An Alloy of Pleasures

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REVIEW: *The Oxford Book of Modern Science Writing,* edited by Richard Dawkins. Oxford University Press, 2008. ISBN 978-0-19-921680-2.

1 Prelude

During the Christmas holidays last year, my mother and I were visiting a bookshop, and we passed by a display of general-audience science books. As a child, I had devoured such things, and propelled by sentiment mixed with curiosity, I looked over the titles, browsing for ones which I'd seen recommended or were written by authors I knew. Momentarily, however, a harsh edge cut through my sentimental reverie. "Look at this," I said. "This book props up its thesis with phony numbers and citations which point to papers that don't even discuss what the book says they do! And this one, here, tells a version of 1990s physics history which, to put it mildly, doesn't match up with what other physicists remember. Oh, and *this* author, well, everybody is just *astonished* at how the clarity of his thinking implodes halfway through, when he *stops* thinking and starts faith-ing. And what's this — *quantum healing?*"

If the Gentle Reader were to deduce a "moral" from the story, it might be that I am a cantankerous individual with an acerbic disposition, and the reader would not be gravely in error. Beyond that, one could say that a science education nearly killed the general-interest bookshelf for me, and what University did not do, the science-blogging world definitely tried to finish. Caught up in this electronic tangle of opinions, discoveries and arguments, where new findings and reactions to them are all free for the taking, I'd seen the flaws of a great many books exposed. Precisely because online science writing makes irascible iconoclasm a way of life, though, it teaches the joy of discourse and the admiration of written words which, finally, *work.* Both of these aspects play into the value of *The Oxford Book of Modern Science Writing,* edited by Richard Dawkins.

This book collects passages written by seventy-nine scientists over the previous hundred years; though Dawkins himself has more than proven his talents as an expositor, his own writings are confined to introductory remarks giving context for each selection. Biology is represented quite strongly, and physics makes a good showing. Astronomy, other than the cosmological variety, makes mostly cameo appearances, and chemistry seems rather the poor stepchild. (Max Perutz, a Nobel Laureate, contributes a bit on X-ray crystallography which is largely an admiring biographical sketch of fellow laureate Dorothy Hodgkin, and the well-known neurologist Oliver Sacks is roped in to give a quirky reminiscence about tungsten! Primo Levi's tale of a carbon atom, though, is not to be missed.) Truly commendable is Dawkins's inclusion of mathematics, a subject which provokes an unnatural fear even in literate readers who appreciate science and enjoy reading about the latest fossil or the most newly discovered extra-solar planet. The selections chosen for *The Oxford Book* are clear, memorable and not infrequently poetic. Upon occasion, they deliver on that great promise of science education: to provoke the learner into seeing the natural world and the products of the human mind in a new and unforgettable light. After reading what Stephen Jay Gould wrote about Charles Darwin's take on the humble earthworm,[1] for example, it is difficult to see in the same way such a simple thing as worms coming out on a pavement after the rain.

The Oxford Book would serve as an excellent smörgåsbord of introductions for the reader who has grown interested in science but doesn't know where to begin. Likewise, those who catch the biggest headlines and read about the flashiest new breakthroughs will likely benefit from a book about science which has stood the test of time, about discoveries which have kept on inducing breathlessness for several decades. A specialist trained in one scientific field could also enjoy an interlude of lateral thought, poking into a new domain of learning to flex the thought-muscles.

When I've heard people talk about a movie or a book being "an unalloyed pleasure," they mean it to be joy without stopping, all good and nothing bad. Given that an alloy is a mixture of metals, the phrase also carries a trace contamination of the idea that the book or the movie being talked about only offers *one kind* of goodness — all drama and no comedy, let's say. Consequently, I find myself describing *The Oxford Book of Modern Science Writing* as an *alloyed* pleasure, a mixture of different satisfactions, in unequal amounts. The amazing facts, the flashes of wit, the moments of rapturous wonder are all there to be had, but Dawkins has also provided a series of portals to debate. I'm not talking about a nasty kind of political infighting, with accusations and character assassination, but rather the academic version of the same process: the rolling up of sleeves, the setting down of the teacup and the declaration of intellectual combat.

The book club meetings for this volume can, and *should,* be... volatile places.

[1] See `http://darwin-online.org.uk/EditorialIntroductions/Freeman_VegetableMouldandWorms.html`.

2 Sins of Science Writing

A science book can go bad in several ways. First, and most obviously, it can be just plain wrong. The bilious denials of evolution turned out by creationist frauds qualify most excellently in this department. Second, a book can grow out of date; indeed, the very nature of the scientific process makes this an occupational hazard in the expository profession. Also, a book can purport to set out the facts but in reality be an exercise in polemic, substituting spin for science or making emotional appeals where evidence is required. More subtle, but upon occasion just as pernicious, is when an author presents the right facts in the wrong context, making an ordinary workaday development out to be a revolution[2] or presenting a tentative proposition as incontrovertible. It's easier to tell a stock "human interest" story than it is to present a detailed finding correctly.[3]

Nothing in *The Oxford Book* struck me as horrifyingly wrong — as befits its pedigree, it comes nowhere near creationist-caliber wrongness. Now and again, the selections dated themselves: we know more about photosynthesis than we did when Primo Levi wrote his prose poem about carbon, for example, and Loren Eiseley's "How Flowers Changed the World" mentions the extinction of the dinosaurs but hails from a time more than twenty years before Luis Alvarez and company even proposed the asteroid-impact explanation.

Dawkins is often conscientious about indicating when an idea described in an excerpt is contested or poorly established. He leans on Roger Penrose to explain Gödel's Incompleteness Theorem,[4] but he observes that Penrose's pet proposals about human consciousness are "controversial, not to say eccentric," and the anthology doesn't bother to quote them. This, I'd wager, is putting it mild compared to the responses one could elicit from other quarters, but a full explanation of the controversy would entail lessons in quantum physics and computer science both. While the Gentle Reader doubtless has sufficient patience for such an excursion, the window in which I am typing these words may be too narrow to contain it. Suffice to say that Penrose has found a peculiar way to conclude that computers can never match the powers of the human mind, by esteeming computers poorly and humans too well.[5] To resolve what others see as a non-problem, he invokes quantum physics, but not *just* quantum physics: rather than saying that the human brain supports the kind of quantum computation which physicists and engineers are currently trying to implement, using the rules of quantum behavior we already understand, Penrose's formulation requires a new

[2] PZ Myers debunks one example of this at `http://scienceblogs.com/pharyngula/2007/03/scott_adams_reads_newsweek_uho.php`.

[3] I made a rough attempt to catalogue these types of stock narratives at `http://www.sunclipse.org/?p=49`.

[4] For a good introduction, see `http://www.scottaaronson.com/democritus/lec3.html`.

[5] See, *e.g.,* `http://scottaaronson.com/democritus/lec10.5.html`.

kind of trans-quantum physics with extra-spooky powers that let it beat Gödel.[6] (Physicists are typically leery of inventing new fundamental postulates to account for a phenomenon — like human thought — which has only been observed in an infinitesimal fraction of the Universe.) Likewise, the suggestions for specific structures within brain cells which could support quantum computation, whether regular or the hypothetical trans-Gödelian kind, have essentially tanked.[7]

Similarly, the second selection in the book comes from *Just Six Numbers* (1999), a physics popularization by Martin Rees whose title refers to six "fundamental constants" of Nature. We know the values of these numbers, and we have to plug them into our equations for the fundamental physical laws, but we don't know why they have the values that they do. Dawkins notes, "They are just there; and many physicists, including Rees himself (though not, for example, Victor Stenger, a physicist for whom I also have a very high regard) believe that their precise values are crucial to the existence of a universe capable of producing biological evolution of some kind." The subtleties in this question are manifold, and by turns fascinating and exasperating. First of all, why *six* numbers? A reckoning made by physicist John Baez finds twenty more![8] What's going on here?

The excerpt which Dawkins picked out discusses one particular number, the ratio of the gravitational force to the electromagnetic force. Of the four basic forces of Nature, these are the two whose effects can extend over distances larger than an atomic nucleus. Rees compares them by taking the ratio of the electrical repulsion between two protons and the gravitational attraction between the same two protons. Because both the electrical repulsion (remember, like charges repel) and the gravitational attraction depend in the same way on distance, that distance dependence drops out of the ratio. It works out that the force of gravity pulling the proton masses together is weaker than the electrical drive pushing them apart by *ten to the thirty-sixth power,* the figure which Rees calls N.

But waitaminnit! The strength of a gravitational pull depends on the mass which is doing the pulling (remember those astronauts jumping around on the Moon?). What if the proton had a different mass — wouldn't the ratio between electric and gravitational forces then turn out different? Where does the proton mass *come from,* anyway?

If you've been reading the news, you'll be jumping up now and screaming, "The Higgs boson!"[9] Yes, thanks to the Large Hadron Collider, the Higgs is all over the Net these days; physicists are looking for it, in part, to explain why particles have the masses they do. But

[6]This point is made in, *e.g.,* `http://www-formal.stanford.edu/jmc/reviews/penrose1/penrose1.html`.

[7]A good, recent reference on this subject is A. Litt *et al.* (2006), "Is the Brain a Quantum Computer?" in the journal *Cognitive Science.*

[8]See `http://math.ucr.edu/home/baez/constants.html`.

[9]If you've been hanging around science blogs too long, you'll even scream with a built-in hyperlink: `http://www.hep.yorku.ca/what_is_higgs.html`.

that's not the whole story:[10]

The Higgs mechanism gives mass to *elementary* particles, but the proton and neutron are not elementary. The majority of their mass comes from the forces binding their constituent quarks together! By Heisenberg's uncertainty principle, if you want your quarks to be localized in a tiny space, their momentum has to be, well, uncertain: the more you squeeze the possible places a quark can be, the more possibilities its momentum will "want" to explore. But if there's a chance for the momentum to be large, that means there's a chance the *energy* is large, and in relativity, energy and mass are interconvertible — remember Einstein's $E = mc^2$? So, having an attractive force bind three quarks together into a proton means that the proton will necessarily have mass, even if the quarks inside have none!

Thus, we can change our perspective, and instead of asking why gravity is so *weak,* ask instead why typical masses are so *small.* A conclusive answer to that will require finding the Higgs, or showing that the Higgs doesn't exist and finding whatever goes in its place. (As Baez points out, twenty-two of the twenty-six parameters he regards as "fundamental" relate to the Higgs and how it interacts with other particles.) Then we have to consider the binding forces which also contribute to the masses of composite particles, and the parameters which describe them. And it's by taking *combinations of these quantities* that we get down to Rees's "just six numbers." The ratio N must depend on the strong-force coupling constant, the masses of the up- and down-quarks inside the proton, the expectation value of the Higgs field. . . you get the idea.

Whether other values of the "Rees six" or the "Baez twenty-six" could yield Universes which might contain life, evolution and intelligence — well, that's a tough one, and the fairest answer is probably *we just don't know.* One might also ask, justifiably, "Even knowing these twenty-six different numbers, we have to have equations to plug them into! Why do the *equations* have the forms that they do? Could altogether different sets of formulas also describe Universes with life in them?" Arguments can be made to that effect,[11] but again, admitting ignorance might be the better part of intellectual valor.

3 A Puzzle Regarding Selection

So far, I've addressed points where, in my view, Dawkins edited as a good editor should. However, one selection has perplexed me, and after rereading and rethinking, I cannot shake the impression that Dawkins choose poorly. The passage in question comes from Robert Trivers's book *Social Evolution* (1985) and is called "The Group Selection Fallacy."

Ever since Darwin, biologists have tried to explain how social behaviors — cooperation,

[10]See, *e.g.,* `http://scitation.aip.org/journals/doc/PHTOAD-ft/vol_54/iss_6/12_1.shtml`.

[11]See, *e.g.,* Sean Carroll's essay at `http://www.infidels.org/library/modern/sean_carroll/cosmologists.html`.

even self-sacrifice — could emerge from natural selection, which seems to embody a dog-eat-dog, dog-eat-cat world. What follows here is a physicists' caricature of an ongoing biological debate, one whose description this particular physics boffin has botched before, so reader, beware.

One explanation for how evolution could yield altruism, popular up through the 1950s, went something like this: imagine a species divided into several smaller sub-populations, like flocks or wandering herds. Some of the herds might be full of selfish individuals who act without regard to others in their vicinity, but other sub-populations might be full of altruists, whose cooperative behavior allows those sub-populations to produce *more* sub-populations, *also* full of altruists. If something in the environment kills off sub-populations, then the clusters of altruists will produce more offspring clusters than those comprised of selfish individuals, and this non-random survival of randomly varying replicators — in this case, the replicating units being taken as clusters — will lead to a species dominated by altruists.

On a first hearing, it sounds like a neat idea. But in the real world, it runs into problems: populations aren't rigidly divided, and instead, individuals flow through whatever demarcations you'd care to draw. Forces which kill off entire clusters at one go aren't so easy to come by. And the whole process is vulnerable to cheaters: a selfish mutant surrounded by altruists can benefit from the others' hard work. (The one lemming which doesn't jump off the cliff would, you'd think, have a better shot at spreading its genes all throughout lemming-kind.)

For a while, "group selection" was the default explanation for cooperative behaviors. For example, in the early 1960s the zoologist V. C. Wynne-Edwards compiled a thick volume documenting how different species use signaling mechanisms to determine their population density and, effectively, figure out how crowded the living situation is. Introducing the compendium, he said that group selection would have to be the explanation for these observations, since, well, that's how cooperative behaviors are explained. The responsibility of later generations is to separate the observations — on the aggressive behaviors of red grouse, the wintering habits of monarch butterflies, the roosting of starlings and so forth — from the explanation which was, in its time, superseded.

During this time, great advances were made in genetics: DNA was found to be the genetic material, the mapping from DNA sequences to protein sequences was unraveled, and — most crucially for this discussion — knowledge of genetics was combined with the principle of natural selection. Dawkins sets up this part of the story well, by quoting from George C. Williams:

> Socrates consisted of the genes his parents gave him, the experiences they and his environment later provided, and a growth and development mediated by numerous meals. For all I know, he may have been very successful in the evolutionary sense of leaving numerous offspring. His phenotype, nevertheless,

> was utterly destroyed by the hemlock and has never since been duplicated.

The extract from Williams's *Adaptation and Natural Selection* (1966) goes on to emphasize that the adaptations yielded by evolution must benefit *genes,* since all else dissolves, and only genes preserve an identity. (An ecologist might argue that organisms don't just inherit shuffled copies of their parents' genes, but also the environment which their parents' generation produced.[12] A developmental biologist might insist that genes do not directly yield behaviors, but rather, they code for proteins which mediate the expression of other genes in a mosh pit of biochemical interaction, unleashing patterns of cell growth which eventually unfold to form bodily structures which then exhibit ranges of behavior.[13] What counts as a "gene" for a population biologist might be an assemblage of different DNA sequences, each one of which a biochemist might call a "gene" — coding genes, non-coding genes, promoter genes, overlapping genes, Mexican jumping genes... The simplest solution might be to go mad.[14] But never mind all that now!)

How does this help us understand why one organism might give up its own chances at reproduction in order to help another? Well, take a gene's-eye view: copies of many of my particular genetic variants will be sitting inside the cells of my close relatives. So, as far as my genes are concerned, if my relatives survive, that's almost as good as *my* surviving. (If I live in a population which is scattered across a geographical region, and movement is limited, then I don't even need to go to the trouble of recognizing who's kin to me, since odds are, just about everybody I meet will be related to me at least moderately closely.)

Now, being an outsider to the whole biology profession, I'd like to be able to quote a biologist on this. Preferably a classic statement by a well-known biologist... wait, I've got this anthology of modern science writing, sitting right here! What does Robert Trivers say about how "kin selection" works?

> Most examples of altruism can easily be explained by some benefit to kin or return benefit to the altruist, but these explanations were not well developed until the 1960's and '70's.

Fin.

The passage chosen from Trivers doesn't actually *explain* these "benefit to kin" or "return benefit to the altruist" ideas. Instead, we read at some length about how group selection dilutes the potency of the Darwinian insight, and how biologists might have embraced group selection because it was more difficult to read "Social Darwinism" implications in it. But it is Nature who determines how widely applicable the Darwinian insight is, and Social

[12] See Simon Levin's remarks at `http://www.seaturtle.org/PDF/Levin_1992_Ecology.pdf`.

[13] PZ Myers addresses this issue in an introductory way at `http://scienceblogs.com/pharyngula/2007/09/basics_master_control_genes_an.php`.

[14] As evidenced by `http://www.plosone.org/article/info:doi/10.1371/journal.pone.0001231`.

Darwinism is fraught with so many flaws that if TwenCen biologists felt intimidated by it, well, so much the worse for them. *Scientific* arguments against group selection get three sentences out of as many pages.

The perplexity I felt upon first reading this selection grew, by fits and jumps, into a detectable irritation. After building up the case for a gene-centered view of evolution, when three pages on kin selection would be natural and almost necessary — say, a showcase of how benefit to kin can explain a particular, memorable observation — we tumble into a polemic which speculates about the sociology of scientists and makes only a glancing brush with scientific knowledge!

Arguments over the various proposed explanations for altruism are beyond the scope of this essay. They have featured strong personalities and biting condemnations; too often, they are complicated by confused terminology and failures of interdisciplinary communication. Field biologists argue with computer modelers who argue with microbiology experimentalists, while physicists fool themselves into thinking they can make real contributions, when in fact their points were made by ecologists years before. Some of the things called group selection are proven to be mathematically equivalent to some of the things called kin selection. Perhaps, stochastically, progress is made. I would have been happier if Dawkins had chosen a passage which explained biology rather than taking pot-shots at biologists; however, seeing that I've spent all this time talking about it, the Gentle Reader might infer that I inwardly enjoy doing so. As I said, *The Oxford Book of Modern Science Writing* provides an alloy of pleasures.

4 Mathematics

As indicated above, Dawkins includes mathematics in the sciences which his anthology samples. Some of the topics have a distinctly philosophical flavor (Gödel's Incompleteness Theorem), while others have great historical significance (Cantor's hierarchy of infinities, the transcendence of π and the irrationality of $\sqrt{2}$), and some, like Shannon's theory of information, see a great deal of practical use. Reading *The Oxford Book* will not turn the student into a practicing mathematician, nor will it directly build fluency in the mathematical tools used in scientific practice. However, as antidotes to the *fear of mathematics* induced by traumatic schoolhouse experiences, these selections are superb.

I should pull out one mathematical item for special consideration, as it is both a historical classic and, in regrettable consequence, one of the places where the age of the writing shows. Dawkins reproduces Martin Gardner's October 1970 column in *Scientific American,* the one which introduced Conway's Game of Life to the unsuspecting public.[15] (For some reason

[15] A Python implementation of Conway's Game of Life, perhaps pedagogically useful, can be found at `http://www.sunclipse.org/?p=473`.

I do not fathom, Dawkins cites Wolfram's doorstopper as a viable reference on the kind of "emergence" which Life makes so entrancing. The meme of citing Wolfram's name in this regard exhibits a fascinating infectiousness.[16]) Gardner's article has provoked almost forty years of madness and intricate beauty. So much has been said about Life elsewhere that I have little to observe here, except to note an item which perhaps should have been clarified in the context-setting material. Back in 1970, Gardner wrote,

> Conway conjectures that no pattern can grow without limit. Put another way, any configuration with a finite number of counters cannot grow beyond a finite upper limit to the number of counters on the field. This is probably the deepest and most difficult question posed by the game. Conway has offered a prize of $50 to the first person who can prove or disprove the conjecture before the end of the year. One way to disprove it would be to discover patterns that keep adding counters to the field: a 'gun' (a configuration that repeatedly shoots out moving objects such as the 'glider', to be explained below) or a 'puffer train' (a configuration that moves but leaves behind a trail of 'smoke').

Bill Gosper of MIT led a team which found a "glider gun" and made the result public in November, 1970. Gosper later discovered a puffer train, as well.

Dawkins chose to anthologize portions of the paper in which Alan Turing proposed what we now call the Turing Test. Leaving out Turing would be a sin of the first magnitude, and I suppose it's a bit of a crapshoot whether one decides to include the Test or the Machines. The former is our classic criterion for telling whether an artificial intelligence is thinking like a human, and the latter is a type of abstract device which lets us talk mathematically about what computation really *is.* Losing the Turing Machines is a sad occasion, since via the halting problem they provide a smooth path to Gödel,[17] while behind the scenes

[16]See `http://www.cscs.umich.edu/~crshalizi/reviews/wolfram/`. After this essay was first posted, a researcher in the cellular-automata field commented as follows:

> My impression is that Wolfram's impact has been negative rather than positive; when serious people see a call to rebuild science on a CA basis, coming from a megalomaniac maverick who doesn't even acknowledge prior work by others, they are more likely to steer away than to follow. I blame on him most of the CA-crap I find on the web; the real research was started before he came in, went on without him, and was not impacted at all by his latest doorstopper. Yes, the volume he edited in the 80s was (and remains) an important reference, his numbering scheme became a standard and his pseudo-classification scheme was influential (motivating people to look for real classifications). All that said, I guess that the reason for the "fascinating infectiousness" of citing Wolfram is the lack of alternatives that are as conspicuos and as comprehensive; however, better science writing can be found in Holland's books, or Morovitz's, or Wikipedia, for that matter.

[17]The ever-dependable computer science guru Scott Aaronson demonstrates this at `http://www.scottaaronson.com/democritus/lec3.html`.

they're joining forces with the cellular automata, because a Universal Turing Machine can be built in Conway's Game.[18] Every now and then, I wonder if, somewhere else in the multiverse of possibilities which string theory seems to permit, two-dimensional creatures with cellular-automaton brains made of a hundred trillion glider guns each are going about their Flatlander business and philosophizing about the impossibility of three-dimensional life. . .

5 Conclusion

I'm glad the world has this book in it. A book for the present day, *The Oxford Book of Modern Science Writing* is informative and inspiring, a departure point for new exploration. Far better to have it in hand and use it to anchor those discussions than to let its possibilities go to waste.

The volume ends on a note which had to have been deliberately chosen to soar. Like the conclusion of *Yes, Virginia* or *Dark Side of the Moon,* if it doesn't encompass absolutely everything, it's not for lack of trying. The final entry is taken from Carl Sagan's *Pale Blue Dot* (1994), and reproduces his famous contemplation on the picture *Voyager 1* returned, showing Earth from six billion kilometers away — just a point, filling less than a pixel in *Voyager*'s camera, almost lost in an accidental ray of scattered sunlight.[19] A more recent photograph from the *Cassini* probe revisited the same theme: passing behind the planet Saturn in September 2005, *Cassini* saw the ringed world backlit by the Sun, a view which Earthbound astronomers could only glimpse in imagination.[20] Seeing *Cassini*'s pictures is to think, how clever we are, for sending our servant so far.

But the image has a flipside as well, a consequence of geometry: Earth is always much closer to the Sun than Saturn is, so to look towards the Sun from Saturn is to look in Earth's direction as well. And there, seemingly floating among Saturn's outer rings, is Earth, 1.5 billion kilometers distant. Just a touch of color, with the faintest trace of the Moon visible on close magnification — that's *Cassini*'s home, and ours. In the years since Carl Sagan died, it has been perhaps the clearest example of a moment when those whose lives he touched all knew, "Carl would have loved that." From the vantage point our curiosity and our ingenuity have afforded us, we again look back to the world where we evolved, the world we share with untold millions of kindred species, the world beyond which we have never made a permanent home.

Again, we reflect: On this planet, a pixel across and a hyperlink in circumference, have lived every pacifist and every war criminal; every saint, prophet and demagogue; every

[18]See `http://rendell-attic.org/gol/tm.htm`.
[19]This has been made into a video, viewable at `http://www.youtube.com/watch?v=p86BPM1GV8M`.
[20]JPL provides this image at `http://photojournal.jpl.nasa.gov/catalog/PIA08329`.

parent and grandparent; every child lost to a preventable disease and every victim of natural catastrophe; everyone who has ever claimed to know divine will, and everyone condemned as heretic and infidel; every advocate of group selection or kin selection; everyone who has wanted to defang science for the swing voters or unleash it as a cleansing fire; all your ancestors and all of mine — all of them, all of us, spending our brief lives to contend for splinters of the infinitesimal. It is good to be a part of understanding Nature, however much we can, here on this place which might be mistaken for a moon, or a lost lump of methane ice.