Evolution Finds Shelter in Small Spaces

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When RNA is replicated in cell-free systems, a ubiquitous problem is the hijacking of the system by short parasitic RNA sequences. In this issue of *Chemistry & Biology*, Bansho et al. show that compartmentalization into water-in-oil droplets can ameliorate this problem, but only if the droplets are small. This result helps to both recapitulate abiogenesis and optimize synthetic biology.
recombination described by Chetverin et al. (1997). Bansho et al. (2012) propose that spontaneous Mg$^{2+}$-ion-catalyzed strand exchange at the hot-spot is the most likely explanation for the production of the minimonsters, but it is also possible that the Qβ polymerase itself plays a role or that the 3’ end of the RNA is involved in a trans-esterification reaction (Lutay et al., 2007). However, given that the Qβ-directed replication is rather sloppy, odds are that producing an RNA species that has some recombinase activity itself, aided by Mg$^{2+}$ (Lehman, 2008), is indeed the more likely explanation.

Encapsulation in water-in-oil microdroplets (Tawfik and Griffiths, 1998) solves this problem. This turned out to be because in smaller droplets, the Qβ genomic RNA can win the selection numbers game (Figure 1). The authors compared the parasite loads in droplets of 10 μm and 100 μm in diameter and found that after an hour there were on average 1,000 times more parasites in the larger compartments. In the smaller droplets then, the Qβ RNA can replicate for several hours without a decline in yield.

As Bansho et al. (2012) point out, this result can guide our thinking on how life got started and made the transition to cells. The notion is that compartmentalization must have been a critically important evolutionary discovery and probably happened quite early in the history of our planet. The numerical consequences of “smallness” are not restricted to spherical structures that we normally associate with cells, however. One can easily imagine more shelter from the parasite plague driving life into the smaller interstices in rocks in a deep-sea hydrothermal vent (e.g., Baaske et al., 2007) or even into riding the more fragmented of traveling waves propagating through a semi-viscous solution (e.g., Boerlijst and Hogeweg, 1991). And lastly, when modern-day synthetic biologists are searching for optimal compartments in which to churn out desired polymeric products, they will find that bigger is not always better.

REFERENCES


