Pathological Science & General Electric: Threatening the paradigm

From the original article in 2012. Author: Ray Peat.

Everything in biology depends on the internal order of cells, and on the interactions of each cell with its surroundings. All of these orderly interactions involve contacts between biological molecules and water. The forces regulating interactions on that scale must be understood before life can be understood, but the nature of the forces at these interfaces has been controversial for 100 years.

In 1953, physicist Irving Langmuir gave a talk at the General Electric laboratory about what he called "pathological science." That talk is still resonating in the scientific culture, and it is used to reinforce attitudes similar to those held by Langmuir, i.e., the dominant scientific paradigm of the 20th century, and to justify certain institutions that regulate innovation.

For Langmuir, there was a clearly defined "scientific method," and he said some people were led away from the proper method by wishful thinking to interpret ambiguous results as confirmations of their hypothesis. He listed 6 symptoms of pathological science: 1) An effect produced by a barely detectable cause, and 2) the effect is barely detectable, or many measurements are needed because of the very low statistical significance of the results, 3) claims of great accuracy, 4) they involve fantastic theories contrary to experience, 5) criticisms are met by *ad hoc* excuses, and 6) the ratio of supporters to critics approaches 50%, then fades toward zero. He failed to mention these features in any research that supported his view of things, and called an idea pathological when people continued to work on it despite disapproval by the recognized experts. He didn't mention the Nobel prizes that were given for the worm theory of cancer or for treating psychological problems with lobotomies, and he didn't mention that there were organized campaigns against the publication of disapproved ideas.

The dominant view in biology, which is analogous to Langmuir's view in physics, is that all decisive cellular processes involve the direct mechanical contact of one molecule with another, the activation of a lock (an enzyme or receptor) by a key that has the right shape, or the adhesion of a molecule to another substance according to its chemical composition. An alternative view, now clearly supported by the evidence, is that there are forces that aren't merely between molecular surfaces, but rather that the local conditions at the surfaces of proteins and other molecules, and the properties of the solvent water, are modified by the surrounding conditions. It is this alternative view that is now making progress in understanding disease and health, regeneration and degeneration. But to judge the new work, it's important to know the nature of the opposition.

Thomas Edison, who was adept at publicizing himself as the inventor of ideas he had bought or stolen, founded General Electric. Attempting to eliminate Nikola Tesla's system of alternating current, since Edison was invested in direct current systems, Edison's GE tried to convince the public that direct current was safer, by using alternating current to electrocute an elephant, and by promoting its use in the electric chair. GE eventually gave up the direct current technology for electrifying cities, and they refined the electric light bulb and were fairly successful in controlling, practically monopolizing, that market, and in shortening the life of incandescent bulbs. Carbon filament bulbs made around 1900 often lasted decades; I had one that kept working until it was broken during a move in 1960. Light bulbs made in England 65 years ago, and in the Soviet Union, and bulbs currently made in China, had a life expectancy five times as long as the bulbs made in the US since GE learned how to carefully control the rate at which the tungsten filament deteriorates.

Irving Langmuir was their leading light bulb scientist. In his 1932 Nobel lecture, he tediously argued that molecules of gas can form only one layer on a surface such as a filament. About 17 years earlier, Michael Polanyi had demonstrated that molecules can be adsorbed in multilayers, but his evidence was dismissed because, according to the understanding of industrial experts such as Langmuir, and the leading scientific authorities, Einstein, Nernst, and Haber, it was impossible. They were committed to an explanatory system that didn't allow events such as those Polanyi described.

Although Polanyi knew that his adsorption isotherm was more realistic than Langmuir's (he had demonstrated many cases that Langmuir's didn't describe correctly), and also easier to understand, he taught Langmuir's isotherm to his students, because he knew that they would be required to know it to pass their examinations. He knew he had risked his career by his earlier exposition of his ideas, and he was unwilling to endanger his students' careers by involving them in the controversy.

From 1920 to 1926, before the advent in 1927 of "quantum physics" (with its still-argued features of delocalized electrons, molecular orbitals, resonance, non-locality, incommensurability, indeterminism), Polanyi had turned his attention from the physics of adsorption to chemical structure, and his group was the first to show that cellulose was made up of long molecules, polymers, rather than of just associated clusters. That idea didn't catch on, so he turned to the behavior of crystals and metals. He found that crystals were much weaker than they should be, according to the strength of the bonds between their atoms, and showed that this was because of defects, and that during repeated stresses, they became weaker, as energy migrated through relatively long distances in the substance, to concentrate the defects. The idea of lattice defects was acceptable at that time, but long-range mobility of bond energy was no more acceptable then than it had been when J.C. Bose described metal fatigue, decades earlier.

Polanyi also showed that the strength and rigidity of a crystal were altered when the crystal was immersed in water. Again, such an influence of a surface on the over-all physical properties of a solid substance had no noticeable effect on the scientific culture, although his results were published in the major journals. To adjust one's interpretive system at that time to rationalize Polanyi's results would have required discarding the basic assumptions that were behind Einstein's explanation of the photoelectric effect, and maybe even his theory of Brownian motion. However, by 2011, fewer people have invested their personal development in those ideas of short-range electrical binding forces that prevailed early in the 20th century, and now, for example, the evidence of "delocalized holes in DNA" can be discussed more openly. Eventually, science textbooks may be rewritten to show a steady progression of understanding from Bose, though Polanyi, Perutz, Szent-Gyorgyi, Ling, and Damadian (inventor of the MRI, holder of the patents infringed by GE, non-winner of the Nobel prize).

In 1933 J.D. Bernal had proposed a structural model of water that contained a considerable amount of order (Bernal and Fowler, 1933) but by the 1950s the idea of spontaneous ordering in water was out of style, and he worked out a more random structure. Max Perutz, continuing the study of hemoglobin he had begun with Bernal, became concerned with long range forces acting through water: "The nature of the forces which keep particles parallel and equidistant across such great thicknesses of water is not yet clear." Normal wet crystals of methemoglobin contain regular layers of water 15 Angstroms thick. He suggested that a laminated structure of the water could plausibly explain his measurements. Comparing the protein crystal to montmorillonite particles, which incorporate several layers of water, each 3 Angstroms thick, each layer of water in the protein crystal would be 4 Angstroms thick, since swelling proceeds in discrete steps of that thickness. 52.4% of the volume of Perutz's normal, stable, wet protein crystals consisted of liquid. Part of the water is a fixed monolayer, but the rest is apparently in the form of mobile, interactive, multilayers. By 1952, Perutz had decided that long range forces weren't involved in hemoglobin crystallization, but he didn't comment on the long range ordering of clays, tobacco mosaic viruses, and other particles and gels. In 2005, an interlaminar distance of 17.9 Angstroms, or six layers of water, still seems to be stable in hydrated montmorillonite (Odriozola & Aguilar, 2005). Clay continues to be studied in relation to nuclear waste disposal, so the effects of surfaces on water's properties haven't been entirely excluded from science. The interfacial water in clay has special catalytic properties that make it interesting to many researchers (Anderson, 1970)

Bernal's and Perutz' conformity in the 1950s rejection of long range forces and an ordered structure of water represented the dominant ideas in physics and physical chemistry, but many people (with very little financial or institutional support) were continuing to study the structure of water, both in the bulk phase and near surfaces, as in cells. Philippa Wiggins, Albert Szent-Gyorgyi, Carlton Hazlewood, Freeman Cope, and Ray Damadian were among the most active proponents of the importance of structured water in living cells. Walter Drost-Hansen showed that water near surfaces (vicinal water) is several percent less dense, and has a greater heat capacity, than bulk water, and that bulk water undergoes transitions at certain temperatures that alter its effects on enzyme reactions.

The question regarding the nature of the forces at surfaces or interfaces affects how we think about everything, from life to nuclear energy. The political and economic implications of "non-local energy" (which is most obvious at surfaces) have at times led to organized campaigns to discourage research in those areas. When Alexandre Rothen found (beginning in 1946) that enzymes and antibodies had non-local effects, several prestigious publications claimed to show how he must have been mistaken**:** The films he used must have been porous, despite his demonstrations of their continuity.

The methods he developed at Rockefeller Institute quickly became standard for accurately measuring very thin films. In the early 1970s, a GE employee, Ivar Giaever, visited Rothen's lab to learn his methods. Shortly after his visit, he demonstrated his "new method" to the press. I saw an article about it in Science News, and wrote them a short letter, pointing out that the method had been developed and used by Rothen much earlier**;** they printed my note, which could be seen as a criticism of the author of the news article. About a week later, I got a letter from Rothen, thanking me for writing to the magazine; he said they had refused to publish his own letter explaining the situation, including his interactions with Giaever during the visit. I assume that the magazine felt some kind of pressure to protect Giaever and GE from an authoritative accusation of scientific dishonesty.

In 1968 when I began studying biology at the University of Oregon, the professor of microscopy, Andrew Bajer, posted a display of dozens of micrographs, with explanatory captions, along the halls near the entrance of one of the science buildings. The one that interested me most showed orderly rows of regularly formed objects on a smooth surface. The caption described it as clusters of sodium atoms, deposited from vapor, on a film of a polymer (formvar, I think), under which was a quartz crystal. The caption noted that the sodium atoms had condensed in a pattern representing the crystal structure of the underlying quartz. Although Rothen's work involved proteins deposited from solution, rather than sodium atoms deposited from vapor, Bajer's image illustrated visually the projection of the forces of crystal structure through an amorphous film. This seemed to be a graphic representation of Polanyi's adsorption potential, a force acting on atoms in the space near a surface, as opposed to Langmuir's local atomic force that didn't reach beyond the first layer of atoms. The long range order in this case arranged atoms geometrically, while Rothen's preparations showed a "projected" specificity, but of a more complex sort.

Just a few months later, someone who knew of Stephen Carter's demonstration that fibroblasts will migrate on a glass slide coated with a gold film, toward areas of greater thickness of the metal, did a similar experiment, but with a formvar film between the gold and the cells. The cells still migrated up the gradient, toward the area of thicker gold under the film. The reaction to that publication was the same as the reaction to Rothen's work 20 years before, the formvar films contained holes, and the cells were reaching through the film to touch the metal surface, sort of like kids peeking around a blindfold when they aren't supposed to be watching. I didn't understand how the holes would explain anything, even if there were holes and if the cells had put out many long filopodia to reach through the film, but in fact making a formvar film is a very standardized technique. They can be made "holey," or like a very open net, or they can be made solid, just by choosing the concentration of the polymer used. The difference is very clear, under an electron microscope, but the professors needed an excuse for dismissing something they didn't want to understand. Further work was discouraged by their ridicule.

In Russia, GE had very little influence on the acceptability of ideas in science, and Boris Deryagin continued (from the 1930s until 1990) to study the properties of water near surfaces. In 1987 his group demonstrated that cells can clear particles from a space around themselves, extending more than a cell's diameter away. This distance is similar to the cell free zone in flowing blood adjacent to the walls of arterioles, which is probably the result of multiple interacting forces. At present, processes such as cell adhesion of leukocytes and stem cells (and tumor cells) to the blood vessel wall and movement through the blood vessel into the tissues (diapedesis) is explained in terms of adhesion molecules, disregarding the plausible effects of long range attractive or repulsive forces. Clumping or sludging of red blood cells occurs when the organism is failing to adapt to stress, and could be reasonably explained by a failure of protective repulsive fields. These fields are developed and maintained by metabolism, primarily oxidative energy metabolism, and are modified by endogenous regulatory substances and external conditions, including electromagnetic and electrical fields.

100 years ago, Albert Einstein was a major influence in popularizing the "only local" dogma of atomic interactions. (His work

led directly to "quantum physics," but he never accepted its irrational implications.[1] I don't think he ever considered that the assumptions in his [atomic-quantized] theory of the photoelectric effect were the problem.) One charged atom is completely neutralized by its association with an oppositely charged atom, and the force is described by the inverse square law, that the force decreases with the square of the distance between point charges, meaning that the force is very strong at very small distances. However, a physical***surface***, a plane where one substance ends and another begins, follows different rules.

Different substances have different electron affinities, creating a phase boundary potential, a charged layer at the interface. (Electrical double layers at interfaces are important in semiconductors and electrodes, but biologists have carefully avoided discussing them, except in the very narrow context of electrodes.) The electrically active surface of a substance, even though it's made of atoms and electrons, projects its electrical field in proportion to its area. This principle is as old as Coulomb's law, but the habit of thinking of electrical charge on the atomic scale seems to make people forget it. It's exactly the sort of space-filling field that Polanyi's adsorption isotherm describes. It's also involved in crystal strength and elasticity as studied by Polanyi, in piezoelectricity, and in generation of semiconduction in amorphous materials, as used in Stan Ovshinsky's processes.

Long range structural and electronic interactions produce "antenna" effects, which are sensitive to very weak fields, whether they originate inside or outside of the organism. Magnetobiology is often treated as a pseudo-science or pathological science, because "real science" considers heating and chemical bond reactions to be the only possible effects of low energy fields or radiation. Solco Tromp, beginning in the 1930s, showed that cells behave like liquid crystals, and that liquid crystals can respond to very low electrical and magnetic fields.

If the adsorption potential structures the water in its region of space, this interfacial water is now a new *phase*, with different physical properties, including new catalytic properties, such as those recognized by the clay investigators (which increased its ability to dissolve the clay minerals).

Several versions of Langmuir's Pathological Science talk have been published, some of them adding new examples, including "polywater." Langmuir died in 1957, and the first example of polywater was observed by N.N. Fedyakin was observed in 1961. When finely drawn quartz or Pyrex glass capillary tubes (with inside diameter of up to a tenth of a millimeter) are suspended in a container with the air pressure reduced, above a container of distilled water, so that they are exposed to pure water vapor at room temperature, after a period of an hour or more (sometimes days or weeks were required) a small drop of liquid condenses inside some (a small percentage) of the capillary tubes. Above some of the original drops, a second drop sometimes appeared, that would enlarge as the first drop shrank. This separation of water into two fractions was itself anomalous, and the upper drop was found to be denser than normal water. Many people began studying its properties. Fedyakin found that its thermal expansion was greater, and its vapor pressure lower, than ordinary water. Others found that it had a higher refractive index, viscosity, and surface tension, as well as greater density, than ordinary water. Birefringence (the splitting of a beam of light into two rays when it passes through an ordered material) was observed in the anomalous water, and this usually indicates the presence of a polymer (Fedyakin, et al., 1965; Willis et al., 1969; Lippincott, et al., 1969) or crystallinity. The water associated with clay is also birefringent (Derjaguin and Greene-Kelly, 1964), and its properties are different when the clay absorbs it from the vapor phase or from liquid water.

Hysteresis is a lag in the behavior of a system, resulting when the internal state of the system is altered by an action, so that it responds differently to a repetition of that action; it's the memory of a system that exists only when the system has internal structure. For example, a gas has relatively little hysteresis. Perfect elasticity is one extreme of an ordered solid, but most solids have some hysteresis, in which the deformed material fails to spring back immediately. Hysteresis of adsorption can be seen at the edges of a drop of water on a tilted surface, with a steeper contact angle on the newer contact at the lower edge, showing a reluctance of the water to wet a new surface, a lower contact angle where the drop is pulling away from the upper surface, a reluctance to break the contact. The same is seen at the edges of an evaporating-shrinking drop, or a growing drop. Everyone perceives this memory function of water.

Boris Deryagin studied both the elasticity and the hysteresis of water near surfaces, and both approaches showed that it contained internal structure. Many dogmatic professors denied that water could show elasticity or "memory," because of their interpretive system/mental rigidity.

When Fedyakin got the help of Deryagin's lab in analyzing the anomalous material, many different methods of purifying the glass and the water and the vessel were tried, and its properties were analyzed in many different ways. When Deryagin first described the material at a conference in Europe, there was great interest, and eventually hundreds of people began investigating it.

A British laboratory was the first to get a sample of Deryagin's material in 1966, and their tests confirmed Deryagin's.

The US Bureau of Standards, having the best analytical instruments in the world (including a microscope spectrometer), studied it carefully. They (Lippincott, Stromberg, Grant, & Cessac, 1969) found that its bonds were stronger than those in ordinary water, and they compared its absorption spectrum (by computer) with those of 100,000 known substances, and found that it corresponded with nothing previously known. It didn't have the absorption band of normal water. When it evaporated, it left no visible residue, and it turned into ordinary water when heated. They concluded that the physical structure that would best fit its absorption spectrum was a polymerized form of water, so they called it "polywater." Later, Lippincott and others (Page, et al., 1970; Petsko, 1970) did proton magnetic resonance analyses that showed a difference of polywater from normal water in the hydrogen bonding, a "deshielding" of the protons, meaning that the electrons were arranged differently in the molecules.

In 1969 there were many threats to the dominant paradigm, and many people were demanding a change in the government's funding priorities. The public excitement about polywater following the many confirmations of its existence was disturbing to the defenders of the paradigm. Philip Abelson, the chief editor of Science magazine, used the magazine to further his political beliefs.

Denis Rousseau, a young researcher at Bell Labs (who now writes about pathological science), published a series of articles in Science describing his tests of polywater. He played tennis until his tee-shirt was soaked with sweat, then extracted and concentrated the sweat into a small gummy pellet. He reported that the infrared spectrum of the sweat concentrate (largely sodium lactate) was very similar to that of polywater. One of the techniques he used to identify impurities (electron spectroscopy) requires a high vacuum, so there couldn't be any normal water present. The water associated with ionic impurities is driven off at low temperatures compared to the temperature needed to decompose the anomalous water.

Although Rousseau's "explanation" was ludicrous, it was just the thing the professors needed to prevent further challenges to their paradigm. Although Deryagin published more evidence of the purity of the anomalous water in 1972, by 1973 the mass media, including Science magazine, were saying that polywater didn't exist, and that Deryagin had admitted that he was mistaken. But polywater was Lippincott's term, and what Deryagin said was that silica was the only impurity that could be identified in the anomalous material.

There are many antecedents to anomalous water in the literature. In the 1920s, W.A. Patrick of Johns Hopkins and J. L. Shereshefsky at Howard university investigated the properties of water in fine capillary tubes and found that the vapor pressure wasn't the same as that of normal water. (This is what would have been expected, if Polanyi's adsorption isotherm had been accepted.) The density of water in clay has been found to be slightly less than normal. This water bound to clay requires a high temperature to eliminate, similar to the decomposition temperature of polywater. The catalytic properties of interfacial water in clay are recognized, causing it to solublize components of the clay. So it's hard to imagine that there wouldn't be some silica in the material formed in quartz or glass capillary tubes.

The only thing pathological about the polywater episode was the extreme effort that was made to stigmatize a whole category of research, to restore faith in the old doctrine that insisted there are no long range ordering processes anywhere in the universe. The successful campaign against polywater strengthened the mainstream denial of the evidence of ordering in interfacial and intracellular water, kept the doctrine of the lipid bilayer cell membrane alive, and up until the present has prevented the proper use of MRI scans in medical diagnosis.

In 1946, while the government was studying the way nuclear fallout was influenced by the weather, a group at GE, led by Langmuir, began experimenting with weather control by means of "cloud seeding." Langmuir observed that the energy in a cloud system was greater than that in an atomic bomb, and that by seeding clouds in Europe, disastrous weather effects could be created in the Soviet Union. The GE group convinced the Pentagon to become involved in weather control. (The physicist Ross Gunn was transferred directly from work on the atomic bomb to direct the cloud seeding project.) In one of Langmuir's seeding experiments, he claimed that he had changed the direction of a hurricane moving toward the U.S. When a young researcher pointed out that the weather service had predicted exactly that change of direction, based on the temperatures of ocean currents, Langmuir became angry, and told the man that he wasn't going to explain it to him, because he was too stupid to understand.

Langmuir's attitude toward science was exactly what GE wanted; his career and reputation were part of the corporation's public relations and business plan. Science was whatever GE thought was good for their business. That science was pathological, sometimes by Langmuir's own defining features, most of the time by the effects it has had on society. The Manhattan Project was central to GE's business plan, and when the bomb project was completed GE and the Atomic Energy Commission found that the same subsidies could be used to develop nuclear generators of electricity. Following Edison's pioneering work with x-rays, x-ray imaging machines had become very profitable for GE. It was important to assure the public that medical, industrial, and military radiation was well understood, well controlled, safe, and essential for the general welfare. In their view, if every woman could have access to GE's x-ray mammograms, for example, almost all breast cancers could be cured. The radiation exposure from living near a GE nuclear power generator is infinitesimal compared to living in Denver or flying in an airplane. (There is some discussion of these issues in my January, 2011 newsletter, "Radiation and growth.") Public relations involves everything from "basic research" to television advertising.

If nuclear energy is as safe as the industry and governments say it is, the reactors should be located in the centers of large cities, because transmitting electric power long distances is presently wasting 50% of the power (Hirose Takashi, The Nuclear Disaster that could destroy Japan...and the world, 2011). Admiral Rickover, influential advocate of nuclear power, said "...every time you produce radiation, [a] horrible force [is unleashed,] and I think there the human race is going to wreck itself. [We must] outlaw nuclear reactors" (January, 1982 congressional testimony) Helen Caldicott says Fukushima is many times worse than Chernobyl. The radioactive cesium in German mushrooms and truffles hasn't decreased 25 years after Chernobyl, and the German government is spending increasing amounts to compensate hunters for the wild boars (who eat truffles) that must be disposed of as radioactive waste.**[2]**

General Electric sent its condolences to the people of Japan, and said the reactors of that design had functioned well for 40 years; they didn't mention that Unit I at Fukushima had been scheduled to be shut down on March 26, 2011, the end of its 40 year life expectancy. In late March, as the accident continued, Tepco applied for a permit to build two new reactors at the Fukushima site. In the US, the government continues its loan guarantee policy to subsidize new reactor construction.

After many years of working with his metalized slides, Alexandre Rothen found that their activity, the strength of their long-range influence, varied with a 24 hour cycle, and that their activity could also be destroyed or restored by putting them in a magnetic field, parallel or perpendicular to the surface. Around the same time, a Russian biochemist, Simon Shnoll, noticed that there were cyclic changes in well defined enzymic reactions. Like Rothen, Shnoll did experiments that showed that the earth's motion (relative to the stars) affected measurements in the laboratory, even measurements of alpha particles produced by nuclear fission. Organized matter, whether it's cellular or in the crystalline solid state, is susceptible to surrounding conditions.

In 1971 or '72 I learned of H.C. Dudley's idea of a "neutrino sea," that he suggested might be equivalent to the "luminiferous ether" that had previously been used to explain light and electromagnetism. I wrote to him, asking if he thought neutrinos could be involved in biological ordering processes by resonating with matter under some circumstances. He had been developing a theory, in which atomic nuclei might interact with a neutrino "ether," in ways that could affect the decay rate of the unstable isotopes, and so it didn't seem unreasonable to him that biological structures might also interact with neutrinos. In October, 1972, he published a purely theoretical article in which he explained that nuclear reactors might under some conditions become dangerously unstable. I had earlier seen a newspaper article about an experiment by a physicist, J.L. Anderson, in which radioactive carbon-14 didn't follow the normal rules of random decay, when the isotope was incorporated into an oil, which was spread in a monolayer on a metal surface. By chance, Anderson's experimental article was published simultaneously with Dudley's theoretical article, though neither one knew of the other's work.

Nearly all physicists said his results weren't possible, because the small forces involved in adsorbing an oil to a metal surface were infinitesimal compared to the force needed to cause nuclear reactions. Over the next few years, Dudley and others did some experiments that appeared to confirm Anderson's results, showing that the rate of nuclear reactions can be modified by mild changes in the physical state of the unstable elements.

Anderson's and Dudley's work didn't get much attention from the public, so there was no need for the defenders of the dominant paradigm to attack it. There was no financial support for continuing their research.

Behind the industries' assurances that "low level" radiation is safe, whether it's ionizing radiation, microwave or broadcast frequency electromagnetic radiation, is their reductionist approach to physics, chemistry, and biology. Those doctrines no longer have the prestige that they once did, but their pathological, authoritarian "science" culture is being sustained by the influence of corporations on mass culture.

With the institutions of research and education controlled by pharmaceutical, military and industrial interests for their own benefit, fundamental progress in knowledge is a threat to the system.

Notes

1. From Einstein's 1926 letter to Max Born: "Quantum mechanics is very worthy of regard. But an inner voice tells me that this is not yet the right track. The theory yields much, but it hardly brings us closer to the Old One's secrets. I, in any case, am convinced the He does not play dice." Quoted in P. Busch and G. Jaeger, "Unsharp quantum reality," 4 May 2010.

2. None of the major institutions in the US are providing basic information about protection from Fukushima's radioactive fallout. Eating foods produced before the arrival of the radioactive rain, feeding old foods to chickens and milk animals, and keeping your metabolic rate high, are the main defenses. Eventually, fertilizing crops with mined minerals, and enriching the atmosphere with carbon from coal will dilute the radioactive isotopes from the nuclear accidents.

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