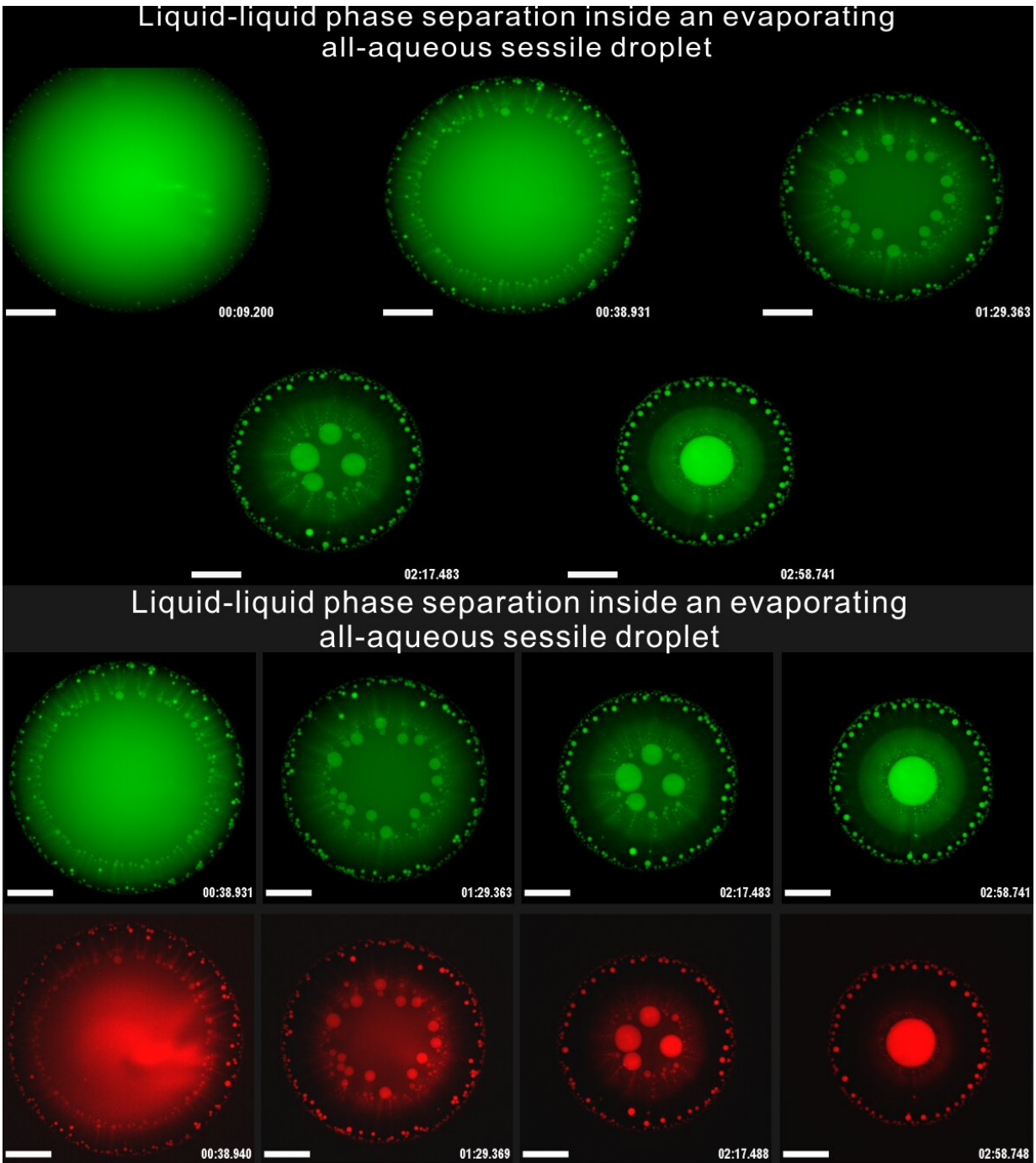


Team discovers a new approach to unveil the Origin of Life: Evaporation

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The image shows the evaporation-induced phase separation process inside an all-aqueous sessile droplet (Scale bar: 500 microns). The droplet is initially single-phase with PEG (Polyethylene glycol) and dextran dissolved. Upon evaporation, the concentration of PEG and dextran increases and incompatibility arises, forming tiny dextran-rich droplets (green fluorescently labelled) dispersed in the

continuous PEG-rich phase. These tiny dextran-rich droplets move towards the center of the sessile droplet with the inward Marangoni flow.

Compartmentalization and localization of biopolymers like nucleic acids (red fluorescently labelled) inside these dextran-rich droplets are achieved, with great potential in serving as all-aqueous reactors for a wide range of biochemical reactions. Credit: The University of Hong Kong

What is the origin of life? It is a question that has consumed the work and time of scientists for centuries. Recently a group of researchers from the University of Hong Kong (HKU) has shed light on the possible ways forward to examine how living things are formed.

The team was led by Professor Anderson Shum from the Department of Mechanical Engineering and their collaborators in the laboratory of Professor Julian Tanner from the School of Biomedical Sciences of the LKS Faculty of Medicine, HKU. They discovered that evaporation could facilitate compartmentalization of biochemical compounds relevant to the [living cells](#), providing an environment within which early evolution could have started.

The latest discovery has been published in *Nature Communications* in an article entitled "Non-associative phase separation in an evaporating droplet as a model for prebiotic compartmentalization."

The synthetic pathways of life's building blocks are envisaged to have emerged through a series of complex prebiotic reactions and processes. Concentration and compartmentalization of early functional biomolecules and their precursors were essential to the formation of the first living cells, which were believed to have evolved from the hypothetical Primordial soup, the liquid substance that existed on the Early Earth around 4.0 to 3.7 billion years ago before the emergence of

cellular life.

A strategy to compartmentalize and concentrate biopolymers under prebiotic conditions remains elusive. Liquid-liquid phase separation (LLPS), a mechanism by which membraneless organelles form inside cells, has been hypothesized as a potential mechanism for prebiotic compartmentalization. LLPS is affected by several factors including pH values, temperatures, and salt concentrations of the solution. It has been difficult to trigger in a laboratory setting a dilute and stochastic "primordial soup." In particular, concentrations of ingredients involved in LLPS need to be sufficient for phase separation.

Professor Shum's team found that LLPS can be triggered and maintained through evaporation of droplets. In their experiment, researchers achieved biomolecule compartmentalization through the evaporation of an all-aqueous droplet containing polyethylene glycol (PEG) and dextran. The resulting spontaneous compartmentalization enhances reactions, as demonstrated by the localization and storage of nucleic acids, in vitro transcription, as well as a 3-fold enhancement of ribozyme activity.

"We have shed some light on how molecules may have been separated before the evolution of membranes in early life forms. An important aspect of life is compartmentalization and concentration of biomolecules in sufficient quantities for chemical reactions," said Dr. Andrew Brian Kinghorn, a post-doctoral fellow from HKU's School of Biomedical Sciences who specializes in making tools for RNA tracking.

He compared the dissolution to a spontaneous separation of milk and coffee—the life substances inside living cells, in ready-to-drink blended coffee—"Primordial Soup."

"Evaporation or drying, in other words, results in the

compartmentalization and concentration of all chemicals that are needed for life," added Dr. Kinghorn.

"With evaporation the [water content](#) in the droplet decreased, leading to an increase in polymer concentration," explained Ph.D. student Wei Guo, who witnessed the process with excitement, where the initially homogeneous, clear droplet dissolved into two phases.

"The dissolution of a bigger droplet into smaller ones could be useful for future study on living cells." Guo said the finding laid a very strong foundation in understanding physical phenomena in terms of fluid dynamics.

Professor Shum said the latest finding was an example of how curiosity fostered scientific discovery. "Aqueous two-phase system had been studied previously but this is the first time evaporation was used to initiate this kind of phase separation." He said.

A renowned researcher in microfluidics, Professor Shum said the technique could also be used for the purpose of diagnostics or making droplets in a controlled manner—should the need arise. More can be found on molecular reactions if controlling factors, such as controlling for the temperature or rate of evaporation, are put in place.

Meanwhile, his team is keen to hear feedback from the scientific community about their "chance discovery." "We don't have a pre-set agenda on what to do next; we did the experiment more out of curiosity. It is about how things can emerge from a very simple system, the emergence of complexity from a very simple system; like the [origin of life](#), the key part of it is how something complex can come out of a simple system."

Professor Shum and Professor Tanner have been collaborating on

various projects, involving post-doctoral fellows, undergraduates and postgraduates.

Professor Shum is committed to uncovering more mysteries about liquids and beyond. "Good science discoveries, interesting observation and phenomena lead to more questions. That is the fun part to me of doing science; you realize what you don't understand and you know what the questions are; occasionally you have small wins, in terms of small answers to certain questions, and that's the encouragement. But a project does not end after you have got all answers. Sometimes you just have answers to subsets of questions that are worth sharing with the community," he said.

More information: Wei Guo et al, Non-associative phase separation in an evaporating droplet as a model for prebiotic compartmentalization, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-23410-7](https://doi.org/10.1038/s41467-021-23410-7)

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