and their fate and heritability. This note briefly reviews these last aspects.

Mosaicism and chimerism differ in the types of organisms where these processes occur with greater frequency. Among plants and animals, chimerism resulting from coalescence and fusion, seems largely restricted to coalescing seaweeds and colonial marine animals,

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including sponges, hydroids, corals, bryozoans and ascidians (Sommerfeld & Bishop, 1999). Mosaicism may occur in all kinds of organisms including, in addition to those mentioned above, unitary animals and clonal and aclonal terrestrial and marine plants. While mosaicism may be expected in any kind of environment, chimerism has been reported much more frequently from marine environments, primarily from benthic organisms with planctonic larvae or propagules.

Mosaicism and chimerism also differ in the mechanisms by which each is prevented. Although internal and external factors may increase the mutation rate in different kinds of organisms, there does not seem to be any mechanism known to prevent mosaicism. Those mentioned by Pineda-Krch & Lehtilä (2004), including single cell sequestration, intraorganismal selection, intraorganismal structural compartmentalization and shedding of parts, are all mechanisms of eliminating, not preventing mosaicism. In the case of chimerism, at least among invertebrates and fungi, different recognition systems govern whether somatic tissue contacts between individuals would lead to compatible fusions or to histocompatible reactions, including rejection and non-fusions (Buss, 1987; Grosberg, 1988).

The above differences between mosaicism and chimerisms also result in some significant differences in the costs and benefits of the two processes. For example, the occurrence of size-specific attributes enhancing fitness, including increased growth rates, reproductive success and survivorship, is a benefit resulting from chimera formation, not from mosaicism. In an analogous way, perturbations to developmental pathways during ontogeny in modular organisms are related to mosaicism not to chimerism. Even when similar responses are described for the two processes, they may differ depending on whether originating from chimerism or mosaicism. Take intraorganismal competition as an example. The outcome of cell-lineage competition is likely to depend, among other factors, on the initial number of cells involved. Mosaicism generally starts as one or a small group of mutant cells while chimerism generally involves a more massive input of genetically different cells. These differences in the initial number of cells will certainly influence the potential outcome of competition between the original and the newly coalesced cell lines.

The fate of intraorganismal genetic heterogeneity in multicellular organisms is also likely to be different whether resulting from mosaicism or from chimerism. Somatic mutations often occur in meristematic cells which are more abundant in the growing axes and branches than in other parts of the modular structure. Depending on the strength and intensity of competition between the wild and the mutant cell lineages, there is a substantial probability that the mutant tissue may be passed on to the next generation as a multicellular propagule, via clonal fragmentation (e.g. several green and red algae). Such a possibility is very unlikely under chimerism,

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because many of the fused tissues are often part of the supporting structure (e.g. base, holdfast, body) of the coalesced organisms (e.g. red algae and ascidia). Depending on the growth pattern of the organism, and on the intensity of the interaction between the two cell lineages, the new modules produced after fusion or coalescence will usually only contain the tissue of one lineage or the other and only rarely will it include tissues from both.

It is expected that future research on intraorganismal genetic heterogeneity will help sharpen the distinctions between mosaicism and chimerism. Both appear as processes differing in their causes, prevention mechanisms, frequency, consequences to the organisms and the eventual fate and heritability of the tissues.

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