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Phase separation and the formation of the pyrenoid, a carbon-fixing organelle BIN XU, Department of Physics, Princeton University, ELIZABETH FREEMAN ROSENZWEIG, Department of Biology, Stanford University, LUKE MACKINDER, Department of Biology, University of York, MARTIN JONIKAS, Department of Molecular Biology, Princeton University, NED S. WINGREEN, Department of Molecular Biology and Lewis-Sigler Institute for Integrative Genomics — In the chloroplasts of most algae, the carbon-fixing enzyme Rubisco is concentrated in a non-membrane-bound structure called the pyrenoid, which enables more efficient carbon capture than that of most land plants. In contrast to the long-held assumptions of the field, the pyrenoid matrix is not a solid crystal, but behaves as a phase-separated, liquid-like organelle. In this system, the linker protein EPYC1 is thought to form multivalent specific bonds with Rubisco, and the formation of the pyrenoid occurs via the phase separation of these two associating proteins. Through analytical and numerical studies, we determine a phase diagram for this system. We also show how the length of the linker protein can affect the formation and dissolution of the pyrenoid in an unexpected manner. This new view of the pyrenoid matrix provides important insights into the structure, regulation, and inheritance of pyrenoid. More broadly, our findings give insights into fundamental principles of the architecture and inheritance of liquid-phase organelles.

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