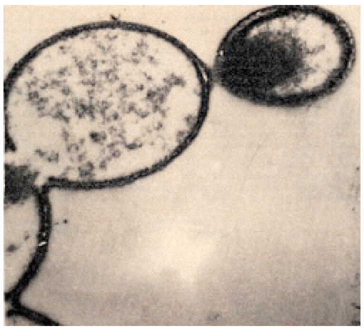
Protobionts

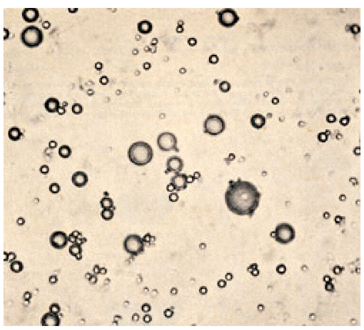
WHAT DID THE EARLY PROTOBIONTS LOOK LIKE? We shall probably never know for sure; but investigators are able to manufacture complex droplets which have many of the attributes of living cells and may resemble the early protobionts.

The photograph below shows Oparin's coacervate droplets. Each droplet is a cluster of macromolecules surrounded by a shell of water in which the individual water molecules are rigidly oriented relative to the macromolecules. Such droplets have a tendency to selectively adsorb and incorporate various substances from the surrounding medium.



COACERVATES, polymer-rich colloidal droplets, have been studied in the Moscow laboratory of A. I. Oparin because of their conjectural resemblance to prebiological entities. These coacervates are droplets formed in an aqueous solution of protamine and polyadenylic acid. Oparin has found that droplets survive longer if they can carry out polymerization reactions.

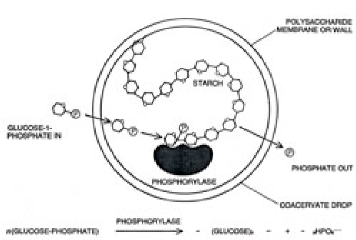
Sidney Fox's proteinoid microspheres are formed by heating dry mixtures of amino acids to moderate temperatures, then cooling the mixture. The microspheres show many of the characteristics of living cells. (See Campbell text pages 533-534.)



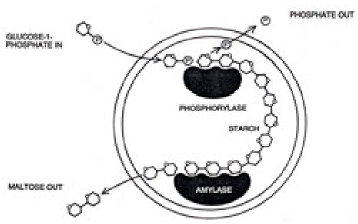
PROTEINOID MICROSPHERES, another kind of microspheroidal aggregate, studied by Sidney W. Fox of the University of Miami, forms from "thermal proteinoid," a polymer produced by heating dry mixtures of amino acids to moderate temperatures. Under suitable conditions thermal proteinoid will form microspheres several micrometers in diameter, which grow slowly and eventually bud. The microspheres seem to have a two-layer membrane suggestive of that in bacteria.

Oparin has reported another self-growing system in which the coacervate droplets are made from histone and RNA. The enzyme RNA polymerase is introduced into the droplets, and ADP is added to the surrounding medium as "food." When the ADP enters the droplet, it encounters the RNA polymerase and is polymerized into polyadenylic acid. The energy for polymerization is contained within the ADP itself. The new polyadenylic acid adds to the total RNA in the coacervates. The droplets grow with time and break up into daughter droplets.

Such systems eventually wind down because the supply of enzyme molecules for polymerizing ADP does not increase with the total mass of the coacervate droplets. As we saw earlier, however, nucleic acids can be polymerized nonenzymatically with small, energy-rich coupling-agent molecules such as cyanogen. It should be possible to construct coacervate droplets from protein and RNA, to provide them with ADP and the appropriate coupling reagents, and to see them grow and multiply without limit as long as their "nutrients" continue to be supplied.



POLYMERIZATION INSIDE A COACERVATE DROPLET causes the wall of the droplet to thicken and the droplet to grow. The droplet, consisting of protein and polysaccharide, contains the enzyme phosphorylase. Glucose-1-phosphate diffuses into the droplet and is polymerized to starch by the enzyme. The starch migrates to the wall and increases volume of droplet.



TWO-STEP REACTION takes place inside a protein-carbohydrate droplet provided with two enzymes. One enzyme, phosphorylase, polymerizes glucose-1-phosphate to starch. The second enzyme, amylase, degrades the starch to maltose. Droplets in this instance do not grow because the starch disappears as fast as it is made. The maltose diffuses back into surrounding medium.