Back to basics: Scientists discover a fundamental mechanism for cell organization (w/Video)

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Scientists have discovered that cells use a very simple phase transition -- similar to water vapor condensing into dew -- to assemble and localize subcellular structures that are involved in formation of the embryo.

The discovery, which was made during the 2008 Physiology course at the Marine Biological Laboratory (MBL), is reported in the May 21 early online edition of *Science* by Clifford P. Brangwynne and Anthony A. Hyman of the Max Planck Institute for Molecular Cell Biology and Genetics in Dresden, Germany, and their colleagues, including Frank Jülicher of the Max Planck Institute for the Physics of Complex Systems, also in Dresden.

Working with the worm C. elegans, the scientists found that subcellular structures called P granules, which are thought to specify the "germ cells " that ultimately give rise to sperm or eggs, are liquid droplets that transition between a dissolved or condensed state. In newly fertilized one-cell embryos, the P granules are dissolving throughout the cell, like water droplets at high temperature. But prior to the first cell division, the P granules rapidly condense at one end of the cell, as if the temperature were suddenly lowered there. The progenitor germ cell subsequently forms where the P granules have condensed.

"This kind of phase transition could potentially be working for many other subcellular structures similar to P granules," Brangwynne says. P

granules are ribonucleoprotein assemblies (RNPs), and a given cell may contain dozens of different types of RNPs.

"It is interesting to think about this in the context of evolution and the origin of life," he says. "What we have found is that, in some cases, simple physical-chemical mechanisms, such as a classic phase transition, give rise to subcellular structure…This is likely the kind of thing that happened in the so-called primordial soup; but it's not surprising that even highly evolved cells continue to take advantage of such mechanisms."

The insight emerged when Brangwynne, a biophysicist who was a teaching assistant in the MBL Physiology course, watched a movie of P granules fusing that had been made by a student in the course, David Courson of the University of Chicago. "We were looking at that and thinking, man, that looks exactly like two liquid droplets fusing," Brangwynne says. They began making measurements of liquid-type behaviors in P granules, and made the first estimates of P granule viscosity and surface tension. By the end of the course they were "90 percent sure" that P granules are liquid droplets that localize in the cell by controlled dissolution and condensation, a concept that Brangwynne further confirmed after he returned to Dresden.

Brangwynne credits the discovery to the "dynamic nature" of the MBL Physiology course, where scientists from different fields (biology, physics, computer science) work intensively together on major research questions in cell biology. In addition to Courson, the other co-authors of the Science paper who were in the Physiology course are Hyman, and Jülicher, who were Physiology faculty members, and Jöbin Gharakhani, who was a teaching assistant. The paper also credits Physiology course co-director Tim Mitchison for valuable discussions.

"There are so many molecules in the cell, and we are coming out of the

age of cataloguing them all, which was critical, to find out who the players are," Brangwynne says. "Now we are putting it all together. What are the principles that come out of these complex interactions (between molecules)? In the end, it may be relatively simple principles that help us understand what is really happening."

More information: Brangwynne, C.P., Eckmann, C.R., Courson, D.S., Rybarska, A., Hoege, C., Gharakhani, J., Jülicher, F., and Hyman, A.A. (2009) Germline P Granules are Liquid Droplets that Localize by Controlled Dissolution/Condensation. Early publication online by the journal Science, at the Science Express web site: www.sciencexpress.org .

Source: Marine Biological Laboratory