What life isn't

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Astrobiologists claim there are only three prerequisites for life—organic molecules, water, and energy. But Earth life can sustain itself indefinitely only in communities based on primary producers—specialized organisms that can manufacture their own food from the energy contained in sunlight, inorganic chemicals, or electrons. In any naturalistic scenario such specialized primordial cells must have formed in water because all functioning cells require more water than all other ingredients combined. However, the thermal properties of liquid water are so destructive on the molecular scale (briefly violating the 2nd Law of Thermodynamics) that life could never have originated merely from organic chemicals, water, and energy. Water therefore defines life, not in the positive sense of what it *is*, but in the negative sense of what it *isn't* and could *never be*—a product of nature. Water's destructive power sets such high standards for cell design, construction, functionality, and time scale—just a minuscule fraction of a second—that it excludes all naturalistic scenarios. Genesis-style fiat creation remains the only rational explanation.

Astrobiologists from Cornell University have recently claimed there are just three prerequisites for life—organic molecules, water, and energy. Since all three occur throughout the universe, they went on to calculate that about 100 million planets in our galaxy could harbour complex life, ecosystems, and biospheres.[1] But for over 60 years now scientists have been doing experiments with organic molecules, water, and energy, and they have produced nothing other than chemistry. Biology clearly requires more than chemistry.

Harvard University's Nobel prize-winning origin-of-life researcher Jack Szostak admits that *cells* are the essential prerequisite for life:

> "We're looking at a very narrow slice of the whole problem. We assume we have the chemical building blocks of life: the question we're looking at is what do we need to do to make these chemicals get together and work like a cell?"[2]

Another Nobel prize-winning biochemist, Christian de Duve, identified intelligent design as one of seven possible origin scenarios.[3] He rightly pointed out that this possibility can only be entertained if all naturalistic causes are excluded,[4] and he took comfort in the thought that naturalistic causes could *never* be exhaustively ruled out. In this article, however, I use the thermal properties of water to demonstrate that natural causes can be ruled out with great certainty, leaving Genesis-style fiat creation as the only rational explanation.

What is Life?

The Cornell astrobiologists' calculations were based upon a faulty understanding of biology. Other astrobiologists have recognized that "a general theory of living systems" is an essential prerequisite for knowing what life is.[5] Nobel prize-winning physicist Erwin Schrödinger addressed this question in his 1944 book *What is Life*?[6]

> "What is the characteristic feature of life? When is a piece of matter said to be alive? When it goes on 'doing something', moving, exchanging material with its environment, and so forth, and that for a much longer period than we would expect an inanimate piece of matter to 'keep going' under similar circumstances. When a system that is not alive is isolated or placed in a uniform environment, all motion usually comes to a standstill very soon as a result of various kinds of friction; differences of electric or chemical potential are equalized, substances which tend to form a chemical compound do so, temperature becomes uniform by heat conduction. … The physicist calls this the state of thermodynamical equilibrium, or of 'maximum entropy'. Practically, a state of this kind is usually reached very rapidly."[7]

Life, according to Schrödinger, is that which sustainably *avoids* such rapid return to equilibrium.

You can see something of what he is talking about in this home experiment. Pour a teaspoon of soy sauce into the middle of a shallow bowl of water. A furious reaction takes place. The water molecules attack the sauce droplet and the sauce is scattered in all directions. Come back a short while later and the mixture will be uniformly quiet—it has 'decayed to equilibrium'.

The energy that powers this reaction is called 'thermal energy.'[8] Free water molecules always race around at supersonic speeds because of their thermal energy. We don't normally notice it because they quickly encounter other water molecules doing the same thing, bouncing off each other, jiggling about a lot, and ending up as a 'sea of thermal noise'. Thermal noise is the 'dance' that all kinds of molecules engage in when nothing else is happening. Water always wins the battle against soy sauce, however, because its molecules are smaller, faster, and vastly more numerous than the larger and slower organic molecules in the sauce.

So how does life avoid this kind of decay to equilibrium? Schrödinger used the laws of physics to define three conditions:

- Cellular machinery operates at a scale where thermal noise interferes, so it must have some means of overcoming this.
- The primary means must be through strong chemical bonds.
- To remain operational over a long timescale ('indefinitely' is a suitable term that covers the history of life on Earth) life must have a means—which he simply called 'metabolism'—of feeding upon 'negative entropy' in the environment.

Schrödinger was the first person to develop the concept that life operates within a sea of thermal noise.[9] Few, if any, seem to have subsequently realized the enormous significance that it has in biology. Recently, however, improvements in technology have allowed us to watch life at work in molecular detail, and suddenly there it is before our eyes! It now gives us an extremely powerful way of answering the question "What is Life?" because it clearly defines what life is *not* and can *never be*.

The molecular heat storm

Thermal noise is heat. Heat is not a substance that resides in hot objects and can be passed on to cold objects. Heat is the motion of atoms and molecules. If a thermometer says it is 20°C outside, it means air molecules are impacting on it at about 1,840 km per hour. That's around 50% faster than the speed of sound.[10] At the bottom of the temperature scale all heat motion stops at –273.15°C, also known as zero on the absolute temperature scale. That's colder than intergalactic space, where the temperature is around –270°C, and hydrogen gas molecules race around at about 700 km per hour. In comparison, life as we know it is quite 'hot'. It usually exists within a temperature range of 0° to 100°C because it requires liquid water. In the narrower range, where most organisms live (5–40°C), the average speed of a water molecule is about 2,300 km/hour. That's almost twice the speed of sound!

Here is what the 'heat storm' looks like at the biomolecular level. Figure 1A shows a model of a common molecular machine found inside bacterial cells (a ribosome 30S subunit) at single-atom resolution.

This is what the molecular machine might look like at absolute zero temperature. At 4°C the atoms are moving too fast to see and the image is smeared out (figure 1B). At 18°C even less detail is visible (figure 1C), and at 37°C—the

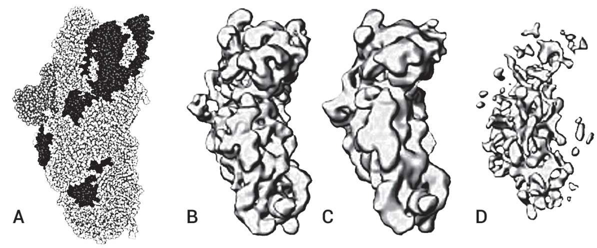

Figure 1. Molecular images of the 30S subunit of a bacterial ribosome. A—atomic model showing where each atom is and the space it fills.[11] B—electron microscope image taken at 4°C; heat motion obscures the individual atoms. C—at 18°C heat motion obscures even more of the atomic detail. D—at 37°C heat motion is too fast for the camera to capture.[12]

internal temperature of the human body—it looks like the machine is flying apart (figure 1D). This is partly true—at slightly higher temperatures many cells (including our own) die from overheating—but it also reflects the inability of the imaging system to capture the incredibly fast action. This is what the heat storm looks like in a molecular machine!

Brownian motion

The earliest physical evidence of the molecular heat storm was published in 1828 by Scottish botanist Robert Brown.[13] While studying live plant cells under a light microscope he noticed that tiny particles were incessantly jiggling. Even when the cells were killed the jiggling continued. On further investigation he found that any kind of tiny solid particles suspended in liquid also engaged in similar random jiggling (figure 2). It has since become known as 'Brownian motion'. Today it remains a constant problem in studying bacteria—they have to be 'fixed' onto glass slides to *stop* the jiggling!

Albert Einstein published a theory in 1905 explaining Brownian motion as the result of the molecular heat storm. He calculated that

> "... according to the molecular-kinetic theory of heat, bodies of microscopically visible size suspended in liquids must, as a result of thermal molecular motions, perform motions of such magnitude that these motions can easily be detected by a microscope."[14]

If his theory turned out to be true, he noted, then it would also demonstrate that "classical thermodynamics [could] no longer be viewed as strictly valid". Einstein's theory was soon experimentally verified.

The particles investigated by Einstein were one micrometre (millionth of a metre) in diameter, while the water molecules that moved them were ten thousand times smaller, at around 0.1 nanometres (billionths of a metre) in diameter. That means the water molecule's heat motions are so powerful they can displace objects a trillion times

($10{,}000^3$ = 1 trillion) larger than themselves. It's no wonder that Schrödinger was concerned about what would happen on the much smaller scale of molecules *inside* a cell!

The trillion times 'punching power' that Einstein believed would violate classical thermodynamics has since also been vindicated. The *fluctuation theorem* precisely describes the effect,[16] it has been experimentally verified, and it does indeed briefly violate the 2nd Law of Thermodynamics. On timescales of about 1 second or less, particles can randomly 'collaborate' so that their combined thermal energy goes from a 'colder' state to a 'hotter' state. It is only on timescales of about 2 seconds or greater that the classical statement of the 2nd Law is valid—that thermal energy normally flows from a 'hotter' state to a 'colder' state.[17]

Let's summarize what this means for a bacterium. Brownian motion shows that the heat storm on the outside can create something comparable to gigantic ocean waves that throw ships around like corks in a perfect storm. Simultaneously, random pounding by individual water molecules continues from every direction. Biophysicist Peter Hoffman quantified this battering in his book *Life's Ratchet: How Molecular Machines Extract Order from Chaos.* He compared it to a car experiencing a wind speed of seventy thousand miles per hour![18] These horrendous forces are also at work *inside* the cell! Molecular machines function via myriad shape-changes, and these can only be achieved in the presence of abundant free water. As a result, functioning cells require more internal water than all other ingredients combined. About 80–90% of cell water in both *E. coli* and red blood cells displays single-molecule dynamics similar to that of bulk water, while only about 10% of the total is immobilized by adsorption onto internal surfaces.[19] Add to this mix the bizarre distortions caused by the heat storm *within* molecular machines themselves (figure 1) and we see that bacteria suffer molecular violence at all scales!

Strong molecules

How do cells avoid being disrupted by this incessant molecular heat storm? Schrödinger's answer was 'strong chemical bonds'. Strong chemical bonds are universal across all living organisms. The most common strong bond occurs when one carbon atom links up with another carbon atom to form a carbon-carbon bond. This forms the 'backbone' of nearly all biological molecules. Variations are produced by adding other strong bonds with oxygen, nitrogen, phosphorus, and some trace elements. These atoms make strong bonds because they have multiple electrons that can produce complex interactions with neighbouring atoms.

In contrast, hydrogen usually forms weak bonds because it only has one electron in its outer shell and only one proton in its nucleus to positively attract it. Most organic molecules have a core structure of strong bonds, with hydrogen atoms more loosely bound around the outside. A few examples are given in figure 3.

Molecules in cells rarely act alone—they usually form *molecular machines*. But if a whole machine had to be rigidly strong, then it could not do the things that these machines need to do. It is the presence of hydrogen atoms on the outside of biomolecules that allows them to function as machine parts by repeatedly making and breaking some of the weak hydrogen bonds. However, if a machine becomes too 'floppy'

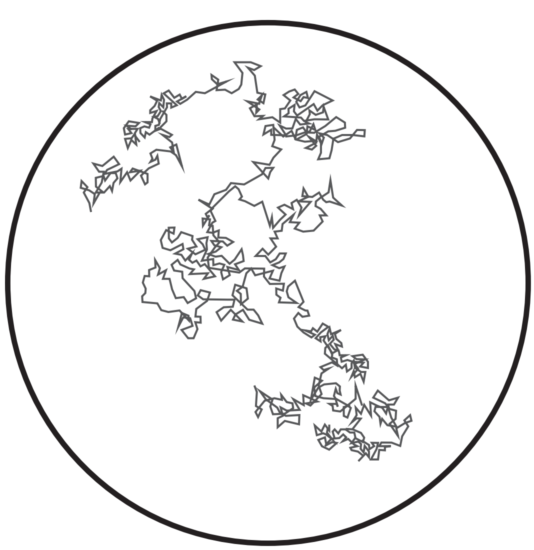

Figure 2. Computer simulation of Brownian motion of a solid particle 1 micrometre in diameter suspended in water, and moving across the field of a microscope at 400x magnification. It is driven by the 'heat storm' of the water molecules.[15]

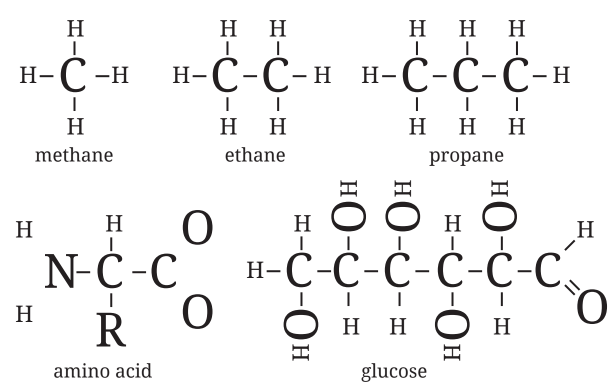

Figure 3. Organic molecules are based on strong carbon bonds. Methane (gas), ethane (gas), and propane (gas) illustrate how carbon atoms can link together, surrounded by hydrogen atoms. Amino acids (which make proteins) contain a nitrogen, two carbons, and two oxygen atoms, all surrounded by hydrogen atoms, plus a variety of side chains (R) that yield different properties. Glucose is the simplest sugar, with six carbon atoms surrounded by hydrogen and hydroxyl (OH) groups, and one oxygen atom. Lipids (not shown) are long carbon chains surrounded by hydrogen atoms, with an oxygen and hydroxyl group at one end.

the molecular storm will soon destroy it. According to Hoffman, "evolution over billions of years" provided the 'just right' solution—"highly sophisticated molecular machines" that can "tame the molecular storm and turn it into the dance of life". But this explanation is a *non sequiteur*—Darwinian evolution can only begin to occur when all the molecular machinery is already in place and sustainably functional over indefinite timescales! In Jack Szostak's words, a naturalistic origin of life requires *molecules* to "get together and work like a cell". Such an origin must begin with 'highly sophisticated' *molecules*, not with fully functional cells!

Biological candidates for first life

In the naturalistic worldview, life is an 'emergent' property of matter. Szostak's approach is typical in looking for 'the right conditions' that will allow life to emerge of its own accord from 'the right combination of molecules'. But what could such 'highly sophisticated' protolife molecules look like? They would at least have to meet Schrödinger's criteria of 'strong molecules' that 'do something' biological. Here are some possible examples.

A small protein candidate could be a *prion* (figure 4A). Prions cause contagious diseases like scrapie in sheep, mad cow disease, and kuru and Creutzfeldt-Jakob disease in humans. They are strong enough to transmit their properties beyond their cell-of-origin, through the heat storm of an animal's digestive systems, and pass across the cell membranes of different organisms and species. When the prion comes in contact with its normal protein counterpart it causes the normal form to spontaneously change shape into the 'rogue' form, and the reaction cascades through the nerve tissues of the host. Prions can 'evolve'—they always have the same amino acid sequence, but they can vary in their 3-dimensional form. When exposed to anti-prion substances, some of these variations can be resistant and are naturally selected.[20] However, they only arise and become active in the already-living nerve cells of mammals—much too far removed from life's origin.

A well-understood small piece of DNA that can 'do something' independently of a cell is a *plasmid.* It consists of a piece of double-stranded DNA, usually in a loop (figure 4B) and separate from the host's genome. It can replicate itself independently of the host's genome (but only inside the host cell) and/or splice itself into and out of the host genome. Plasmids exhibit stable molecular structure that can survive transfer from one organism to another—artificial plasmids are important tools in genetic engineering. However, like prions, they can only function inside other organisms, so life could not have originated from plasmids.

Many researchers believe that the current DNA-based life is so complex that it must have been preceded by a simpler kind of life based upon RNA. Proponents of this idea talk about an 'RNA world'—a whole world full of RNA-based life that subsequently gave rise to DNA life, then disappeared.[22] The only remnants that we see today, so they say, are RNA viruses and the multitude of RNA mechanisms that operate in modern cells. But there are no known RNA plasmids, because RNA is too unstable on its own in the natural environment. This is just one of multitudinous flaws in the RNA-world concept.[23] Every 'latest breakthrough' in this field ever more surely reinforces the fact that life requires a great deal of intelligent design and manipulation.[24]

The next step up the chain of molecular complexity brings us to *viruses,* which consist of a piece of DNA (or RNA) usually wrapped in a protein coat (figure 4C). There are vast numbers of viruses in the natural environment in, on, and around all kinds of living organisms. Very few cause disease. They make important contributions to life's diversity through their ability to transmit small amounts of DNA across species and across all of life's kingdoms. They are also remarkably stable. The protein and DNA components can be separated, stored in the laboratory, then reassembled years later and they will behave exactly as they did originally! Giant viruses—such as *Mimivirus* and *Pandoravirus*—come tantalizingly close to the requirements for minimum life.[25,26] But these viruses are thought to have originated via 'reductive evolution' from a bacteria-like common ancestor.[27] They cannot replicate outside of a host cell, and they destroy their host cell in the process, so they cannot qualify as first life.

Cells

There are no molecular assemblages known today that can "get together and work like a cell", so we are forced to 'jump the gap' and begin life with cells! They occur in three different kinds that make up the three 'domains' of life: bacteria, archaea, and eukarya. Bacteria and archaea are single-celled microbes (jointly known as *prokaryotes*), while eukarya covers all other forms of life (*eukaryotes*)—single-celled protists, multicellular animals, plants, fungi, and algae.

Bacteria and archaea are similar in size and shape, but very much smaller than eukarya. Their genome usually consists of a single loop of DNA ranging in size from 160 thousand to 12 million nucleotide pairs.[28] They both lack internal membrane-bound organelles (e.g. no nucleus) but their genomes are quite distinct and their membranes and aspects of their biochemistry differ. Despite their lack of internal membranes they do have complex internal structure. This includes close-packing of large molecules, various configurations of watery voids, and micro-compartments that can be composed of dozens, hundreds, or thousands of protein subunits.[29] The smaller compartments provide safe containers for highly active enzymes, and the larger ones isolate metabolic cycles and pathways that are mutually incompatible.[30] Prokaryotes are not 'simple' forms of life—they are masterpieces of ingenuity.[31]

Archaea often live inside other organisms, but none are known to cause disease. Bacteria often live inside other organisms also, and are crucial in the digestive tracts of humans and animals, but quite a few are pathogenic. Many archaea live in extreme environments, such as hot springs and hyper-saline lakes, where they produce food from the energy in inorganic chemicals or sunlight. Bacteria generally feed on organic matter produced by other organisms, but some can produce food from the energy in sunlight, inorganic chemicals, and even 'raw' electrons from rocks.[32] Neither can build multicellular bodies, but they can cooperate to form multi-ellular biofilms of various kinds.

Eukaryote cells are much larger and they contain internal membrane-bound organelles. Their DNA has up to several billion nucleotide pairs, which are broken up into multiple sets of linear chromosomes, all packed inside a membrane-bound nucleus. They do occur as single-celled organisms (e.g. diatoms, yeasts) but they can also build multicellular bodies as large as dinosaurs, redwood trees, and blue whales.

Scientists are divided in their opinions over which of the three different kinds of cells is the most likely ancestor of the others. All three have unique features, and archaea have a number of features in common with eukarya, so they are not 'archaic'. A recent review concluded that "The origin of [cells] is the central and perhaps the hardest problem of evolutionary biology."[33] Since prokaryotes are much smaller and simpler in their structure than eukarya, then one of them must come first in any naturalistic origin scenario. The smallest bacteria include *mycoplasmas* (figure 4D) and the smallest archaea include *nanoarchaea* (figure 4E).

Only those cells that can live independently of others—the *autotrophs* or *primary producers* that make their own food from the energy contained in sunlight, inorganic chemicals, or electrons—can qualify as candidates for first life. All of the others would quickly decay to Schrödinger's equilibrium. One example of a primary producer is *Candidatus desulforudis audaxviator*, a bacterium that lives entirely on its own, deep underground in cracks in the rocks where there is no light or oxygen. This tiny creature is able to manufacture everything it needs from water and bare rock.[34]

Schrödinger's criterion of indefinite persistence rules out any kind of first life that might arise from a 'primordial soup' which then continues to feed upon 'left-over soup'. Survival by this means would eventually exhaust the 'soup' and the organisms would die. First life, by Schrödinger's definition, must be able to sustain itself indefinitely—and only the 'high-tech' *autotrophs* can do that!

Cell walls

A naturalistic origin of life must, on present knowledge, begin with cells. The only thing—apart from the strong molecules already mentioned—that prevents today's cells from succumbing to the chaos of the molecular storm is the cell wall.[35] This is not the place to discuss cell walls in detail so I will just give two examples of what happens when cell walls are breached.

Smear some blood on a microscope slide so that you can see the cells, then add a drop of water. The cells swell up and within a short time explode like popcorn, instantaneously disgorging their contents (figure 5). These blood cells have the same kind of cell wall (a *cytoplasmic membrane*) as is found in all other kinds of life, but they have no power to resist the heat storm. They remain safe in the blood stream only because blood is a concentrated solution of many different components. If you drink too much fluid too quickly it dilutes your blood, the cells rupture, and you can die![36]

Bacteria have a similar kind of cytoplasmic membrane around them, but it needs extra reinforcing to survive in the outside world (figure 6, left panel). We see what happens

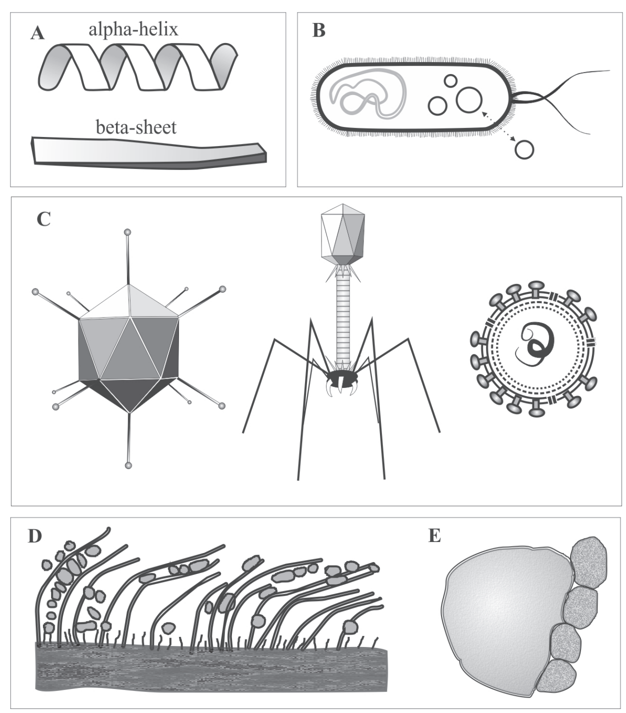

Figure 4. Possible candidates for first life. A—prions are protein molecules, a portion of which can spontaneously change shape from its normal 'alpha-helix' shape to a toxic 'beta-sheet' form. B—plasmids are small loops of DNA that can move between bacteria and splice into their DNA. C—viruses usually consist of a protein outer coat surrounding a DNA or RNA genome. D—mycoplasmas are small bacteria that live inside other organisms (in this case on the ciliated inner surface of the lung). E—*Nanoarchaeum* (the four cells on the right) can only live attached to their host, *Ignococcus*, a hot water sulphur-reducing bacterium.[21]

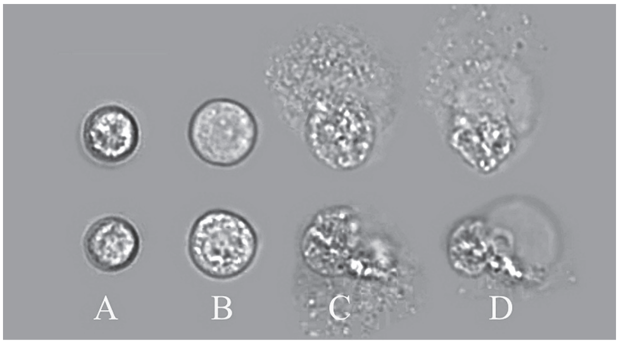

Figure 5. Selections from a video of white blood cells bursting in water.[37] The two cells left (A) are normal white blood cells as seen under a microscope. In water they swell up (B) and explode, expelling their contents (C) and leaving the empty cell wall behind (dark circles in background at D). The disgorged cell contents (bright foreground material in C and D) disperse more slowly because they are tangled up in membrane and cytoskeleton remnants.

when this protection is lost whenever certain bacterial infections are treated with an antibiotic like penicillin. Penicillin destroys the bacterium's ability to build the molecular cross-linkages in the fibrous reinforcement in the wall.[38] When the bacterium divides in the presence of penicillin the newly made dividing wall is weak and it swells up and explodes (figure 6, right panel time sequence A–D).

The cell explosions that we witness in these two examples are the result of the heat storm interacting with at least two other processes—osmotic pressure and the capillary effect. Osmotic pressure arises whenever a more concentrated solution meets a less concentrated one—as illustrated in the soy sauce experiment. The molecules inside a cell must be densely packed for the machines to function correctly (figure 5A; figure 6 left panel) and this necessarily creates a powerful osmotic pressure gradient across the cell wall. This happens regardless of the kinds of molecules involved—their size, shape, composition, and electric charge don't affect the outcome, only their concentration in relation to the medium outside.[41]

The capillary effect occurs because water molecules are polarized. The two hydrogen atoms are attached asymmetrically to the oxygen atom, and their single electrons are strongly attracted by the large oxygen atom. As a result, the oxygen end of the molecule carries a small excess negative charge, and the hydrogen end carries a small excess positive charge. When liquid water molecules come into contact with a solid surface the electric charge imbalance generally attaches it to the surface more readily than to other water molecules. The first layer of water molecules attaches most strongly to the surface, and layers further away are subject to both the surface attraction and the downward pull of gravity. This results in a 'meniscus'—the water surface turns up in a smooth curve where it touches the container walls (figure 7A).

Water's molecular polarity also creates 'surface tension'. Within a body of water every molecule is surrounded on all sides by other water molecules and the polarity charges are

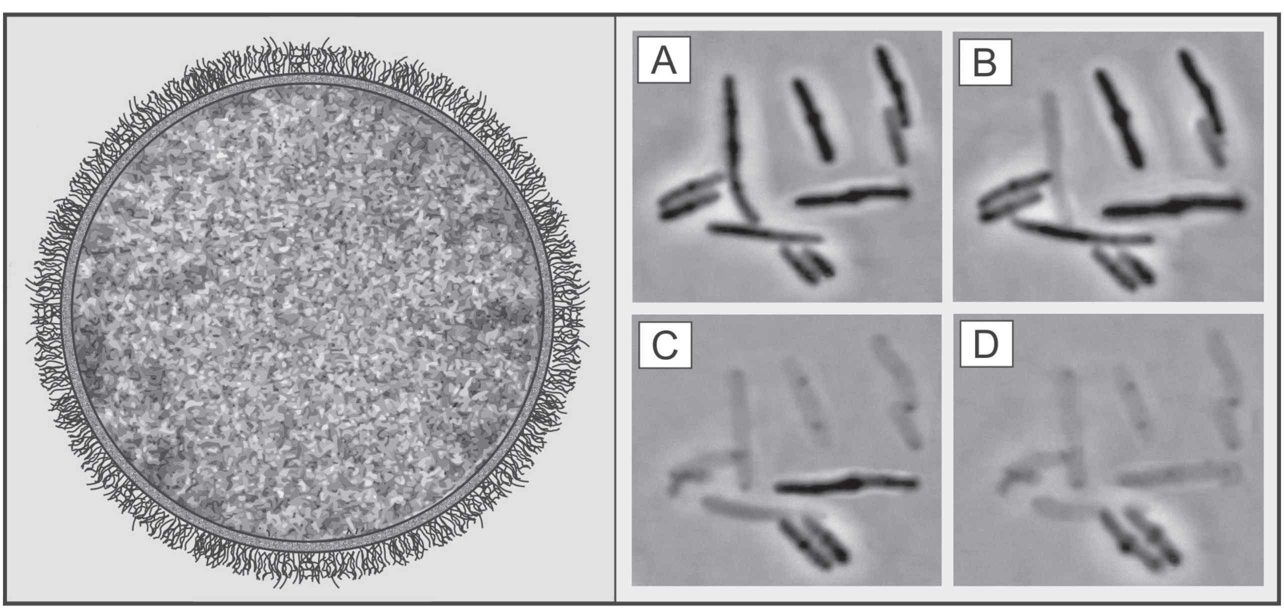

Figure 6. Schematic cross-section of a rod-shaped bacterium (left panel) showing its reinforced cell wall.[39] Right panel, composite time sequence of extracts from a video of rod-shaped bacteria treated with penicillin.[40] They grow length-wise and divide in the middle, but penicillin weakens the newly constructed dividing wall and it bulges out under osmotic pressure (A). In the blink of an eye the weak points explode, expelling the cell contents, leaving only the ruptured walls behind (grey shapes in B, C and D). The heat storm disperses the whole cell contents instantaneously because these cells are about a hundred times smaller than those in figure 5 and bacteria have no internal membranes or cytoskeleton to inhibit the dispersion.

shared equally in all directions. At the surface, however, a water molecule has no other water molecules above it. The free polarity charge at the surface causes it to bind more strongly than usual to its surface neighbours than to those within the liquid, and this produces a skin-like layer of ‘surface tension’. Insects such as the water strider can walk on this surface layer without falling through.

Surface tension adds to the meniscus effect in such a way that it raises up the free water surface in narrow vessels to produce ‘capillary action’ (figure 7B). In extremely narrow tubes capillary action can raise the water surface up to spectacular heights (figure 7C). Plants use this effect to help them get water from the soil up to the tops of very tall trees.

Because the spaces inside a cell at the molecular scale are so tiny, capillary action has enormous power. A vertical tube 3 nanometres internal diameter (the width of a DNA molecule) could theoretically lift water more than 9 km—higher than Mt Everest—against the force of gravity.[42] This enormous capillary force is at work in the ruptured cells, sucking water onto every internal surface and into every space. And it happens at colossal speed—the tiny distances inside cells would be crossed in just picoseconds (million millionths of a second). If we add up the ever-present power of osmotic pressure, the lightning speed of water molecules, the huge sucking force of capillary action, and the ability of water molecules to collaborate and move objects a trillion times larger than themselves, then we can perhaps understand why these cell explosions occur. Once the wall is breached the cell contents are forcefully disgorged because they instantaneously swell up in the presence of the excess water and the cell walls can no longer contain them!

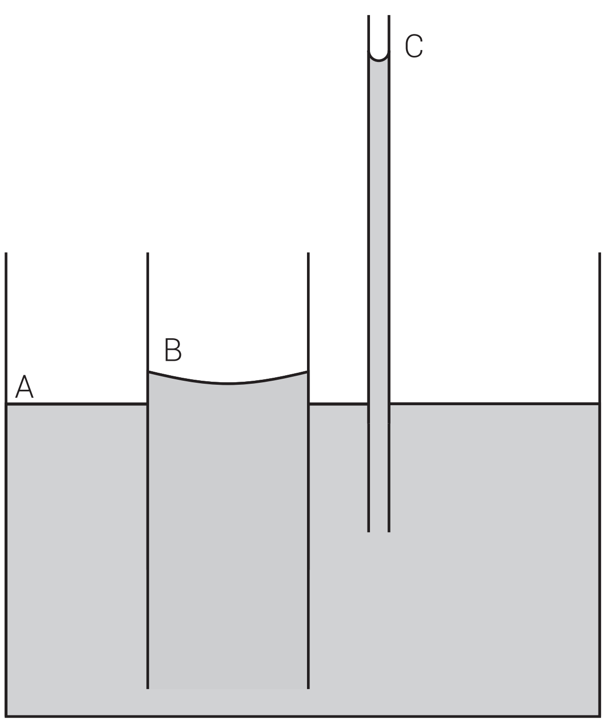

Figure 7. Capillary action. Water’s molecular polarity produces a small ‘meniscus’ when it touches the edge of a large vessel (A). In a narrower vessel (B) surface tension adds extra lift. In a very narrow tube (C) the combined ‘capillary effect’ can produce much larger lift.

Answering the question

Life is that which ‘does things’ to sustain itself indefinitely, and this ‘biological equilibrium’ has to be very far away indeed from Schrödinger’s physical equilibrium. Textbooks describe the methods that cells use, but to demonstrate what life is *not*, we need only look at two things: the molecular heat storm, and the cell wall.

All naturalistic theories of the origin of life must at some stage propose the development of a cell wall. There is only one way to make a cell wall—from a lipid bilayer vesicle in water—the ‘porous bag’ model.[43] The primordial cell wall has to be porous enough to accept continuing help from special conditions in the environment that bring the whole cell to the point of sustainable functionality, and to periodically obtain food and eject waste. There is no way to sidestep this stage—similar principles have to be followed in manufacturing artificial cells.[44]

All naturalistic scenarios require this ‘porous bag’ stage to hold the proto-cell contents, and this is the very thing that destroys them! The white blood cell example demonstrates that even a state-of-the-art ‘porous bag’—a ‘modern’ cytoplasmic cell membrane—is no match for the power of ordinary water. The penicillin example demonstrates that *sophisticated reinforcing* is required for cell walls that are exposed to the natural environment. A cell wall must be strong, selectively permeable, and sensitive to outside conditions so the cell can adapt to its environment. And all this (together with Hoffman’s ‘highly sophisticated’ cell machinery) must be assembled in less time than it takes water molecules to cross the space inside a prokaryote cell—a minuscule fraction of a second. Millions of years are of no use in helping this process along because they just make the problem at least a hundred quadrillion times harder!

Conclusion

The simplest known biological entity that can perpetuate itself indefinitely is an autotrophic prokaryote cell. Naturalism requires primordial cells to form in water because all functioning cells require more water than all other ingredients combined. Even if cells could arise naturalistically without water, they would require introduction to abundant water at some stage to explain life on Earth.[45] The physical properties of water require all the machinery of life to be encased within a strongly constructed cell wall with all necessary properties and *no weak spots*, on a picosecond timescale. Water thus sets a threshold for cellular origin that excludes all scenarios other than Genesis-style fiat creation!

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