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Entropic hourglass patterns of animal and plant development and the emergence of biodiversity

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One surprising observation going back to pioneering works of Karl Ernst von Baer in 1828 and Ernst Haeckel in 1866 is that embryos of different animal species express on average evolutionarily young genes at the beginning of embryogenesis, evolutionarily old genes in mid-embryogenesis, and again evolutionarily young genes at the end of embryogenesis.

Focusing our attention on plants, which represent the second major kingdom in the tree of life that evolved embryogenesis, we have found that this phylotranscriptomic hourglass pattern also exists in plant embryogenesis, which is surprising as multicellularity and embryogenesis evolved independently in animals and plants. Moreover, we have found that phylotranscriptomic hourglass patterns also exist in the two main transitions of post-embryonic plant development, germination and floral transition, suggesting the convergent evolution of phylotranscriptomic hourglass patterns in animal and plant development.

The origin of these phylotranscriptomic hourglass patterns has remained concealed, but here we find that not only the mean age of expressed genes changes in an hourglass-like manner, but the whole age distribution of expressed genes changes. When studying the entropy of these age distributions as functions of time, we find hourglass patterns that surprisingly are orders of magnitude more significant than the original phylotranscriptomic hourglass patterns of the mean, which might indicate that the entropic hourglass patterns are more fundamental than, and possibly even the origin of, the original phylotranscriptomic hourglass patterns of animal and plant development.