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Synchronization of Eukaryotic Flagella[1]

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From unicellular organisms as small as a few microns to the largest vertebrates on earth we find groups of beating flagella or cilia that exhibit striking spatio-temporal organization. This may take the form of precise frequency and phase locking as frequently found in the swimming of green algae, or beating with long-wavelength phase modulations known as metachronal waves, seen in ciliates and in our respiratory systems. The remarkable similarity in the underlying molecular structure of flagella across the whole eukaryotic world leads naturally to the hypothesis that a similarly universal mechanism might be responsible for synchronization. Although this mechanism is poorly understood, one appealing hypothesis is that it results from hydrodynamic interactions between flagella. In this talk I will describe a synthesis of recent experimental and theoretical studies of this issue that have provided the strongest evidence to date for the hydrodynamic origin of flagellar synchronization. At the unicellular level this includes studies of the beating of the two flagella of the wild type unicellular alga *Chlamydomonas reinhardtii* in their native state and under conditions of regrowth following autotomy, and of the flagellar dominance mutant *ptx1*, which displays unusual anti-phase synchronization. Analysis of the related multicellular organism *Volvox carteri* shows it to be an ideal model organism for the study of metachronal waves.

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