LETTER

"What Is Life?"

The question "What is life?" was proposed as "An activity to convey the complexities of this simple question" by Prud'Homme-Généreux (2013). This activity was successfully carried out with freshman undergraduate students, but "could easily be adapted for a high school or even an elementary school audience." I believe it is such a fundamental question that it probably should be introduced in some form as early as possible in biology classes and revisited periodically as students mature in their biological knowledge. For example, determining whether a plant or animal is living or dead sometimes depends on the environment (such as temperature or the availability of liquid water) or the technology (instrumentation sensitivity) used to detect metabolism. This *ABT* article cites a frozen frog (in "hibernation") as a living organism, but does not list a desiccated plant seed as living. A frozen frog would not be able to survive thawing if it had been cooled to less than –4°F, a moribund state rather than hibernation (Svoboda, 2005). Many desiccated seeds are able to germinate when rehydrated.

As supplementary material to the activity in that *ABT* article, I suggest here some examples of physical/chemical systems that appear to have some of the features of living organisms. It has been known since at least 1917 that when a drop of mercury is placed in a weak nitric acid solution in a Petri glass and a crystal of potassium dichromate is placed at a distance from the mercury, the mercury begins to move as the concentration gradient of the dissolved crystal reaches the mercury. I have observed that the blob of mercury sometimes appears to attack the undissolved portion of the crystal in an "amoeboid" motion, but nothing is taken internally into the blob. The blob may segment into one or more lobes or divide completely into two or more independent blobs. After about 5 to 10 minutes the blobs stop moving. This experiment was introduced to readers of *ABT* by Mickle & Aune (2011).

Sumino et al. (2005) immersed a glass strip in water containing a surfactant, placed a drop of oil saturated with iodine ions on the strip, and observed the drop move until all the iodine ions in the oil were used up. Movies of this system can be seen online (ftp://ftp.aip.org/epaps/phys_rev_lett/E-PRLTAO-94-066507).

When fatty acids are dissolved in fresh water, they have been reported to aggregate into bubbles or vesicles. By evaporating the fatty acid solution, these bubbles can swell into elongated tubes and then break up into daughter vesicles (Marshall, 2013).

Maselko & Strizhak (2004) "report the observation of the spontaneous formation of a cellular structure in a simple inorganic system. The system is obtained by immersing a pellet of calcium and copper chlorides in an alkali solution containing carbonate, sodium iodine, and hydrogen peroxide. The system produces a cell surrounded by a semipermeable membrane. Reactants diffuse and react inside the cell with copper ions serving as catalyst. The products diffuse out of the cell. The system sustains itself far from thermodynamic equilibrium."

According to Brian Dunning (http://skeptoid.com/episodes/4224), red rain fell in the Indian state of Kerala in July 2001. Early investigators found structures microscopically resembling biological cells, but they could not detect any nuclei or DNA within them. Later workers concluded that these particles were spores from *Trentepohlia* algae, found locally in association with fungi in lichens, and heavy with red-orange carotenoid pigments. The story of why earlier workers failed to detect nuclei or DNA in this alga is worth having students read this online article for themselves, and then asking themselves if the mystery of red rain in India, and in other places and at other times, has been solved. Additional information, references, and a photomicrograph of red rain cells are available online (http://en.wikipedia.org/wiki/Red_rain_in_Kerala).

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