Preface

> Writing projects was always an agony for me … I always tried to live up to Leo Szilard's commandment, 'don't lie if you don't have to do'. I had to. I filled up pages with words and plans I knew I would not follow. When I go home from my laboratory in the next afternoon, I often do not know what I am going to do the next day. I expect to think that up during the night. How could I tell then, what I would do a year hence?
>
> —Albert Szent-Gyorgi (1893–1986), Nobel Laureate, quoted on pg. 382 of *Discovering* by Robert S. Root-Bernstein [1]

This book is literature, not journalism.

Although it is unusual to apply labels like "literature" and "journalism" in science and mathematics, it is nevertheless true that oceanographic observations and contour plots of supercomputer flow are as ephemeral as yesterday's newsprint. The lonely oceanographic research vessels of the twentieth century, laboriously deploying an instrumented mooring here, a tide guage there, painfully struggling with leaking batteries, failed anchor releases, storms and heavy seas, were crewed by heroes. Their data, though, has already been forgotten. Who in his right mind will consult a field experiment in which the whole of the tropical ocean was inferred from a diamond of five moorings when thousands of data points are available from the Argos drifters?

In contrast, good theory is literature. To replace awe with understanding, we must walk the theory road through increasingly complicated approximations. The stepping stones remain unchanged even as the road is extended. In this sense, most of the analysis presented here will be as long-lived as Shakespeare, though without the swordfights and iambic pentameter.

This book reflects my biases. First, most oceanographers flock to oceanographic conferences, exchange the latest oceanographic gossip, and follow each hint of new trends and programs from ONR and NSF with the zeal of the Enigma codebreakers, and talk only to other "water people". They are connoisseurs of five hundred coastal

currents, refer to vortices as "Ring Bob" and "TIV Samantha", and nod sagely at every wiggle in a CTD sounding. Even the theorists share war stories, with rogue waves and forty-degree rolls replacing artillery and charges up the hill, earned by many months at sea. Their job, as they see it, was expressed eloquently by a student whose response was the title of Dallas Murphy's book [2]: *To "Follow the Water"*.

Yes, but a physical and mathematical science is healthy only if some of its citizens follow mathematics and physics, too.

Second, although I have published 69 papers that employ some form of singular perturbation theory, I also have written two long books on Chebyshev, Hermite, and Fourier numerical methods and nearly two hundred articles that employed them. As visualized in Fig. 1, analysis and perturbation expansions ("chirugery") and spectral methods and other numerical algorithms ("arithmurgy") are not separate worlds, but rather the view from the left eye and the right eye fused into a single scene.

This book also bears the scars of its long and difficult genesis. The text began as a graduate course I first taught in the early 1980s. Unfortunately, the audience for my advanced classes dried up, our undergraduate oceanography major went away, and finally my department changed its name to entirely eliminate "oceanic". I told myself that I would return to the book when I was older. My father died at 97, active and independent for almost all of a very long life. Plenty of time, I thought.

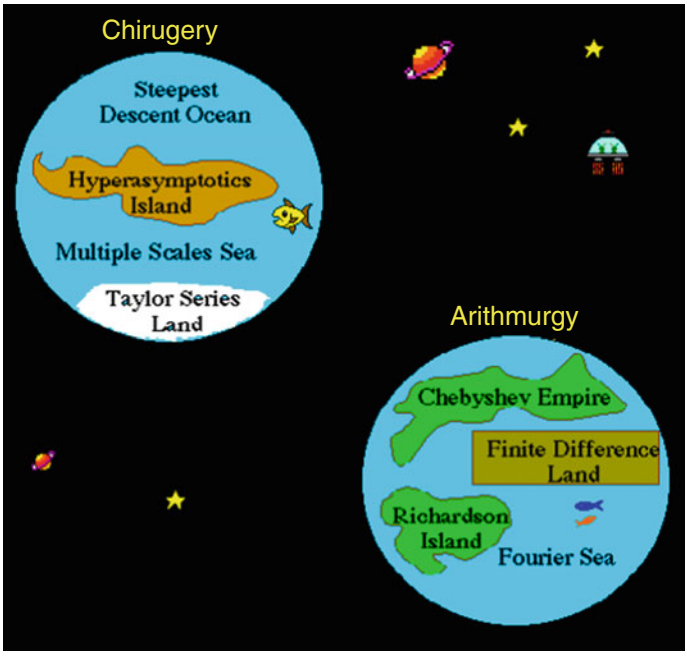

Fig. 1 The Unity of Chirugery and Arithmurgy

Unfortunately, Parkinson's disease intervened. My arms and legs are always sore ("cogwheel rigidity"). My handwriting trails off into tiny random squiggles; three tries and 30 seconds to write a single word that I might perhaps read tomorrow but not in a week ("micrographia"). I limp due to a semi-permanent cramp in my left foot ("dystonia"). Double-clicking usually takes several tries because nothing happens at first ("freezing" or "festination"). I freeze when walking, too. I often move with tiny, shuffling steps with my left arm motionless, though I can sometimes walk almost normally if I consciously take long steps and swing my bad arm. My soft voice is even softer now ("hypophonia") and a little slurred; my wife is urging speech therapy. My typing is slow and error-prone, three or four typos per sentence ("bradykinesia"). With heavy use of dictation software and a student scribe hired by my department, I manage. I have twice reviewed the final manuscript of this book, line by line, for typos, but my typing is so compromised that the errors were twice as numerous as the stars in our galaxy. I ask the reader's forgiveness for the mistakes that remain.

There are some consolations. An incurable, steadily progressive disease is a great foe for procrastination, and otherwise perhaps this book would never have been finished.

Illness has released me from grant-chasing, and that, too, is a blessing.

My department, with few students and great dollops of NASA space money, always expected every faculty member to provide academic year salary support. This became rather awkward after OCE changed its policy to reject such support for tenure track faculty. For 30 years, my proposals had huge budgets for page charges and sundries, but I published only in "free" journals and diverted the funds to pay the department chair's tax.

After many years of failure, I finally got a grant from the Math Directorate! It all went in tax, and I never spent a dime.

My project descriptions were even more fantastic than my budgets, alas. Three years of milestones and detailed plans, focused on a single project, dummied-down to what a graduate student can do. Actually, I averaged 20 to 30 journal articles every 3 years, and hardly ever did I know that I was going to do a problem 6 months in advance of submitting the paper solving same. Year after year, reviewers and program managers scolded me: One project per proposal! Three years! Work plans! Deliverables!

In my other life, I have published twenty science fiction and fantasy short stories. (A list can be found on the Internet Speculative Fiction Database at www.isfdb.org) It is wonderful that my future fantasies will all be literary!

Still, I mourn the terrible waste of time spent preparing and reviewing proposals. Only one of my last fourteen proposals was funded before I was finally cut off by NSF physical oceanography after nearly 40 years. "Not really an oceanographer" was said at the review panels. "Not enough face time at oceanography meetings". A real oceanographer must "follow the water", apparently, even if the water is Powerpoint fakery at a giant conference center in the Rose City. If I still had a face, instead of a Parkinsonian mask, I would even so wish to be judged on what I had written instead of my skill in networking.

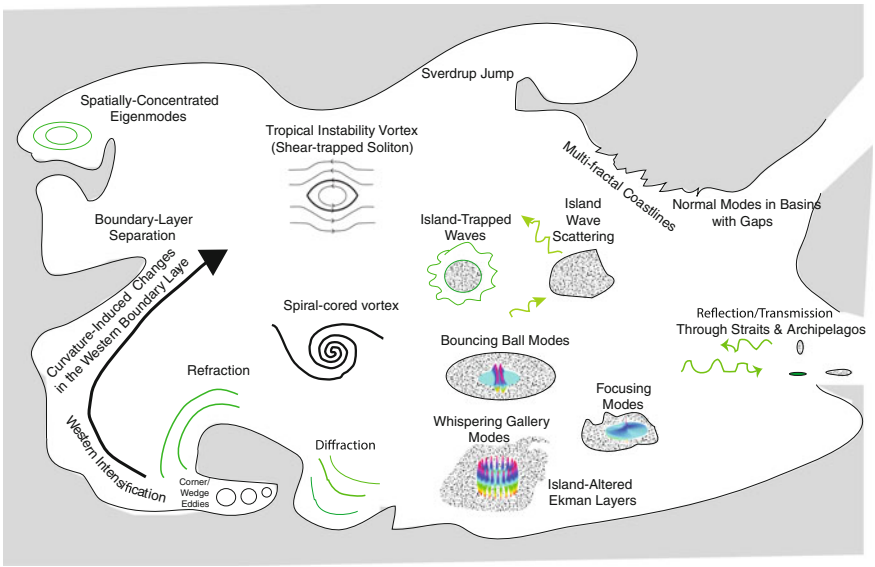

Fig. 2 Geometric Oceanography

An oceanography cutoff from mathematics, insular, is ill-prepared for parallel-in-time reduced basis models. As visualized in Fig. 2, the future of oceanography is as much in geometry as in the connoisseurship of currents.

My 8-year-old laptop can run the LINPACK benchmark four hundred million times faster (50 floating operations per second versus 20 gigaflops) than the HP personal computer I used as a grad student and has a million times more memory (eight kilobytes versus eight gigabytes), but oceanographers do not have a million times more insight. Rather, number-crunching is bound by the following:

First Law of Arithmurgy:
Insight grows no faster than logarithmically with resolution
—J.P. Boyd [3]

Supercomputers shall not accelerate us into a wiser future unless numerical algorithms and oceanographic theory push and push and jump in the bobsled to descend the turns together.

Of course, deans and department chairs were indifferent to such philosophy-of-science issues but just as frowny as the civil servants.

The horror! I program.

The horror! I expand, derive and integrate.

The horror! Didn't I know I was supposed to leave all that to the graduate students? Science is quantized and the quanta are [grad] student triennia.

Where were my big grants? A sausage factory is supposed to turn out sausage in bulk, and where was all my fine doctoral bratwurst? And awards? Surely in a time

when departments and professional societies spend enormous energy on self-congratulation, why was I not a fellow of AGU and AMS? (I was nominated but not elected AMS fellow three years running.) In my own reckoning, to be blessed with the time and opportunity to write four books and 250 journal articles and mentor more than twenty graduate students is prize enough. And I am not yet done.

STEM education is focused entirely on inspiring the young with the joy of science, but many students see professors as Not-Scientists. Faculty at a teaching institution have such heavy teaching loads that they have no time to *do science*, as opposed to merely sharing the classics. Professors at a research university are managers, a hundred parsecs from the lab bench or computer simulation, and are Not-Scientists, too. I suffered for being a Not-Not-Scientist and don't know what to say to students who see no real career in science except an endless succession of postdocs, moving as often as military families, always working on someone's else agenda to impress a review panel, scientific *ronin*.

It is doubtless a great relief in Arlington that the agencies are no longer tortured by someone who consistently Colored Outside the Lines. My chair no longer needs fret about my academic year tax. Our research administrators are happy that one who paid little attention to budgets and balances has been replaced by junior faculty who have been drilled since candidacy in the importance of good management.

I was an awful manager, accountant, and pitchman, but mostly by ignoring those roles entirely, I was mostly, honestly, a scientist, and had a lot of fun. And through blatant dereliction of duty, as defined by deans and federal agencies, I had time to write this book.

I thank Dennis Moore for his review. Thanks also to Peter Gent, James Luyten, Julian P. McCreary, Jr., Mark Cane, and Edward Sarachik for permission to reproduce figures and for helpful comments.

I also express appreciation for permission to reproduce figures to the American Meteorological Society, the Royal Society of London, and the Journal of Marine Research.

I thank Kristina Neal, Temitope Akinlua, Miesha Williamson, and Ninad Ramachandra Naik for help with illustrations.

I thank Leah Lindsey, my scribe, for her assistance, especially with the innumerable corrections.

I acknowledge a little support for more than 35 years from the physical oceanography section of the NSF and also small, non-renewed grants from NASA and the Department of Energy. For many years, my one and only little grant was split-funded between physical oceanography, atmospheric sciences, and computational mathematics, but the latter two dropped out and then physical oceanography refused repeated renewal proposals a few years later.

In view of the huge amount of time lost in reviewing, review panels, and proposal writing, whether the agencies helped or hindered my research is known but to God.

The funds did support some of my students. I was blessed to be chair or co-chair for seventeen doctoral students and two master's students, collaborated on papers with four other students though not an official advisor and mentored three doctoral students who visited from China. I dedicate this book to them.

I am fond of funny words like "arithmurgy", "chirugery", and "hydroarithmomancy" [etymologies in the glossary] not only because I studied Latin and classical Greek and never recovered, but also, I have thought that the spirit of St. Theresa of Avila's advice to her novices was sound for science, too: "God deliver me from frowning saints". It is possible to combine conviction with humility and humor, and I do not apologize for trying my best to do so.

Future work will likely find some of my most charming insights are wrong and some wrong-headed. AIDS was caused only by homosexual contact until it was caused also by heterosexual contact, drug needles, blood transfusions, and mother's milk. All cholesterol was bad until some of it was good. And 30 years of string theory has yield zero testable propositions. Error is not merely a broken formula; sometimes an entire field can chase the ether.

But true scientific understanding is not a drawer of index cards, but rather a structured network which is fault-tolerant to cracks and corrections. And it is also good, both for science and for reading, to reach beyond facts and formulas to a poetic sensibility where number-crunching is arithmurgy and "all of loneliness and grief" is "an empty doorway and a falling leaf".[1]

The poet sees the world on many levels simultaneously, and so must we. Remember, as you read, that John Keats was multiscaled and fractal long before Benoit Mandelbrot.

Ann Arbor, USA John P. Boyd
May 2017

References

1. Root-Bernstein RS (1989) Discovering: inventing and solving problems on the fronters of scientific knowledge. Harvard University Press, Cambridge, Massachusetts
2. Murphy D (2008) To follow the water. Basic Books, New York, p 296
3. Boyd JP (2008) Challenges and controversies in multiscale numerical algorithms for weather forecasting and climate modeling. SIAM News 41(9):1

[1]Archibald MacLeish in "Ars Poetica".

http://www.springer.com/978-3-662-55474-6

Dynamics of the Equatorial Ocean

Boyd, J.P.
2018, XXIV, 517 p. 159 illus., 27 illus. in color.,
Hardcover
ISBN: 978-3-662-55474-6