

How the Snake Lost Its Legs
Curious Tales from the Frontier of Evo-Devo
by Lewis I. Held, Jr. (2014)
Cambridge University Press, 156 pages of text and figures
Review by Larry Flammer, ENSI Webmaster

From the publisher:

How did the zebra really get its stripes, and the giraffe its long neck? What is the science behind camel humps, leopard spots, and other animal oddities? Such questions have fascinated us for centuries, but the expanding field of evo-devo (evolutionary developmental biology) is now providing, for the first time, a wealth of insights and answers.

Taking inspiration from Kipling's *Just So Stories*, this book weaves emerging insights from evo-devo into a narrative that provokes startling explanations for the origin and evolution of traits across the animal kingdom. The author's unique and engaging style makes this narrative both enlightening and entertaining, guiding students and researchers through even complex concepts and encouraging a fuller understanding of the latest developments in the field. The first five chapters cover the first bilaterally symmetric animals, flies, butterflies, snakes, and cheetahs. A final chapter surveys recent results about a menagerie of other animals.

This latest book by Dr. Held expands the revelations in his 2009 book, *Quirks of Human Anatomy - An Evo-Devo Look at the Human Body*, from a largely human focus to many of the strange features (quirks) in the animal kingdom. In doing so, he also updates the accelerating progress in evo-devo research. And, as we should expect, he continues to pose the increasing number of questions and unsolved problems in this field that characterized that earlier book. This is a veritable goldmine for students and established researchers alike, looking for engaging questions to pursue. These books document a living example of how answers to previous questions raise even more questions as we probe the realm of “**deep ignorance***.” In his preface he says: “Every chapter is packed with unsolved mysteries that could furnish offbeat topics for term papers, thesis projects, or journal clubs.” When many potential science students tend to get the impression that “science must have solved all the great problems by now, so there's nothing much left for me to do, so I'll choose another career,” these books become a great antidote. Students and teachers not only come to see that fascinating questions just keep coming - they're all around us - they also see, in these books, the effectiveness of science in solving problems about the natural world.

Dr. Held helpfully points out in his important-to-read preface the different pathways for reading this book:

To ensure accessibility, I have culled as much jargon as possible, compiled a glossary (albeit a spartan one), used a case-study approach, and perforated the book with “rabbit-holes.” Readers can enter this Wonderland by studying the schematics, browsing the bestiary (Chapter 6), sampling the glossary, or just looking at the pictures. Like Alice, readers can then explore whatever piques their curiosity.

He also punctuates his narratives with “take-home” lessons, nicely summarizing the key points of that narrative.

I would add that his glossary is worth more than a cursory overview. He provides excellent explanations of the terminology common to evolution, genetics and developmental biology. In addition, he provides clear examples of those terms, which can be explored in more detail back in the case-study accounts of the referenced animals. For readers who are relatively inexperienced with the intricacies of evo-devo (as is probably true of many secondary science teachers, and hopeful undergraduates), this glossary (which was not in his prior book) becomes a useful reference, as well as a refresher for the many processes explained by evo-devo. The only thing I might suggest (if it's feasible) would be to add a handy alphabetical list of the many modifier genes that influence development (and evolution), with a fair sampling of where and how each one generally works during the development of different features in different animals. [Sharing this request with Dr. Held, he responded with this: “Also, *Imaginal Discs* has an index of all the relevant regulatory genes involved in evo-devo, but the most comprehensive database of fly genetics & its regulatory genes in evo-devo is: <http://www.sdbonline.org/sites/fly/aimain/1aahome.htm> “]

I warn you, though; when you look at the pictures and/or study the schematics, you will be captivated by the full-page captions, and probably drawn into the effort to really understand what is happening. The graphics do, indeed, help immensely to do this.

Suggestion to Dr. Held: The fact that many of the genetic “circuitry trees” are complex and intertwined, and can become “re-wired,” makes me wonder just *how* the scientists figured them out. What are the mechanics of such studies, and how long can they take? Maybe Dr. Held’s next book could share some of those “behind-the-scenes” stories about just what transpires in the labs and in the heads of “evo-devotees.” [Again, Dr. Held responds with: “I’ve already written the sort of book you suggest that I write, & it took me 10 years to write it: <http://www.sdbonline.org/sites/fly/lewheld/imagdisc.htm> “]

We all remember when we were young and kept asking “why...?” and “how...?” It’s most refreshing to finally learn that we can, indeed, explain exactly how many of the strange (and regular) features of life do develop, and how they probably (or could have) evolved. It’s also very evident that a child-like curiosity permeates the psyche of research scientists.

Beyond the result of satisfying our curiosity, we can also see the practical applications of these discoveries, and the author points these out. For example, revelations about “how the newt regrows its legs” is opening doors to the possibility of enabling amputees to regrow their missing limbs. Evo-devo answers to “how the deer regrows his antlers,” or “the sea star regrows missing rays,” or “the planarian regrows excised parts” should also be helpful in that quest. As we learn more about the mechanisms behind the recovery of vision in snake evolution, there may be real hope in helping blind people to see again.

Here are some additional parts that particularly intrigued me:

Most (all?) of the mechanisms behind evolutionary changes seem to involve the re-wiring of the complex genetic circuitry between regulatory genes. The endless ways that new pathways to particular solutions provided by these changed circuits is amazing.

Nearly all mammals, even giraffes, have the same number of neck vertebrae (7)! This conservative condition might well be due to the fact that the diaphragm in mammals traces its development from neck somites C3-C5! Now how could that have happened? Only sloths (7-10 vertebrae) and sirenians (sea cows, 6-7 vertebrae) have different numbers of vertebrae). And why is that?

Many examples of the hypothetico-deduction process of science become apparent as you see how the details of evo-devo are being explored. This isn’t pointed out as such, it’s just there. For example, at the top of page 33, there is an explanation for how the sex combs on the forelegs of male *Drosophila melanogaster* may have evolved. Read it carefully, and you’ll see the elements are there. It begins with “The simplest interpretation of this...is...” [hypothesis]. So, “**If** we can document this linkage... get *Scr* to be yoked to itself [experiment], and see that *Scr* is inhibited by *en* [predicted result], **then** the puzzle would be solved.”

At the same time, we see many of the nuts and bolts of evolution, deeper than just natural selection, but precisely what genetic/physiological mechanisms are being selected for (or against).

I get the distinct impression that Dr. Held, in his evo-devo research, is overwhelmed with so many questions and plausible explanations, begging to be studied more deeply. So he shares these many questions in his books, hoping that his readers (other scientists in the field, interested students), if they can, will take the leap to explore any one or more of them, just so it gets done by someone! So, if this book of questions motivates you, go do it!

For teachers: This is a rich collection of tantalizing treats that would stimulate any biology class. Teachers can select any one or more to stimulate interest and promote discussion. Students don’t really need to know the details behind how traits have evolved. It’s enough to just know that many have actually been figured out, and many more are awaiting their revelation. And don’t forget the practical applications that could come out of this

knowledge. And with the different pathways to follow in this book, I'm sure that any biology teacher would find it to be an enriching experience.

***Deep Ignorance:** Dynamic Opening, First Day of School
<http://www.indiana.edu/~ensiweb/lessons/unt.deep.html>

Take a peek at a sampling of the book (including a sampling of the Glossary) click here
<http://www.sdbonline.org/sites/fly/lewheldsnake/heldsnake01.htm>

For a partial Table of Contents, and partial list of References, click here.

http://books.google.com/books?id=d6wqAgAAQBAJ&pg=PA202&lpg=PA202&dq=held+how+the+snake+lost+its+legs&source=bl&ots=wemgkkaU2&sig=WoHJf-bRLptGEVyw7MepUrLZhw&hl=en&sa=X&ei=ou_UuLwNtLroASnxoLwAQ&ved=0CDgQ6AEwAw-

Google link (some figures are displayed)

http://books.google.com/books/about/How_the_Snake_Lost_Its_Legs.html?id=gBuZAgAAQBAJ