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NATURAL HISTORY FIRST (BUT DON'T STOP THERE)

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> *Go to Nature, take the facts into your own hands, look and see for yourself*
>
> - L. Agassiz

This quote from Agassiz welcomes visitors to the main entrance of the Ruthven Museums Building at the University of Michigan, beseeching them to collect their own data and draw their own conclusions. The sentiment has inspired generations of evolutionary biologists, who continue the long tradition of deductive science epitomized by Darwin and Wallace. The fundamental questions about evolution have always been borne from direct observation of, and curiosity about, nature. In the best cases, the process leads to elegant tests of hypotheses and formulations of general theories. No practitioners of this art of investigation have done it with more rigor, provided deeper insight, or better illuminated the aesthetic qualities of science, than Peter and Rosemary Grant.

It is fitting, then, that the careers of the Grants (while showing no signs of ebbing toward a twilight!) should be celebrated by assembling a fine cadre of scientific naturalists to share their own observations and deductions. *In Search of the Causes of Evolution* is a collection of essays based on presentations at a symposium organized by Princeton University on the occasion of the Grants' official "retirement." The chapters are remarkably true to the theme that observation leads the way to detailed dissections of the underlying mechanisms of evolution. The author list represents some of the most significant contributors at the forefront of evolutionary research. Although readers will recognize most of the study systems (e.g., anoles, beach mice, dung beetles, sticklebacks even make two appearances), the authors generally have done an admirable job of resisting the temptation to rehash old work and have contributed new data or syntheses to the volume. The resultant book thereby serves as a low-altitude reconnaissance flight over some of the most exciting current research in evolutionary ecology.

The ground covered by the essays is extensive, as it should be under a title purporting to encompass the causes of evolution. As anyone who has taught an introductory evolution course can attest, the scope of topics that we seek to explain is staggering. One person's bread and butter might not even be included on another's list. The Grants have at least attempted to span this space by including chapters across the spectrum from the evolution of early earth environments (Andrew Knoll and David Johnston) and macroevolutionary patterns of diversification (David Jablonski) to the search for "behavior genes" (Hopi Hoekstra) and the population genetics of island endemism (Trevor Price and colleagues). True to the tradition of the Grants' own work, however, the majority of essays emphasizes the interplay of selection and genetics as drivers of biodiversity. This is a collection that is unapologetically adaptationist in its perspective on evolutionary mechanisms.

So what do we learn about where the grander field of evolutionary biology is headed when we collect marquis names with license to write about whatever they want? First, evolutionary research is not dominated by traditional model systems. Indeed,

many of the taxa described in the *Causes of Evolution* have begun to emerge as new model systems in their own rights. It is tempting to chalk this trend up to the relative ease of applying molecular genetic tools and developmental biology these days, but to do so ignores some important points. As the editors point out in a summary of Doug Emlen's chapter on exaggerated traits in beetles, "field-initiated inquiry into evolutionary problems. . .starts with observation of conspicuous traits." The choice to explore these new models (and the many others not included in this volume) is fundamentally driven by interesting biological puzzles revealed first through natural history. Joshua Gross and Cliff Tobin present the repeated evolution in cave forms of reduced pigmentation and visual systems in lineages as distant as fish and crustaceans. This widespread convergence is the motivation for developing genetic maps for exploring the regressive loss of pigment and other cave-associated traits in the cavefish *Astyanax*. Hoekstra's work with beach populations of *Peromyscus* mice began in an attempt to reveal the genetic basis of crypsis adapted to different soil backgrounds, but she shows how the genetic toolbox that emerged from that work can be applied to new biological problems. In her essay, she exploits population differences in burrow architecture to begin divining the loci that determine variation in behavioral traits. Similar efforts in other taxa are presented so smoothly that there is a temptation to imagine that developing these tools in new systems is now "easy." Although none of the authors dwell on this point, reading between the lines reveals how absolutely Herculean the effort to develop new crossing populations is. To embark on such efforts without genetic tools at the ready or husbandry protocols perfected must seem to be a fool's voyage at times. The chapters collected here show that the right creativity and vision can make that initial folly pay huge intellectual dividends.

A second message that emerges from the sum of the essays is that a major direction of research is linking genetic variation and developmental processes with phenotypes important to fitness. This attempt to draw the map from genotype to phenotype is at the heart of many questions in evolution. The work presented in *Causes of Evolution* all begins with the ecologically important traits first, but holds out the genes or developmental pathways underlying trait variation as the goal of the studies. These efforts grow beyond gene hunting, however, as each author is hoping to address a larger question with the ultimate information. In the case of butterfly wing patterns, Paul Brakefield and Mathieu Joron attempt to determine how much of the possible morphospace is occupied and to relate those answers to constraints, either genetic or selective. In mimicry systems, we see that few loci of large effect can essentially turn patterns on and off, allowing discrete jumps in mimetic phenotypes. For Emlen, the goal of understanding the developmental network underlying variation in conditionally expressed combat traits might reveal why (or if) so many taxa have similarly structured exaggerated phenotypes. For Hoekstra, identifying genes for behavioral traits might tell us whether the underlying architecture of behavioral traits is similar to morphology and therefore whether we should expect them to follow comparable evolutionary patterns. Whatever the bigger picture, it is clear that uncovering the genetic basis of ecologically important traits will continue to be a popular pursuit in the foreseeable future.

Given the Grants' research contributions, it is no surprise that the power of ecology to drive diversity is another emergent theme. It was especially valuable to see the two classic examples of adaptive radiation, Caribbean *Anolis* and Galapagos finches, compared directly by Jonathan Losos. As Losos admits, a sample size of two is a bit scant for drawing robust conclusions about the process and pattern, but his chapter lays down some of the basis for comparisons to other well-studied radiations.

The editors and authors of *In Search of the Causes of Evolution* make no claim to have produced an unbiased or exhaustive coverage, so it is a bit unfair to comment on what is not included. Nonetheless, with a title like that, some omissions are rather glaring. The one that leaps from of the table of contents is that not a single essay discusses work on plants (save two zoocentric chapters dealing with coevolution of plants and pollinators). Although the causes of evolution might include substantial overlap between plants and animals, there are certainly some core "causes" that seem more prevalent or at least better studied in plants—introgressive hybridization, polyploidy, and spatial structure come to mind. *Helianthus*, *Mimulus*, and *Silene* are all candidates as new model systems that have revealed the workings of evolutionary process comparable to those featured in the book. It is a shame some of the excellent evolutionary biology of plants is not included.

In the Grants' concluding chapter, they point out two major challenges for evolutionary biology that are not covered within the book—genomes and microbes. Certainly these are both important topics not reached by the contributing authors, but these feel more like taxonomic targets than conceptual challenges. Perhaps this is appropriate, given the emphasis throughout the book on observation driving the process of discovery. We are at a phase in genome research that has been compared to the Victorian heyday of natural history exploration. Similarly, microbial diversity is only just now becoming appreciated as we develop new tools to detect those things we cannot see with the naked eye.

The works collected herein would make an outstanding base for a graduate reading group or class in evolutionary ecology or adaptation. The authors have presented current and synthetic discussions of their work, and that work represents some of the best in evolutionary biology today. The chapters do as much to point the way of the future as they review the past, and that is the recipe for a successful symposium collection.

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