Cologne Evolution Colloquium

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Chance and purpose in the evolution of protein complexes

Why does anything complicated exist in biology at all? Organisms contain many structures, from macroscopic organs down to the molecular machines that power cells, that seem complex enough that they are unlikely to be the product of random chance. Classically, such features are thought to exist because they help the organism survive better than it would without it. This would allow purifying selection to preserve them against the constant hail of destructive mutations that occur every time genomes replicate. But at the molecular scale, there are many complex biochemical structures that have no apparent purpose: many protein complexes are built from units that in theory should work just as well on their own. Yet they persist across the eons. If not purifying selection for some useful function, what protects them from mutational destruction? Using ancestral sequence reconstruction and biochemical characterization of resurrected proteins, I will show how protein complexes can persist for long periods of time not because they are useful, but because of a universal mutational ratchet. The ratchet makes it nearly impossible for evolution to return to simpler biochemical forms once a complex has evolved. I will then show unpublished work on a similar ratchet at work in RuBisCo, the enzyme that performs almost all CO_2 fixation on earth. I will recapitulate how RuBisCo acquired an accessory subunit that it quickly came to completely depend on for its function. This happened not because the interaction was useful, but because it allowed mutations to accumulate that would be very harmful in the absence of the interaction. This work suggests neutral processes can be a powerful force preserving complexity at the molecular level.

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