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The Life of a Leaf

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Aside from sequence and transcription complexities, Dupré refers to external factors and processes that are also implicated in both functional and disease phenotypes. For example, methylation can change a gene, and it can be affected by organism-level behaviors, such as maternal care. The conclusion to Dupré's arguments is that a precondition for insight into the nature of biological systems requires a shift in perspective—from one of viewing the static gene as the only candidate for a cause in a linear, bottom-up model to one of seeing a dynamic "two-way flow of causal influence through a shifting and diverse array of entities" (p. 85). We need both a pluralism of entities and a process ontology.

Microbes are the subject of the third section of the book, the bulk of which is cowritten with Maureen O'Malley. Microorganisms (bacteria, archaea, protists, yeasts, and viruses) are the most populous life forms on the planet, but they have been ignored or marginalized by other disciplines, according to the authors. They suggest a shift from seeing microbes exclusively as unicellular, "primitive" organisms to a focus on the multicellular communities they form, which challenges the long-held assumptions of biological individuality, mechanisms of evolution, and biodiversity. Indeed, Dupré and O'Malley state that life itself should be understood as fundamentally collaborative. This conceptual movement away from an internally directed, discrete organism (i.e., the monogenomic differentiated cell lineage) expands the domain of biology for philosophical reflection in important ways.

The arguments in *Processes of Life* support an expansion of consideration to domains of life that may not have previously been the target of philosophizing about the evolution of eukaryotes such as humans. Developments in metagenomics and in the scientific understanding of microbes, their communities, and the processes by which microbes and macrobes interact within functioning (and malfunctioning) organisms introduce into the philosophy of biology important new examples of the hazards of rigid dichotomies (life versus nonlife) and blind reductionism (genetic determinism versus epigenetics).

In the final section of the book, Dupré tracks the implications of his version of pluralism on our conceptions of ourselves. By investigating evolutionary psychology, racial classifications, and free will, he concludes in his final essay that they have "more to say about what human nature is *not* than what it is" (p. 292). Life consists of not just monogenomic organisms (there are biofilms), evolution is not the result of only selfish competition (there is cooperation), and human nature is not inscribed in our DNA (epigenetics, niche construction, and culture all contribute).

Processes of Life is required reading for biologists and philosophers of biology. It is provocative and original, and the questions that Dupré raises will help shape future reflections on life, its constituents, and its dynamics.

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HOLDING A LEAF UP TO THE LIGHT

The Life of a Leaf. Steven Vogel. University of Chicago Press, 2012. 320 pp., illus. $35.00 (ISBN 9780226859392 cloth).

> Until man duplicates a blade of grass, nature can laugh at his so-called scientific knowledge. (Thomas Edison)

The fascination with plant biology is now spreading rapidly in the general public and in universities. Just as plant-related resources are expanding online, so is a corresponding audience: for example, the upper-level plant physiology class at the University of California, Los Angeles, now attracts more than 400 undergraduates from across the life sciences. Worldwide, there is a growing appreciation of the importance of plant biology to food and ecosystem sustainability under climate change, and with this focus on plants comes a recognition of the power and mystery of leaves, plants' metabolic engines. Leaves evolved multiple times in the history of plant life, and they are a perfect example of sophistication and natural beauty in design. They are the source of food and energy for the biosphere, with an efficiency and capacity for energy conversion that humans dream of duplicating. Leaves are ubiquitous and dazzling in their diversity. The life cycle of a leaf, from flush until fall, presents a microcosm of birth, youth, old age, and death. In *The Life of a Leaf*, author Steven Vogel testifies to all of these points, even as he focuses very specifically on clarifying the design of the leaf using basic concepts in physics.

Vogel finds the leaf to be an ideal subject for his approach to science. Vogel is an emeritus professor at Duke University and the author of several very popular books explaining biological phenomena in terms of physical relationships. He advocates for close examination of an everyday object, such as the leaf, until we can match our thoughts to directly observed forms and processes. He updates this Goethe-like quest for "intuitive reality" by further urging us to unite each observation with physics-based mathematical models. According to Vogel, the leaf is "a 'biological everyman,' an ordinary and ubiquitous living thing that provides the subject of an exploration of our immediate physical world" (p. 2). In the best parts of the book, the author matches thought to form and process to mathematical model perfectly. *The Life of a Leaf* contains the best practical demonstration that I have ever seen of math used as a fluid extension of intuition.

The book focuses on the challenges faced by the "typical" leaf. In successive

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chapters, Vogel describes the physics of the light absorption of the leaf, the diffusion and flows of water and gases in and out of the leaf, the leaf's temperature balance, its avoidance of freezing, its mechanical support, and its ability to survive storms and herbivores. Vogel is always searching for the functional consequence of each leaf feature, and he finds explanations in the first principles of physics. In most of the text, the major points are not new, but the synthetic explanation is innovative. The book's sections on light absorption, the diffusion of gases, temperature convection, surface tension, and internal pressures are especially brilliant and insightful. In addition, Vogel presents his own creative and untested explanations for phenomena such as root pressure and leaf rolling. He also highlights biomimetic applications based on leaves and analogies of leaf design in human physiology, textiles, home appliances, and building construction. The book is impressive as both a broad synthesis of so many topics and as a resource for basic equations and explanations.

The volume also abounds with ideas for teaching students of all ages the principles of physics and the basics of plant physiology. One of Vogel's missions is to reach young readers and to persuade them to take up science as a pursuit. Vogel remarks throughout the text about the fun he has when pondering and practicing science, and he includes numerous, beautiful photos of plant adaptations and Martin Gardner–esque do-it-at-home exercises. However, in this attempt to reach a general and young audience, the book faces several challenges. Vogel aims for the style of a jovial senior lecturer, laden with crusty comments, puns, and alliterations (e.g., "We're all familiar with the perverse, perfidious, and pervasive power of flatulence," p. 48), and this style can become long winded and tedious. Parenthetical tangents run off topic, sometimes rambling to dead ends. (For example, this book is not the place to read about plant water use in detail.) Sometimes Vogel attempts to meld his scientific brain with that of the reader: He stops in the middle of his description of a process to explain his attempts to guess at its mechanism; then describes how he mentally tested his reasoning; then how he chose another explanation, rejected that one, arrived at an impasse, and so on. Likewise, it is difficult reading when Vogel walks us through his calculations at length, describing in the text how he plugged numbers into equations.



Unfortunately, there are also many errors of important detail regarding plant anatomy, physiology, systematics, and nomenclature. Key terms for plant tissues are inaccurate, as is information on the size of plant cells and on stomatal and xylem anatomy and their physiological function. In addition, several sections of the book contain out-of-date information on whole topics, such as those on C_4 photosynthesis and leaf development. (On the upside, a young scientist might, in fact, use this book as a training exercise by finding the errors.) These issues arise from and are made worse by the author's apparent unfamiliarity with the recent literature. Of the approximately 110 references, only a third date from within the last 10 years, and only half of those are from the last 5 years. Vogel misses out on important breakthroughs in the last few years on leaf development; venation; economics; volatile compounds; and the evolution of leaf form, anatomy, and physiology in multiple lineages. Regarding leaf water transport and biomechanics, Vogel makes do with discussions of wood, being presumably unaware of numerous leaf-focused papers on these topics in the last decade. Most critically, classical and recent research have made obvious that diversity is the leaf's most compelling aspect and the one most necessary for science to explain. That diversity, drawing increasing attention of scientists worldwide, is barely covered in this book—mentioned only briefly in the beginning and final chapters.

The Life of a Leaf offers unique insight but does not completely live up to its title. A book that truly did that would certainly clarify and explain not only the physics of a leaf but also the rich ecology and evolution of leaves. That book has not yet been written. However, despite its weak points, this book provides an admirable template, proving that a text for a general audience can capture an innovative, sophisticated and integrative approach to science as it makes the point that leaves are important and fascinating on every level.

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WALLACE IN THE MALAY ARCHIPELAGO

Dispelling the Darkness: Voyage in the Malay Archipelago and the Discovery of Evolution by Wallace and Darwin. John van Wyhe. World Scientific, 2013. 420 pp., illus. $49.00 (ISBN 9789814458795 cloth).

Dispelling the Darkness: Voyage in the Malay Archipelago and the Discovery of Evolution by Wallace and Darwin is the latest book by science historian John van Wyhe, who is currently a senior lecturer at the National University

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