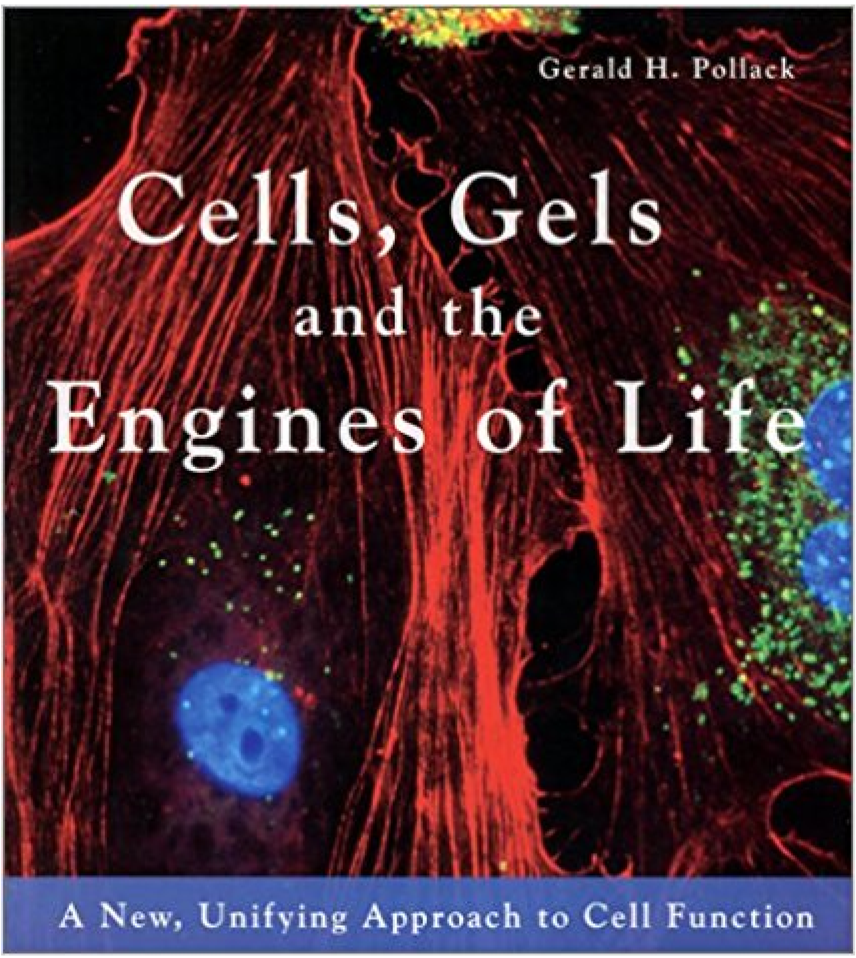
Cells, Gels And The Engines Of Life



Synopsis

An award-winning book that challenges the current wisdom of how cells work in a visionary, provocative, and accessible way...reads like a detective story. This highly praised book emphasises the role of cell water and the gel-like nature of the cell, building on these features to explore the mechanisms of communication, transport, contraction, division, and other essential cell functions. Lucidly written for the non-expert, the book is profound enough for biologists, chemists, physicists and engineers to devour.

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Customer Reviews

"Full of deep physical insights into biological structure / function relationships. I found it refreshingly iconoclastic, sensible, and believable." -- Peter Basser, Chief, Tissue Biophysics and Biomimetics, National Institutes of Health

Dr. Gerald Pollack is a world leader in the area of muscle contraction and cell motility. He is currently Professor of Bioengineering at the University of Washington. His previous book, "Muscles and Molecules: Uncovering the Principles of Biological Motion" was recipient of an "Excellence Award" from the Society for Technical Communiction.

An absolutely seminal work in cell biology. An instant classic. Highly recommended.

Excellent

Aother gem from one of the great minds of our time.

This is a very casual book dealing with a very serious and important issue. Control of water state is behind everything the nervous system does, and that is my favorite subject on which to speculate.

This is an exciting book revisiting old models of cells and proposing new ways of looking at structure, permeability, water, etc. I'm not a chemistry whiz, so it took me a while to really think it through, but his explanations are clear, graphic and simple. It was well worth the time !

much of it seems for specialists, but still a great learning experience

The most engaging science books tackle the narratives that scientists believe and on which they base study designs and interpretations. This book provides a detailed case study of how such scientific stories and simple mental images operate to guide entire fields over decades - and not always along the best available paths. This book questions a whole list of "textbook" fundamentals and offers an alternative, integrated framework for explaining a wide range of cell functions. Once a misguided view has been established in any field, it can take a rare blend of courage, expertise, and clarity to budge things in a new direction.Anyone with a firm reading ability can delve into this book and might be surprised, given the school-inflicted association of basic science instruction with soporific textbooks, to be sucked in on the first page. This is much more than a book about how cells work; it is a master class in fresh and precise scientific thinking, an art much in need of renaissance in an age of truth by click-through count, research-grant total, and mere widespread assertion.Pollack starts by peeling back layers of decaying assumptions about the functionality of the living cell, showing how each narrative twist was constructed to salvage some older assumption that was in danger of withering before new evidence. A cell "wall" was originally imagined long ago as being needed to keep the cytoplasmic "aqueous solution" within the cell; otherwise, the cytoplasm would surely dissipate into its surroundings.Eventually, though, a long series of problems with that story began to emerge. But instead of killing the story, each new problem elicited a patch to salvage the old model. First, certain ions had to move into and out of the cell. So to get ions moving in, some "channels" through this "wall" had to be postulated. Then, to get them moving out again, we needed some "conveyers."Researchers gradually discovered more and more substances of myriad shapes and sizes moving into and out of cells in an epic dance. Many of these substances were also staying either inside or outside in precise ratios. The "channels" and "conveyers" that would be needed to make all of this happen started to multiply beyond the wildest nightmares of a factory-automation engineer. Moreover, the energy that would be required to keep all of these imagined mechanisms running seemed to far exceed the available supply.Pollack likens this situation to the crisis of the old geocentric model of the solar system, the one that tried to explain the impossible, winding orbits of planets around the Earth. As it turned out, of course, those orbits appeared so wildly intricate because they weren’t orbits around the Earth at all. Likewise, according to Pollack, the mind-boggling complexity of conventional cellular channels and conveyers has become the crisis of the old story of how cells work. He makes a detailed case that this old picture is misdirected at virtually every step and should be updated by looking with fresh eyes at newly available research while revisiting some older views that were trampled under and mostly lost in the march of scientific "progress."A major source of challenge for the old story, with its central role for the cell wall, is a broad pattern of experimental results in which cell membranes are destroyed or removed and ... nothing much happens (at least not for hours or days). This makes it clear that something else is also at work, but what?Pollack outlines a new model that begins with the fundamentals of how proteins, water, and ions interact at a chemical level. By this time, he has posed some other puzzling questions about cells. Among them, why do they only freeze at temperatures much colder than expected based on their chemical composition alone?It turns out that the cytoplasm is no "aqueous solution" at all, Pollack argues. However, the idea that it is, first made well over a century ago, set the entire field down a misleading path. Instead, cytoplasm is a gel, and one of the long-missing pieces of the cytoplasmic-gel puzzle is structured water (watch his University of Washington Annual Faculty Lecture on structured water). Pollack argues that much of the water within cells is not mere "bulk water" (random molecules in liquid state). Rather, water can structure itself into an ordered grid that builds on charge patterns on protein surfaces. Cytoplasm is infused with a fine interior latticework, the surface area of which amounts to 100 times the surface area of the cell membrane. Structured water lines up along these internal lattice surfaces. This is far from the conventional view of an intracellular solution in perilous need of being held in by a retaining wall.Pollack identifies structured water as a fourth state of matter between normal liquid water and solid ice. Structured water helps explain the odd resistance of cells to freezing. Water molecules are dipolar and can arrange themselves in grids with varying degrees of depth. These structured grids can also rapidly "destructure" as soon as conditions supporting structuring collapse. Triggering sudden destructuring events turns out, according to Pollack, to be one of the key mechanisms through which cells get their work done.Dispensing -- for the moment -- with "channels," "pumps," and "conveyors" of any kind, Pollack is able to show how sodium exclusion, potassium inclusion, and the negative electrical state of cells can all be explained "directly out of the physical chemistry of these ions in relation to the cell's water and proteins." Moreover, unlike previous convoluted explanations, "the system is in equilibrium. No energy is required for its maintenance. No special widgets are needed to keep potassium inside the cell or sodium outside the cell -- all of this follows directly from the cytoplasm's basic physical chemical features" (97). He observes that, "the paradigm offered here is... worlds apart from current views which place most of the action in the membrane instead of in the cytoplasm" (109).Pollack finds the locus of most cell activity and function in the general phase-transition properties of gels. He cites the practical use of phase-transitioning gels in engineering and presents evidence of similar mechanisms at work in the major functions of cells. In phase transitions, "triggering is `razor-edge.' Nothing happens until a threshold is crossed, whereupon contractile action [in muscle cells in this case] is massive" (233).He returns to engineering to note analogs of cellular phase transitions in modern technological innovations that go well beyond conveyors. He explains cellular transport along actin chains as using a "moving melt window," noting that the same principle is used in "zone refining" crystals, which enabled the creation of the first germanium transistors (174-75).After chapters with details on cellular phase-transitions, comic relief arrives when a subway map from the "Cellular Transit Authority" introduces the chapter on transport mechanisms: "We realize you have a choice of fundamental biological hypotheses; we'd like to thank you very much for riding with us." The book then examines how cells move materials from place to place using phase transitions.Pollack next discusses more specific transport mechanisms that at first might seem to harken back to the old "conveyers." By now, however, he has deeply reconceived such mechanisms in a new context -- they use the same phase-transitions described in the general case of the cytoplasm, just in more specific ways. Thus, a "propagating phase transition" passes along actin bundles and microtubules, which are selective about which materials they transport -- and in which direction. As for other transport tasks, even moving whole cells around using cilia and flagella, "the presence of extracellular transport tasks need not imply fresh principles, for the relevant machines are built of the standard parts" (197).After discussing cell division, Pollack hypothesizes that the degree of water structuring within cells may be a key mechanism in cancer. Water disorder promotes cell division. Mutant proteins in cancerous cells are more likely than normal proteins to promote water destructuring. This destructured-water environment may well play a role in stimulating the excessive cell division seen in cancer cells. Therapies directly targeting mutant proteins have already shown efficacy as cancer treatments (221-22).An important recurring theme in the book is that a field can regress. A misleading paradigm can invade and occupy a field and push out a more correct paradigm, taking the field backwards. Pollack reports in the chapter on muscle contraction that, "until the mid-1950s, muscle contraction was held to occur by a mechanism similar enough to the one that will be suggested here that it must be considered a progenitor. The dominant feature was protein folding" (226). But two studies then found evidence of a "filament-sliding" mechanism at work, and this came to replace the earlier protein-folding hypothesis. While the new evidence did not really negate the old model -- it should have enhanced it instead -- the protein-folding model faded before the popular new filament-sliding model.Pollack details the serious problems with the filament-sliding and accompanying "swinging cross-bridge" theory of muscle function and then picks up "where the pioneers of a half-century ago left off." This time, though, the once and future protein-folding model will "not only be required to fit this older evidence, but also the evidence of the intervening years that has come to be considered supportive of the current sliding paradigm" (229).Similarly, Pollack eventually combines key elements from both new and old visions in the case of cell membranes. By the end of the book, a complex cellular barrier zone that includes re-visioned structures that roughly correspond to the old pumps and channels return. However, due to the high explanatory power of gels and phase-transitions, the roles of barriers and channels "may be less specific and less central than generally envisioned" (276). By this point in the book, this comes across as a studied understatement relative to the weight of evidence that has been presented undermining simple conventional images of cell walls and channels.Another treat comes in the discussion of cellular energy production. The basic engine of cellular energy is likened to a process of setting up and knocking down rows of dominoes. The bulk of effort goes into creations of order, essentially setting up dominoes in a row. This order can then be released, creating a rush of work energy with the mere touch of a finger (phase-transition trigger). Cellular work energy derived from sudden controlled-chaos events are only made possible by previous build-ups of order. Energy is thus "stored as order" in cells, with structured water playing a key role in forming the order that is "destructured" in a sudden phase transition.The final chapter summarizes all that is different in the paradigm Pollack presents from conventional textbook views of cellular function. It concludes with additional applications and observations. He notes, for example, that the conventional understanding of how plants can draw water up to impressive heights (as much as 100 meters in the case of redwood trees) remains vague. Yet if the water within xylem tubes is structured and not merely in the form of bulk water, "if the water clings to the matrix, column weight is irrelevant: So long as there is enough adhesive force, a sufficiently long tube could deliver water to the moon"

(271).While quite readable, this is no New-Age-ish pop-science book. It is tightly research-based, yet remains as clear as it can be for the general reader relative to the depth of content. True principles visible in one place often have analogs elsewhere and Pollack is not afraid to note them, yet one can sense the care and precision with which he does so. He keeps his hypotheses tight and specific and asks his questions step by step, proposing possible answers based on a global research literature spanning decades.Pollack also does not skim over the nuts and bolts of the old paradigm in favor of the temptation of engaging with straw men. He encourages his audience to read standard textbooks on cellular function to get a sense of the conventional story on its own terms. In his book, though, he presents the evolution of that old story as a step-by-step historical process, lets that stand in all its duct-tape-the-old-paradigm glory, and asks if there is something wrong with it.

A good and very detailed read, by a master mind of (non-traditional) science, but NOT the tome referenced to validate all manner of "structured water" products. There is no direct connection in this book between the two; no mention of potential health effects, etc. Go to his TED talks for that !I’m not sure how interesting to someone sans graduate cell biology courses (now, maybe undergraduate covers sufficient - mine are dated).

Principles and Practice) Metabolic Activation and Toxicity of Chemical Agents to Lung Tissue and Cells The Use of Human Cells for the Evaluation of Risk from Physical and Chemical Agents (Topics in Language and Linguistics) Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors (The ECS Series of Texts and Monographs) Architecture of Human Living Fascia: Cells and Extracellular Matrix as Revealed by Endoscopy (Book & DVD) Always Hungry?: Conquer Cravings, Retrain Your Fat Cells, and Lose Weight Permanently Stem Cell Therapy: A Rising Tide: How Stem Cells Are Disrupting Medicine and Transforming Lives