Images of a Complex World
The Art and Poetry of Chaos

by Robin Chapman and Julien Clinton Sprott

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The goal of both mathematician and poet is to seek clarity and beauty of expression about the world around us through elegant use of their respective languages. While nature is a common source of inspiration for both mathematician and poet, the poet examines the human response to nature while the mathematician explores the logical order of nature.

Despite these similarities, creative use of both mathematics and poetry together are uncommon. Several mathematicians have written poetry – J. J. Sylvester and James Clerk Maxwell sometimes incorporated poems into their papers, although these are now forgotten (perhaps with good reason) while their mathematics continues to inform new research. Many of us have enjoyed the light verse of Ralph Boas, Jr. [1] and poetry has often graced the pages of *The Mathematical Intelligencer*. But few poets have dared to incorporate mathematical themes in their exploration of the human condition, although Anne Michaels has captured Kepler's life and thought superbly in her long first-person poem, *A Lesson from the Earth* [2], which begins "I begged scraps from the Rudolphine Table – the rinds of orbits, stars scattering like pips spat from Tycho's chewing mouth…" and continues with "…We must learn this lesson from the earth, that the greater must make room for the small, just as the earth attracts the smallest stone…" and "…I used to think that we escape time by disappearing into beauty. Now I see the opposite. Beauty reveals time."

In *Images of a Complex World*, a poet and research psychologist (Chapman) and a physicist and dynamicist (Sprott), both at the University of Wisconsin, collaborate on exploring the beautiful world of dynamical systems and nature through poems, illustrations, and thumbnail essays. Although billed as an addition to your coffee table, this book really belongs in your classroom instead.

By adding depth and dimension to many dynamical ideas and concepts, Chapman's poems enrich our and our students' understanding of them. Here is her poem, *Fixed Point*, from a set of poems entitled *Stillness*:

The Fixed Point

The dot: how it stops
everything.
Finishes the thought.
Ends the sentence.

Where everything vanishes
in the end.
Period.

But it is not
the all of it,
though all come to it.

It is only the idea of no
dimension
over which we exclaim,

the vanishing point
that lends the observer
perspective,

a fiction
of the eye too far away to see –
speck, mote, egg.

The clarity and depth of this poem is not, of course, the pithy clarity and depth of $x^* = f(x^*)$. But just as we teach our students how to unpack an equation to discover its hidden meaning, so does Chapman unpack the concept of a fixed point to uncover its hidden poetic beauty.

The poems also explore the human condition at the same time they illustrate mathematical ideas. How many of us have had difficulty explaining to students the meaning behind the property of nonlinear systems that $f(x + y) \neq f(x) + f(y)$? Here's Chapman's illustration of nonlinear systems, poignant not only for capturing the essence of this property but also for describing an all-too common condition of contemporary human existence:

Def 2: One in which
$f(x+y)$ does not equal $f(x) + f(y)$

This is easily enough understood
By any child of divorce – Mom's house
And Dad's house are not the same
As the house with both Dad and Mom before.
Or think of *f* as happiness,
And know that what they had together
Is not what they have now, whatever
The plus or minus of once-upon-a time.

Of course, the whole thrust of mathematical teaching for the past 150 years or so has been to disembody mathematics, to get away from this "human dimension", but when used with discretion and taste as in the hands of skilled practitioners and teachers such as Chapman and Sprott, I see no harm and even much good in it.

Julien Sprott, an accomplished author [3] and scientific educator (see his website at http://sprott.physics.wisc.edu/) provides clear expositions of the mathematical concepts that are the springboards of the poems, serving as prose counterpoints to Chapman's verse, including entropy, state space, basins of attraction, and the three-body problem, among many others. Here is his explanation of hysteresis, in a section called *Time's Arrow*: ""Hysteresis is a form of memory…. Hysteresis requires a nonlinearity in the governing equations, and the nonlinearity is often in the form of a threshold where the behavior switches abruptly from one form to another as a parameter is changed (a bifurcation)." This neatly balances the first two lines of the next poem, called *Hysteresis*: "Whatever we expected would happen next / it wasn't this…" One could spend a mathematical or poetic lifetime exploring the deep meaning behind these descriptions.

Sprott's other contribution to the book are the stunning illustrations of attractors (strange and otherwise), iterated function systems, and Julia sets. At this point, the reader might wonder why she or he needs to see yet more examples of these, but the cleanliness, clarity, and visual

beauty of these are truly marvelous. All of the attractors are in color, with the color depicting the value in the z-dimension, and most are on a white background, which gives them a crispness lacking in many other books. Because many non-mathematicians find the unstructured appearance of strange attractors difficult to appreciate, Sprott introduces symmetry into some of these illustrations by an interesting transformation of the x and y coordinates to polar coordinates, a technique which he has previously published in [4]. This gives the attractor image the shape of a wedge and several wedges are then assembled into a radially symmetric image, like the arms of snowflakes or bursts of fireworks. I suspect that underlying these polar transformations there may be some interesting ideas in the mathematics of symmetry which may make a nice student project or undergraduate thesis. There is an Appendix for the Mathematically Inclined that discusses these and other mathematics behind the images.

This collection of Chapman's poems with Sprott's visual art and mathematical expositions is a welcome compilation and nicely shows the breadth of their work, both separately and in collaboration. The book comes with a CD with these and many other images, readings of some of the poems by Chapman herself, weblinks, and a variety of other classroom resources. *Images of a Complex World* should set a standard for collaborations between mathematicians or scientists and artists: indeed, the line separating which author is a scientist from which is an artist is often blurred in this book. Buy it or have your library purchase it, share it with your students, and dip into it when your creative pump needs priming.

REFERENCES

[1] Gerald Alexanderson and Dale Mugler, editors. *Lion Hunting & Other Mathematical Pursuits. A Collection of Mathematics, Verse, and Stories by Ralph P. Boas, Jr.* The Mathematical Association of America, Dolciani Mathematical Expositions Volume 15, Washington, DC, 1995.

[2] Anne Michaels. *Poems*. Alfred A. Knopf, New York, 2001.

[3] Julien Clinton Sprott. *Chaos and Time-Series Analysis*. Oxford University Press, Oxford, 2003.

[4] Julien Clinton Sprott. Strange attractor symmetric icons. *Computers & Graphics* **20:** 325-332, 1996.

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