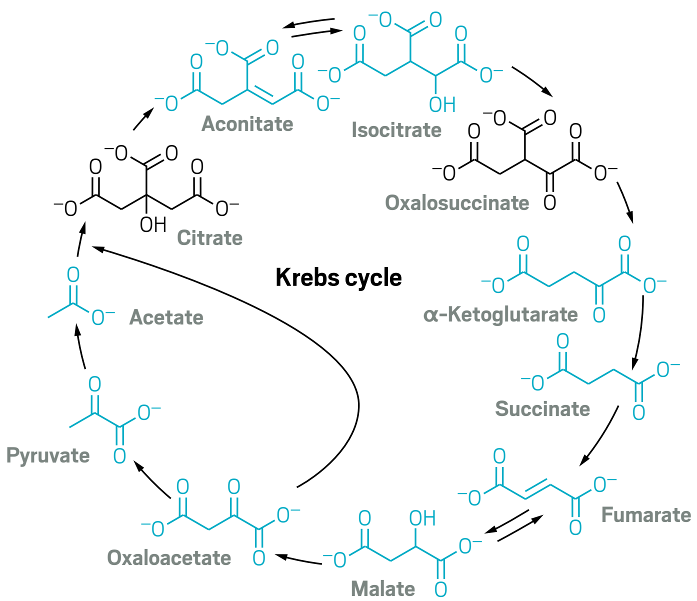
ORIGINS OF LIFE

Iron can catalyze metabolic reactions alone

Metal may have played key role in early biochemistry before enzymes

Enzymes catalyze the critical chemical reactions that help build and power living organisms. But chemists studying the origin of life on Earth face a vexing question: How did these metabolic reactions evolve before their enzymes existed?



In the presence of ferrous iron, pyruvate and glyoxylate can produce all but two (black) components of the Krebs cycle.

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Take the Krebs cycle, for example. Also known as the citric acid cycle, it plays a central role in the metabolism of living things as the only biochemical pathway to produce all five so-called universal metabolites: acetate, pyruvate, oxaloacetate, succinate, and α-ketoglutarate. "Every biological molecule you can make, its synthesis gets traced back to one of these five compounds on the Krebs cycle," says Joseph Moran, a chemist at the University of Strasbourg.

Moran and his colleagues now report that a one-pot set of reactions involving ferrous iron and two simple molecules, pyruvate and glyoxylate, can generate all five universal metabolites (*Nature* 2019, DOI: 10.1038/s41586-019-1151-1). "We speculate that this pathway may have been the precursor to the Krebs cycle," Moran says.

In the past 5 years, a handful of studies have begun to hint that the early Earth chemistry that produced life may have done so without the need for reactive compounds such as cyanide and formaldehyde. For example, a 2017 computational study mapped out a simplified molecular world that could still produce many biochemical reactions and molecules (*Cell* 2017, DOI: 10.1016/j.cell.2017.02.001). Moran's team noticed that in that primitive biochemistry, pyruvate and glyoxylate were linchpin molecules.

The researchers decided to see what kinds of reactions pyruvate and glyoxylate generate in an aqueous solution in the presence of different metals and under different experimental conditions, such as temperature and time. To their surprise, the reaction network they observed with ferrous iron included all five of the universal metabolites.

When the team added hydroxylamine and metallic iron to the mix, they produced four amino acids—glycine, alanine, aspartic acid, and glutamic acid—which are thought to be the first to arrive on the scene as biochemistry got its start.

The study identifies ferrous iron as the "one central electron donor—one central catalyst—that can actually do everything that we think is important in metabolism," says Markus Ralser, a biochemist at the Francis Crick Institute. He thinks this paper may put to rest the old hypotheses of how biochemistry may have started on Earth. "Now, you can clearly see that it's possible to make these molecules in the same fashion as cells do it," he says.—ALLA KATSNELSON, special to C&EN

BIOLOGICAL CHEMISTRY

Deep-trench bacteria eat hydrocarbons

In the western Pacific Ocean, where the Pacific plate meets the Mariana plate, you'll find the deepest place on Earth, the Mariana Trench. The trench runs for 2,550 km along the ocean floor and its deepest spot, evocatively named Challenger Deep, is about 11 km deep. To get down there, you need specialized equipment that can survive the crushing pressures. But once at the bottom, there is still a lot to discover.

In 2016, researchers lowered special water-sampling bottles from a surface ship down to Challenger Deep. Using DNA sequencing to characterize bacteria collected in these bottles, researchers in China, Russia, and the UK have found that the Mariana Trench is rich in hydrocarbon-munching bacteria (*Microbiome* 2019, DOI: 10.1186/s40168-019-0652-3). They confirmed their findings by isolating some of the bacteria and showing that the microbes could metabolize C_{18}–C_{20} alkanes in the lab.

Scientists don't know a lot about life in these very deep areas, but they do know the trenches are biological hot spots, says Ronnie N. Glud at the University of Southern Denmark, who was not involved in the study. "Why is it," he asks, "when we move into the trenches that we have a much higher biological activity than we have elsewhere in the deep ocean?" Perhaps, he says, the hydrocarbons that accumulate in the trenches can be an energy source to sustain life.

"We know more about Mars than the deepest part of the ocean," says Xiao-Hua Zhang of the Ocean University in China, who led the study. More research is needed to understand life in this unique environment as well as the role these bacteria could play in cleaning up oil in the ocean, as do similar microbes found in the Gulf of Mexico.—LAURA HOWES