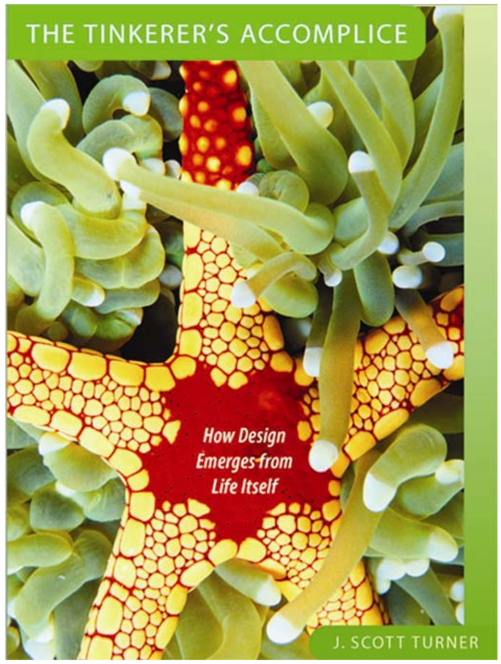
A conversation with the author[i]



Q What do you think readers will like about your book, and what do you think will make them, as you say in the Preface, want to throw it across the room?

A Well, the book is about biological design – why living things seem to be built so well for the things they do – and it's an inherently fascinating subject, I think. I mean, who hasn't marveled at some time or other just how well-crafted our bodies seem to be? And for me, one of the most fascinating things about it is peeling back the layers to reveal just how well-designed biological machines work, and how they come to be that way. Just think for a moment how remarkable it is that our bones, say, are shaped and mineralized in just the right way to bear the loads imposed on them? That's the kind of thing I explore a lot in this book, and it's something I think most people will find captivating.

Unfortunately, I think that's also one of the things that may make some people want to throw the book against the wall. One thing that is quickly revealed by peeling back those layers is that there is something not quite complete about our standard explanation for the phenomenon of biological design: there's still a great deal to learn about it. At least that's my conclusion.

Q Why on Earth would that make some people want to throw your book across the room?

A Design is a pretty emotive subject in science right now, with the whole dust-up over intelligent design theory, and that means any discussion of biological design is going to be burdened with a lot of ideological excess baggage. And unfortunately that sometimes makes otherwise reasonable people behave in unreasonable ways. I've been taken aback, for example, at some of the venom that laces my colleagues' conversations and comments about intelligent design theory. And this book will stir a bit of that up, I think, primarily because of my assertion that modern evolutionary biology hasn't explained biological design as well as it thinks it has. This has already raised a few hackles. When the manuscript was in an early stage, for example, we had a difficult time finding people who would review it. That itself is not surprising – who has the time? – But what did surprise me was some of the reasons given. One simply said that any book written about the problem of biological design could have nothing valuable to say because "there *is* no problem of biological design." Not the kind of native curiosity I expect from my fellow scientists. Another reviewer claimed I had written a "stealth intelligent design book", an almost McCarthyite claim, if you think about it. I've even had hecklers, which for some reason my talks about termites never drew!

Q Is it a stealth intelligent design book?

A That's the other group that will be upset with me! No, it's not. In fact the book is not about intelligent design theory at all, although I do touch upon it from time to time. As I've already said, the book is about the phenomenon of biological design, how I think it comes about and what I think it means for our understanding of life, including its origin and evolution. I wrote it not to advance any political agenda, but because I believe that biological design remains a real, and in my opinion, unresolved problem. While intelligent design theory has its own interesting explanations for these things, it doesn't quite measure up as credible science, which the ID people will not be happy to see.

Q In a nutshell, where do you think Darwinism falls short in its explanations for biological design?

A In a nutshell? Oddly enough, I think Darwinism been a victim of its own stunning success. The Darwinian "church", if I may use the word, has always been a big tent, but the incredible achievements of 20th century biology elevated one particular school, namely Neo-Darwinism, to dominance. Neo-Darwinism central claim, of course, is that evolution proceeds by natural selection among genes, and those genes are *the* sole objects of natural selection. The logic that supports this claim is virtually impeccable, but the logic also perniciously alienates evolution from biology itself. For example, it demotes organisms – the functioning systems that do the work of carrying genes into the future –to afterthoughts, mere vehicles for the genes they carry, unimportant in the long run compared to the genes that really run the show. One of the signs of this alienation is the general indifference that modern evolutionary biology accords to the phenomenon of biological design.

Q So, what's your answer?

A I'm not the only one to criticize the dominance of Neo-Darwinism, of course – evolutionary biology is a "big tent" science, after all, with lots of points of view. My particular critique differs from most others, though, in that I assert that evolution may be a more intention-driven process than "pure" Darwinism might allow. I say this largely because there is a kind of intentionality operating at the heart of the vehicles themselves that can, in a peculiar way, direct their own evolution. Biological design is just the most significant outward sign of this intentionality, which itself stems from a fundamental physiological property of living systems, namely homeostasis.

Q What do you mean by homeostasis and what does it have to do with this problem of design?

A Homeostasis is the tendency of living systems to gravitate toward a particular state. At its simplest, the tendency of your body to maintain a particular temperature is a kind of homeostasis, but the concept ranges far wider than that. To take an example from the book, bones come to be designed – to be built in ways that efficiently bear the loads imposed upon them – because the cells that build and maintain bones are "uncomfortable", for lack of a better word, when bones are built too weakly or too strongly for those loads. When these cells are "uncomfortable," they get busy remodeling the bones – strengthening them here, eroding them there - until they are "comfortable" again. Design of bones is a reflection of the bone cells regulating their local environments. Once you see this, you see design and intentionality everywhere.

Q What got you thinking along these lines?

A Oddly enough, it was termites.

Q Termites?

A Yes, and it was pure serendipity. There was a time in my life many years ago when I was at loose ends professionally: no money, no job, no prospects of one, living far from home, and with a new family in South Africa to look after. To make ends meet, I landed in a temporary teaching post in one of South Africa's so-called homelands universities – this was in the late 1980's, when *apartheid* was coming unraveled, and the homelands were still going concerns. All around my campus, there were these amazing chimneys that rose out of the ground, part of a ventilation system for underground colonies of termites. I happened to have time on my hands – I was essentially in scientific exile - so I started fooling around with air flows in these chimneys, and quickly discovered that there was more to the ventilation than everyone said there was.

That started me thinking about how organisms build structures that can act like organs of physiology – in the case of the termites, the chimneys are part of a wind-driven lung for the colony – which ultimately led me into some very strange conclusions about physiology, what it is, where it comes from, and how it comes about. I wrote about some of this in my first book, *The Extended Organism.*

The thinking about design got its start when I realized these structures were devices not just to ventilate the colony but to regulate the colony's environment. In short, they had to be built in a particular way to perform a particular function well: they were designed, in other words. And that got me to thinking seriously about how the millions of termites could build these structures "to spec" as it were. *The Tinkerer's Accomplice* is the outcome of that thinking.

Q Did you have a "eureka" moment?

A In the sense that I ran naked down the street shouting like Archimedes? No, there wasn't one really – it just kind of dawned on me one day, after a long series of experiments on colony ventilation that made no sense and a lot of head-scratching over why they didn't. Oddly enough, the realization came when I was trying to explain to someone a feature of these termite-built structures that has nothing to do with ventilation: why termite mounds and chimneys tend to point to a certain point in the sky. As I was sketching out my explanation for this person, it dawned on me that it was wrong to think about these things as structures at all. Even though they appear quite solid – and you would smash up your car if you ran into one –they are in fact amazingly fluid and changeable in shape and architecture. In short, they are more processes than structures, and if the things building them – the termites – were agents of homeostasis, then the "designedness" of the structure – its close match between structure and function – emerged on its own. That's when I began to think this might offer a broader model for design in nature.

Q Do you have a favorite example of amazing design in nature?

A Well, I would say that the termite mound stands out, but I don't want to be a bore. Other than that, I think the most intriguing example in the book is the phenomenon of antler shape memory. Deer antlers are well-designed for the functions they perform, but remarkably they do not come to be built that way in the same way that, say a leg bone does. A leg bone's structure becomes matched to its function because the bone is always put under strain. This is not true for antlers – deer never let anything touch a growing antler - yet they still appear to be well-designed. So how do they come to be built that way? It turns out to be a near intentional process – deer carry within their brains a memory of the antler's ultimate shape that remains when the antler is shed – akin to a phantom limb illusion. This memory then directs the growth of the antler in subsequent years. That's essentially a mind controlling an adaptation – very intriguing.

Q You're a teacher and a writer as well as a scientist, so you're in the business of communicating science to a broad audience. What's it like to do that? Is there a difference between talking to students in a classroom versus writing to a broad audience of readers?

A I think science is a cultural activity, just as art, or literature, or even politics and business, is. I also think culture dies if it turns in on itself. Even if it's just for self-preservation, I can't imagine why anyone would not be eager for the chance to get others excited about what you're doing or thinking.

Having said that, I also have to say that I find writing about science to be extremely difficult – I usually have to sweat quarts of blood to get it right. It doesn't help that there are lots of other science writers out there that seem to do it so well and so effortlessly, and that makes me jealous, so I usually don't feel very good about myself when I am writing. Even if I finally do get it right, I can't honestly claim much credit for it – most of that sits with the editors and reviewers and contracts that hold your feet to the fire. But when it really clicks, it does feel really good! And at the end, it's a terrific charge to see your name on a book cover. It's addictive, really. It's why we keep doing it.

Lecturing to students is also very hard – after a lecture, I usually feel quite deflated – but the rewards are just as great, and more immediate. And there's nothing like jousting with a bunch of fresh minds.

Q Finally, you mention in your preface your debt to Hermann Rahn and Charles Paganelli, two scientists who were your mentors when you were a post-doctoral fellow at University of Buffalo. What about your other mentors? What gifts did they give you?

A Well, there are a lot of them. I hope I have enough books left in me to thank them all in prefaces. One of the most important was Dick Tracy, who was my major professor at Colorado State. He's now at University of Nevada at Reno. I think the most important thing I learned from him is that science is mostly about curiosity, and to always trust your curiosity. After I graduated with my PhD, I spent two very exciting years in Knut Schmnidt-Nielsen's lab at Duke University in North Carolina. I think the most important thing I learned from him was that animals have their own logic, and that you couldn't go wrong if you just let that logic lead you to the right conclusion. I also spent quite a bit of those two years hanging around with the Duke Zoology biomechanics group, and Steve Wainwright and Steve Vogel were mentors of a sort, if only by osmosis. Steve Wainwright has what I think is an almost artistic approach to biomechanics, and from him I learned to trust even one's inchoate impressions of how things worked. Steve Vogel, of course, stands out for me as the perfect storm of function, physics and adaptation. I also learned from him the value of good writing, and, of course, the well-turned pun. Gideon Louw at University of Cape Town introduced me to the southern African scientific cornucopia, and was a true gentleman to boot. And Roy Siegfried, also at University of Cape Town, let me play at science, even if it wasn't the science he was paying me for.

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[i] This conversation was compiled by Harvard University Press as part of an information packet for marketing *The Tinkerer's Accomplice.*