Germline immortality: The Little Studied Process that Gave the World Animals

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Germ cells carry out an extensive process of cellular rejuvenation in which each animal generation retains no significant damage from the past, allowing species to persist over millions of years and generations. It is likely that most of the mechanisms that convey "germline immortality" take place during oogenesis. Germline cysts, groups of interconnected germ cells that are the first structures to arise downstream from primordial germ cells or germline stem cells, are an ancient, conserved and essential feature of animal gametogenesis. Using Drosophila as a model, we find that germ cells begin to be revitalized with the help of the terminal filament even as cysts form, starting with cellular membranes and their lipids. Germ cell organelles are concomitantly selected as they move on the asymmetric germline cyst cytoskeleton (fusome) and are either transported into the oocyte to form a Balbiani body, or shunted into nurse cells. Finally, early germ cells each generation pass through a highly open chromatin state before establishing constitutive heterochromatin and more gradually, Polycomb repression. A similar process of germline rejuvenation likely occurs in vertebrates, since we find analogous germline cysts in Xenopus and mice that contribute organelles to their prominent Balbiani bodies.