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Life's most important biochemicals (19 of 20 amino acids, most sugars, etc.) are chiral – they come in one of two possible shapes that are mirror images of each other. The idea that the shape of an organic molecule – its handedness or chirality – determines whether it is biologically active replicating systems. Starting with principal phospholipid cell membrane constituents, the research will identify flow states that promote assembly into micron-sized vesicles from initially dilute millimolar concentrations. Next, the PI will induce simultaneous polymerization and encapsulation of nucleic acid cargo within the synthesized vesicles. Finally, protocells containing polymerized nucleic acids will be isolated and analyzed using single-cell multi-omic profiling methods. This screening will, for the first time, rationally link the physical domain of transport phenomena in hydrothermal microenvironments with the biochemical realm of protocell formation and nucleic acid synthesis, making it possible to identify and select conditions that favor assembly of specific sequences.

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Time-domain superoscillations (SOs) occur when several light waves of different wavelengths combine, over a brief time interval, into an almost perfect destructive interference. During this short interval, the electric field is not exactly zero, but can perform a weak oscillation, the superoscillation, that is faster than the original individual light waves. This counterintuitive property does not contradict any laws of physics and has already enabled breakthrough resolution enhancements in optical microscopy in the spatial domain. In the time domain, optical SOs of the electric field of light have not been demonstrated. A pair of researchers at Tulane University will experimentally synthesize optical time-domain SOs for the first time, and assess their potential for breakthrough capabilities in spectroscopy, communications, and wavelength conversion. They estimate that SOs can enhance ten-fold the sensitivity of light to the out-of-spectral range optical absorption as they travel through an absorbing material. This promises the possibility of spectroscopic substance detection through opaque media, which would provide a new paradigm in remote optical sensing. Super-transmission allows SOs to travel over long distances in an absorbing medium. This could enable breakthroughs in communications, as in THz frequency wireless, where the main obstacle is the strong THz absorption in the atmosphere. Yakir Aharonov at Chapman University predicted that the fictitious high frequency of SO can be converted into a real pro[illegible]

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Conventional crystals use individual atoms as their building blocks. A contemporary goal of synthetic materials chemistry is instead to use clusters of atoms that are subsequently arranged into a much longer-range pattern to form so-called superatomic crystals or supercrystals. Such materials have the potential to display properties that are distinct from those of atomic solids owing to the integration of multiple length scales as well as the emergent properties of the superatomic clusters themselves.